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Highlights

Glass Reinforced Polymer

Finite Element Analysis

Burnishing Effects on Friction

Neem and Cork Wood

Discovering Thoughts, Inventing Future

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Experimental Study and Verification of Wear for Glass Reinforced Polymer using ANSYS

By P. Prabhu, M. Suresh Kumar, Ajit Pal Singh & K. Siva
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Abstract- The current design/manufacturing field looking for value added/engineering projects. In this study, an attempt has been aimed to predict the wear of the sliding surfaces in the development stage it self which will be results in the increase of durability of the components. The wear for a polymer-polymer sliding surface contact in dry condition can be obtained by creating simulation. There are two inputs required for determining the wear volume loss over its usage time. One is the nodal pressure value at the contact area for small sliding steps which can be calculated by subjecting the geometrical model to the finite element analysis. ANSYS was used as finite element tool. Another one is the friction coefficient which can be obtained by custom designed experiments. For the calculation of friction coefficient, prototype to be subjected to unlubricated pin-on-disc experimental setup. The wear rate can be calculated by graph by plotting between pressure and cycles. Swiveling of mirror over the base resulted in the wear. By the above techniques, the wear loss and reliability of the rear mirror can be predicted.

Keywords: glass reinforced polymer, wear, sliding contact, CATIA and ANSYS.

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EXPERIMENTALSTUDYANDVERIFICATIONOFWEARFORGLASSREINFORCEDPOLYMERUSINGANSYS

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P. Prabhu [α], M. Suresh Kumar [σ], Ajit Pal Singh [ρ] & K. Siva [ω]

Abstract- The current design/manufacturing field looking for value added/engineering projects. In this study, an attempt has been aimed to predict the wear of the sliding surfaces in the development stage it self which will be results in the increase of durability of the components. The wear for a polymer-polymer sliding surface contact in dry condition can be obtained by creating simulation. There are two inputs required for determining the wear volume loss over its usage time. One is the nodal pressure value at the contact area for small sliding steps which can be calculated by subjecting the geometrical model to the finite element analysis. ANSYS was used as finite element tool. Another one is the friction coefficient which can be obtained by custom designed experiments. For the calculation of friction coefficient, prototype to be subjected to unlubricated pin-on-disc experimental setup. The wear rate can be calculated by graph by plotting between pressure and cycles. Swiveling of mirror over the base resulted in the wear. By the above techniques, the wear loss and reliability of the rear mirror can be predicted.

Keywords: glass reinforced polymer, wear, sliding contact, CATIA and ANSYS.

I. Introduction

The interactions between two bodies that move in contact with each other manifest in friction and wear. Resulting in supplementary energy loss and failure of sliding elements, both processes have to be minimized. Since the application of a lubricating film between the contacting parts should be avoided for ecological reason or is impossible under certain working condition, polymers are increasingly used as self-lubricating materials in guidance, train boggies, bearings and ball-joints. The formation of a polymer transfer film onto the sliding counter face has beneficial effects on stable friction and low wear. However, the practical lifetime design of engineering polymers used under high loads and low sliding velocities can be troublesome, since most available data about their friction and wear properties are obtained from small-scale tests.

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In many cases, design engineers need specified tribological data to establish the performance of different available polymers for a given operational system in Archard's wear equation.

Experimental determination of life parameters in terms of wear has both cost and time impact. The ability to simulate wear and consequent useful life prediction can benefit product designers and manufacturers in multiple manners as, designing better products, contemplating better maintenance plans to avoid potential failures and avert financial losses. Some of the application areas where wear simulation can augment design are but not limited to: sliding or rotating components in automotives, engines and pumps, consumer products, prosthetic joints and lately MEMS (Microelectromechanical systems)-based micro machines. The finite element analysis-(FEA) based wear simulation and life prediction methodology presented in this research can be leveraged to any of the aforementioned areas.

a) Wear

Wear is the erosion of material from a solid surface by the action of another surface. It is related to surface interactions and more specifically the removal of material from a surface as a result of mechanical action.

b) Types of Wear

The study of the processes of wear is part of the discipline of tribology. The complex nature of wear has delayed its investigations and resulted in isolated studies towards specific wear mechanisms or processes. Some commonly referred to wear mechanism (or processes) include viz., adhesive wear, abrasive wear, surface wear, fretting wear, and erosive wear.

A number of different wear phenomena are also commonly encountered and represented in literature. Impact wear, cavitations wear, diffusive wear and corrosive wear are all such examples. These wear mechanisms; however, do not necessarily act independently in many applications. Wear mechanisms are not mutually exclusive. "Industrial wear" is the term used to describe the incidence of multiple wear mechanisms occurring in unison. Wear mechanisms and/or sub-mechanisms frequently overlap and occur in a synergistic manner, producing a greater rate of wear than the sum of the individual wear mechanisms.

c) Mechanism of Wear

Wear can be split into two majority categories: wear dominated by the mechanical behavior of materials and wear dominated by the chemical behavior of materials as shown in Table 1. Since finite element programs typically do not consider the chemical interactions between bodies or surfaces, these types of wear has not discussed in this paper. There are seven mechanical wear mechanisms listed (Table 1), however there are only three types of surface to surface interaction that can cause them: sliding (one surface sliding relative to another over long distances), fretting (one surface oscillates over minute distances relative to the other) and erosion (solid particles impinging on a single surface from an external source).

Table 1 : Classifications of wear mechanisms [6]

Classification	Wear mechanisms (Wear coefficient K range)
Wear dominated by mechanical behavior of materials	• Asperity deformation and removal (10^{-4}) • Wear caused by plowing (10^{-4}) • Delamination wear (10^{-4}) • Adhesive wear (10^{-4}) • Abrasive wear (10^{-2} to 10^{-1}) • Fretting wear (10^{-6} to 10^{-4}) • Wear by solid particle impingement
Wear dominated by chemical behavior of materials	• Solution wear • Oxidation wear • Diffusion wear • Wear by melting of the surface layer • Adhesive wear at high temperatures

For this study, only dry (non-lubricated) sliding wear has been considered. The actual wear mechanisms for dry sliding wear depends on a number of variables including viz., surface finish, surface geometry, orientation, sliding speed, relative hardness (of one surface relative to the other or relative to the abrasive particles between the surfaces), material microstructure and more. From these variables, it can be seen that wear rate is not a pure material property and does not always occur uniformly.

Finite element modeling of dry sliding wear can be accomplished one of two ways. First, the details of the surface interaction, including surface finish, can be included and calculated in the model. If that approach is taken, it would require that individual finite elements be removed from the model to simulate the gouging or plowing. This in turn requires that the size of the finite element be of the same size as the particles being removed since there are currently no options for removing part of an element (in ANSYS the element is either dead or alive).

As the particles being removed are on the size of molecules, the mesh density, at least near the wearing surface, would also need to be on the size of molecules. This is not a theoretical problem since finite elements are being used to analyze MEMS size devices but it is a practical problem since small size implies a large number of elements which requires large amounts of memory and disk space for the storage of the data generated by a finite element program.

The second approach would be to ignore the details of what is going on at the micro or nano scale and take a macro scale approach to the problem. On the macro scale, the size of the elements would be much larger than the anticipated changes due to wear and the calculations could be performed within the element rather than relying on the birth and death procedure needed at the surface level.

d) The Archard Equation

The starting point for any discussion of wear on the macro scale is the Archard equation (Podra and Andersson, 1999) [13], which states that:

$$W = K \times S \times P \tag{1}$$

where, W is the worn volume, K is the wear per unit load per sliding distance and S is the sliding distance, P is the applied load.

Archard says “K may be described as the coefficient of wear and, in a series of experiments with the same combination of materials; changes in K denote changes in surface conditions”. The Archard equation assumes that the wear rate is independent of apparent area of contact. However, it makes no assumptions about the surface topography (surface roughness effects are encompassed by the experimental wear coefficient) and it also makes no assumptions about variations with time. It must also be stated that although it is widely used, the Archard equation only provides for an order of magnitude estimate and is a true calculation of wear.

One of the more common methods for determining the value for K is to press a stationary pin using a preload of P into the surface of a rotating disk. The load P is known and the sliding distance S can be determined from the rotational speed of the disk and time that the disk has rotated. The amount of wear on the pin is determined by change in mass (weight) of the pin and the constant K calculated. This method for determining a constant wear coefficient for a given pair of surfaces has limitations. It ignores changes in apparent area of contact with time, also known as “running in” effects. It assumes that the direction of the load is constant which may not be the case in real conditions. And, it assumes that the surface topography of the experimental surfaces accurately represent the surfaces of interest.

Despite these limitations, it will be assumed that the values of wear coefficients determined by the pin-on-disk method or by other methods are accurate enough to use in engineering analysis. In engineering applications, the loss of volume (and thus, loss of mass) may not be as important as the change of a given dimension at a given location on the device or structure. For example, we may be interested in the change of length of the pin in the pin-on-disk experiment. Or, we may be interested in the change of diameter for a radial bearing after a long period of time in use. The change of a single dimension can be calculated from the change in volume by dividing by the apparent area of contact assuming that the apparent area of contact is constant. When the contact area changes with time, a more sophisticated calculation must be performed to determine the change in desired dimension over time. This method for generating wear is not universally applicable.

First, it ignores the details of the surface and assumes that the full surface is in contact with the disk. This is similar to the usual assumption for contact in finite elements where the surface is assumed to be smooth. It also assumes that the direction of the load is constant and that the load is unchanging which may not be the case in real conditions. And if the state of stress at the surface is considered, the magnitude and direction of those surface stresses would also remain constant. A common type of wear is that generated by the repetitive application of a load on the same surface. The Archard equation would also imply that the particles would be removed from the surface in a uniform manner and that the surface would maintain the same general shape. That is that particles that exist in the valleys of the surface would be eroded at the same rate as particles at the peaks of the surface.

e) *Stages of Wear*

Under normal operating parameters, the property changes during usage normally occur in three different stages as follows:

- Primary or early stage or run-in period, where rate of change can be high.
- Secondary or mid-age process where a steady rate of aging process is maintained. Most of the useful or working life of the component is comprised in this stage.
- Tertiary or old-age stage, where a high rate of aging leads to rapid failure.

With increasing severity of environmental conditions such as higher temperatures, strain rates, stress and sliding velocities, the secondary stage is shortened and the primary stage tends to merge with the tertiary stage, thus drastically reducing the working life. Surface engineering processes are used to minimize wear and extend working life of material.

f) *Study Approach*

In this study, aim is to calculate the wear of the sliding contacts by using macro level approach. Equation (1) can be solved by using two parameters as inputs.

- Nodal pressure-it is the pressure at the crest of the projection areas, which can be obtained by FEA.
- Wear co-efficient can be calculated by using pin on disc experiment.
- Finding the life cycle of the component.

Above said approach to be followed to test the component shown in Figures 1 and 2.

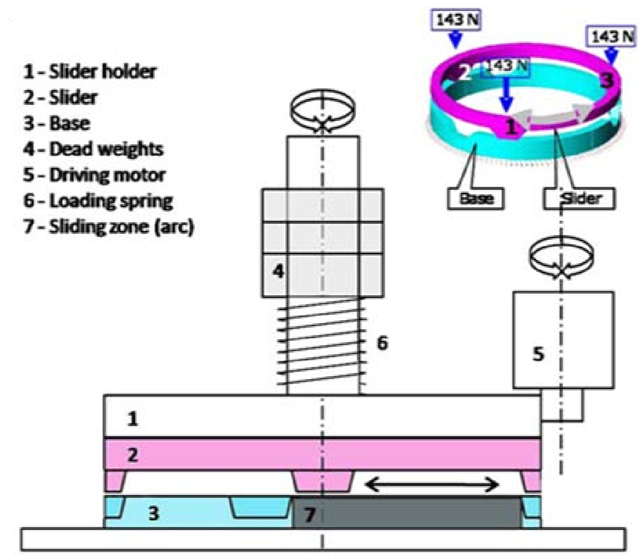

Figure 1 : Side rear view mirror in modern car in 2D

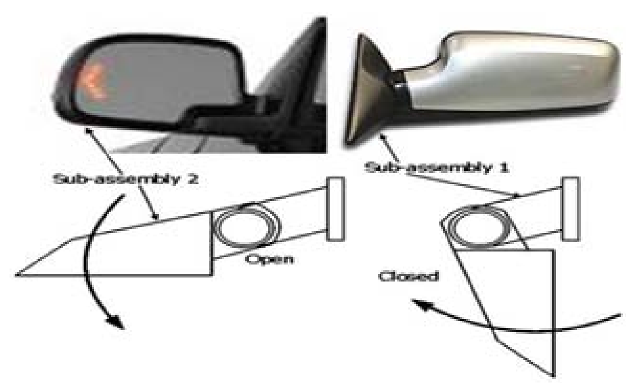

Figure 2 : Side rear view mirror in modern car

Swiveling of mirror over the base resulted in the wear. By the above techniques, the wear loss and reliability of the rear mirror can be predicted.

II. Literature Review

Podra and Andersson, (1999) [13] have studied the wear simulation approach with commercial finite element software ANSYS. A modeling and simulation procedure was proposed and used with the linear wear law and the Euler integration scheme. A spherical pin-on-disc unlubricated steel contact was analysed both experimentally and with finite element method (FEM), and the Lim and Ashby wear map was used to identify the wear mechanism. It was shown that the FEA wear simulation results of a given geometry and loading can be treated on the basis of wear coefficient-sliding distance change equivalence. The finite element software ANSYS was well suited for the solving of contact problems as well as the wear simulation. The actual scatter of the wear coefficient was within the limits of 40-60% led to considerable deviation of wear simulation results. Due to the model simplifications and the real deviation of input data, the FEA wear simulation results was evaluated on a relative scale to compare different design options, rather than to be used to predict the absolute wear life.

Kim et al. (2005) [10] have proposed a numerical approach that simulates the progressive accumulation of wear in oscillating metal on metal contacts. The approach used a reciprocating pin-on-disk tribometer to measure a wear rate for the material pair of interest. This wear rate was an input to a FEA that simulates a block-on-ring experiment. After the simulation, two block-on-ring experiments were performed with the same materials that were studied in the reciprocating pin-on-disk experiments. The results from the FEA were in close agreement with the block-on-ring experimental results. This approach did not either rely on curve fitting or use the block-on-ring experimental data as model inputs. The FEA were performed by progressively changing nodal coordinates to simulate the removal of material that occurs during surface interaction. The continuous wear propagation was discretized and an extrapolation scheme was used to reduce computational costs of this simulation.

Zhang and Meng, (2006) [20] have proposed a linear sliding wear model with ratcheting effects to describe the wearing process and a simplified mathematical method was presented to simulate the wear of the rotor bushing sliding on the ground plane. The effects of geometry parameters, material properties and applied operating conditions on the evolution of dimensional and volumetric wear rates were explored for normally loaded rotating rotor bushing sliding on the ground plane. The hemispherical-bushing-on-ground-plane configuration finite element model was established and the implementation of the contact problem based on ANSYS finite element software and contact element approach was introduced to investigate contact problems in micro motors. Numerical simulations and results of the contact stresses and contact pressure were studied and the effects of wear coefficient, material selections, surface roughness and geometry structures, etc., were discussed in detail. It was indicated that the non-linear effects could not be ignored and these results must be evaluated on a relative scale to compare different design options.

Unal et al. (2004) [17] studied and explored the influence of test speed and load values on the friction and wear behavior of pure polytetrafluoroethylene (PTFE), glass fiber reinforced (GFR) and bronze and carbon (C) filled PTFE polymers. Friction and wear experiments were run under ambient conditions in a pin-on-disc arrangement. Tests were carried out at sliding speed of 0.32, 0.64, 0.96 and 1.28 m/s and under a nominal load of 5, 10, 20 and 30 N. The results showed that, for pure PTFE and its composites used in this investigated, the friction coefficient decrease with the increase in load. The maximum reductions in wear rate and friction coefficient were obtained by reinforced PTFE+17% glass fiber. The wear rate for pure PTFE was in the order of 10^{-7} mm^2/N, while the wear rate values for PTFE composites were in the order of 10^{-8} and 10^{-9} mm^2/N. Adding glass fiber, bronze and carbon fillers to PTFE were found effective in reducing the wear rate of the PTFE composite. In addition, for the range of load and speeds used in this investigation, the wear rate showed very little sensitivity to test speed and large sensitivity to the applied load, particularly at high load values.

III. Materials and Method

For rear side view mirror in modern car is made of polymers. In these base and slider are mating parts, base is rigidly fixed and slider is flexible surface contact with base is as shown in Figure 3.

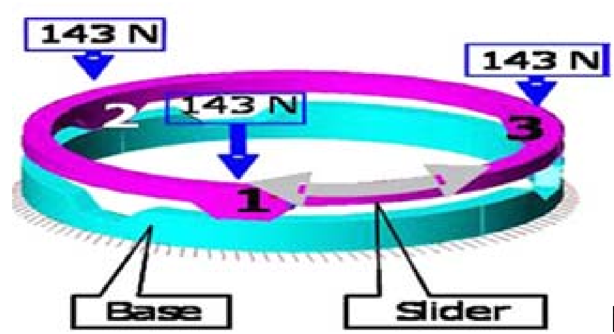

Figure 3 : Sliding contact at the swiveling joint

a) Existing Materials

The following materials (Tables 2 and 3) are used in existing model.

Table 2 : Properties of base material

Material	33% glass reinforced, heat stabilized black nylon copolymer resin
Density	1400 kgm^{-3}
Tensile strength	172 Mpa
Commercial name	Zytel 72G33HS1L by DuPont
Cost (INR)	210/Kg

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Table 3 : Properties of slider material

Material	BK159, 45% glass reinforced modified polyethylene terephthalate
Density	1700 kgm^{-3}
Tensile strength	186 Mpa
Commercial name	Rynite 545 NC010 by DuPont
Cost (INR)	220/Kg

Coefficient of friction between 33% glass reinforced, heat stabilized black nylon copolymer resin and BK159, 45% glass reinforced modified polyethylene terephthalate=0.17 (as per previous experimentation set these values are obtained).

b) Selection of New Materials

In this study new materials were selected for the following reason:

- When the slider is in contact with base material the co-efficient of friction is high, due to this on the slider, the wear formation is high. Therefore changing the material of the slider will reduce the co-efficient and wear rate.
- When the wear formation is high automatically the life cycle of the component is reduced to low level. So in order to increase life cycle of the material. The new material was chosen is of 43% glass fiber reinforced polyamide 66 resin with high tensile strength, density, cost etc.

c) Proposed Materials

The following materials (Table 4) are used.

Table 4 : Properties of slider material

Material	43% glass fiber reinforced polyamide 66 resin.
Density	1490 kgm^{-3}
Tensile strength	236 Mpa
Commercial name	Zytel® 70G43L NC010
Cost (INR)	225/kg

d) Comparison of Materials

Table 5 compares the existing slider of BK159, 45% glass reinforced modified polyethylene terephthalate with 43% glass fiber reinforced polyamide 66 resin. Based on the comparison of proposed material with existing material, 43% glass fiber reinforced polyamide 66 resin properties is better than BK159, 45% glass reinforced modified polyethylene terephthalate, based on properties.

Table 5 : Comparisons of existing and new slider materials properties

Parts	Existing slider	New slider
Material	BK159, 45% glass reinforced modified polyethylene terephthalate	43% glass fiber reinforced polyamide 66 resin
Density	1700 kgm^{-3}	1490 kgm^{-3}
Tensile strength	186 Mpa	236 Mpa
Commercial name	Rynite 545 NC010	Zytel® 70G43L NC010
Cost (INR)	220/kg	225/kg

IV. Experimental Setup

The setup used in this study for the wear test is capable of creating reproducible sliding wear situation for accessing slide as shown in Figure 4. It consists of a pin on disc, loading panel and controller. The slide wears of slider and base polymer are carried out with different load by varying speed.

It determines the wear and co-efficient of friction of polymers under sliding contact. The tester is operated with a pin positioned perpendicular to the flat circular disc. The test machine causes the disc specimen to revolve about the disc centre; the sliding path is a circle on the disc surface.

Figure 5 shows experimental setup in laboratory. It consists of a pin on disc, loading panel and controller.

A sample pin is made up of 33% glass reinforced, heat stabilized black nylon copolymer resin and disc is 43% glass fiber reinforced polyamide 66 resin as shown in Figure 6.

Base is used as the disc and the slider corresponds to pin when it is compared to conventional pin-on-disc method. Slider is mounted on a rotary pneumatic cylinder, which can be revolved in clock and anti-clock wise directions relative to the fixed base. It consists of three contact pairs. The angular stroke of the slider is 32.3° as defined by the operating range of the mechanism. Thus the linear sliding distance can be computed for wear volume loss calculations.

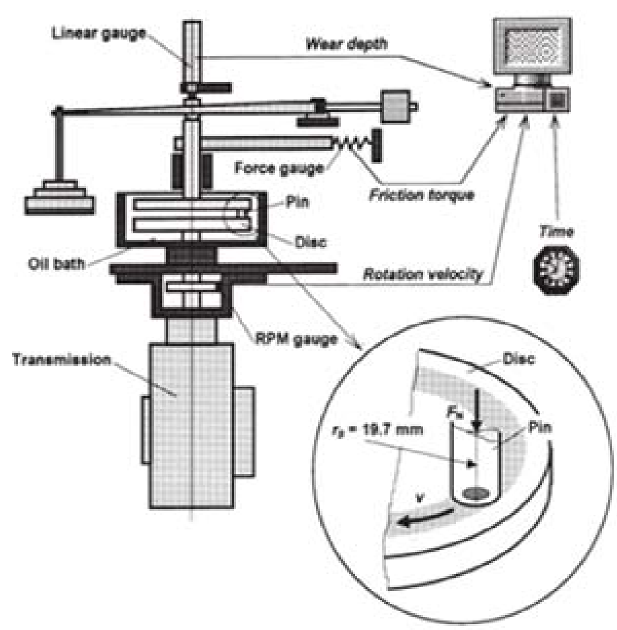

Figure 4 : Pin on disc setup

Figure 5 : Pin on disc experimental setup

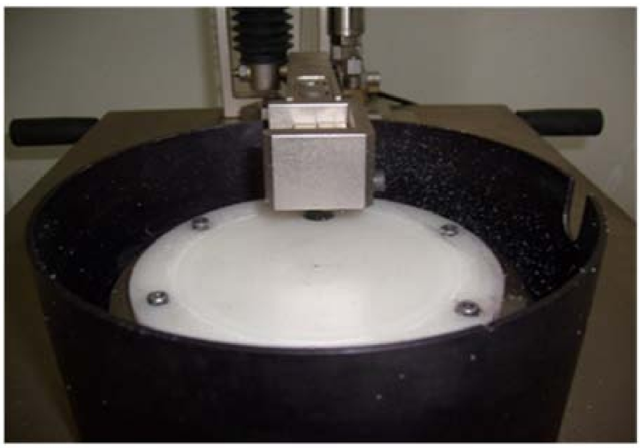

Figure 6 : Pin on disc arrangement

a) Readings

The graph (Figure 7) shows frictional force and wear from the pin on disk experiment.

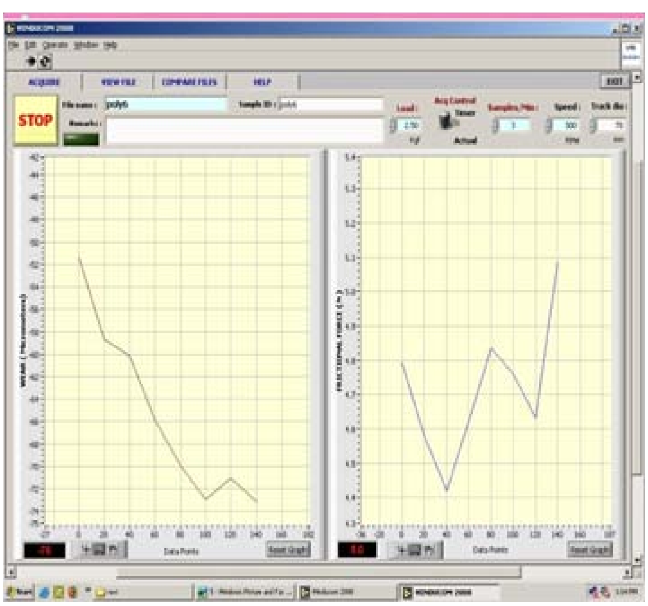

Figure 7 : Constant speed 300 rpm with varying loads

Tables 6 and 7 show the reading taken from the pin on disc experimental according to load and speed.

Table 6 : Under 300 rpm

Load (N)	Speed (RPM)	Time (S)	Wear (Microns)	Frictional force (N)
5	300	180	33	0.6
10	300	180	55	1.4
15	300	180	58	2.5
20	300	180	63	3.2
25	300	180	72	4.0
30	300	180	86	4.62

Table 7 : Under 400 rpm

Load (N)	Speed (RPM)	Time (S)	Wear (Microns)	Frictional force (N)
5	400	180	07	0.56
10	400	180	31	1.32
15	400	180	46	2.5
20	400	180	50	3.06
25	400	180	96	3.89
30	400	180	98	4.52

The graphs are plotted by pin on disc experimental setup according to load and speed (Tables 6 and 7).

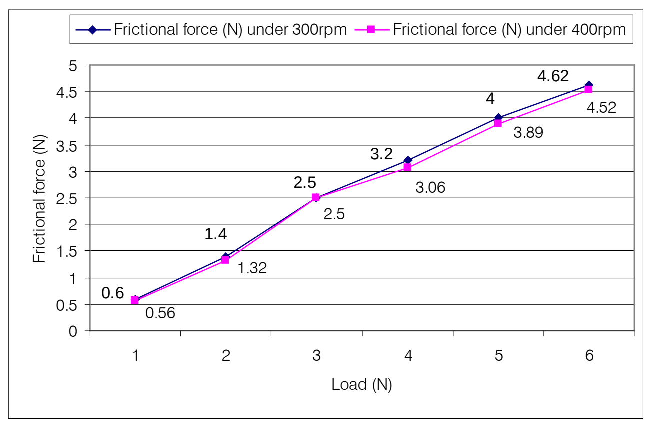

Figure 8 : Frictional force Vs Load (as per Tables 6 and 7)

The graph (Figure 8) reveals that when load is increasing corresponding frictional force is also increases. Based on Tables 6 and 7 data, the graph has plotted between load (N) and wear (microns) (Figure 9).

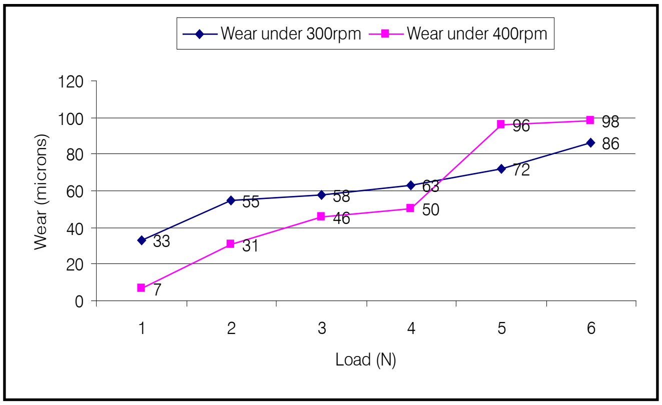

Figure 9 : Wear Vs Load (as per Tables 6 and 7)

The graph (Figure 9) reveals that when load is increasing corresponding wear is also increases. Wear calculated from experimental setup is as follows.

Co-efficient of friction = Frictional force ÷ Normal force Volumetric wear loss = 3.14 × (Radius of disc)^2 × Height of material lost = 3.14 × 6^2 × 0.695 = 78.562 mm^3

Tables 8 and 9 show the co-efficient of friction according to normal load and frictional force in 300rpm and 400rpm. Average co-efficient of friction between the 300 rpm and 400 rpm is 0.145. When compare this value with existing component co-efficient friction value is low. So this material is suitable for further process.

Average co-efficient of friction between the 300 rpm and 400 rpm is 0.145. When compare this value with existing component co-efficient friction value is low. So this material is suitable for further process.

Table 8 : Coefficient of friction under 300rpm

Normal load (N)	Frictional force(N)	Co-efficient of friction
5	0.6	0.12
10	1.4	0.14
15	2.5	0.166
20	3.2	0.16
25	4.0	0.16
30	4.62	0.154

Table 9 : Coefficient of friction under 400rpm

Normal load (N)	Frictional force(N)	Co-efficient of friction
5	0.56	0.112
10	1.32	0.132
15	2.5	0.166
20	3.06	0.153
25	3.89	0.155
30	4.52	0.150

V. Modeling and Analysis

a) Modeling

The modeling of slider and base was done by CATIA. It has three contact surfaces of slider with the base as shown in Figure 10. Figure 11 illustrates the CATIA model for one of the three detents depicted. To simplify the problem it is assumed that all three detents experience uniform and simultaneous wear. The problem is reduced to a two dimensional model with the assumption that wear would be uniform along the 3rd cartesian dimension (depth). In the Figure 11, slider and base are trapezoid and rectangle, respectively.

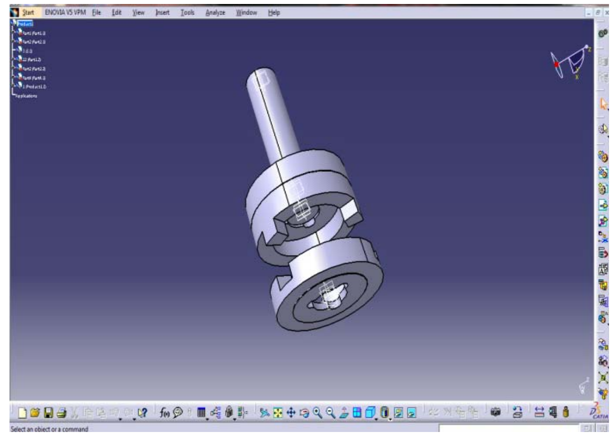

Figure 10 : Model of the component

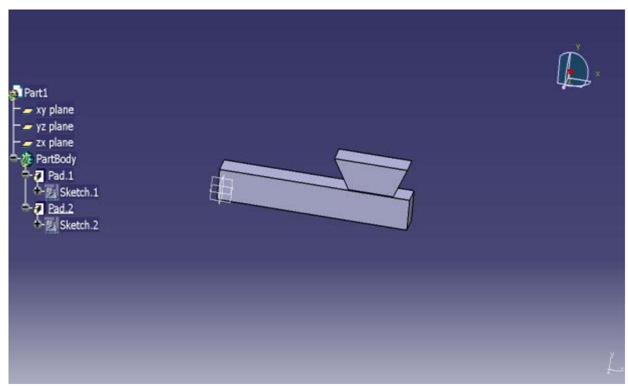

Figure 11 : Slider and base is trapezoid and rectangle model

b) General Contact Classifications

Contact problems fall into two general classes viz., rigid-to-flexible and flexible -to-flexible. In rigid-to-flexible contact problems, one or more of the contacting surfaces are treated as rigid (i.e., it has a much higher stiffness relative to the deformable body it contacts). In general, any time a soft material comes in contact with a hard material, the problem may be assumed to be rigid-to-flexible. Many metal forming problems fall into this category. The other class, flexible-to-flexible, is the more common type. In this case, both (or all) contacting bodies are deformable (i.e., have similar stiffness's).

c) Contact Problems

Contact problems are highly nonlinear and require significant computer resources to solve. It is important that you understand the physics of the problem and take the time to set up your model to run as efficiently as possible.

Contact problems present two significant difficulties. First, you generally do not know the regions of contact until you've run the problem. Depending on the loads, material, boundary conditions, and other factors, surfaces can come into and go out of contact with each other in a largely unpredictable and abrupt manner. Second, most contact problems need to account for friction. There are several friction laws and models to choose from, and all are nonlinear. Frictional response can be chaotic, making solution convergence difficult.

In addition to these two difficulties, many contact problems must also address multi-field effects, such as the conductance of heat and electrical currents in the areas of contact.

d) Nonlinear Analysis

If a structure experiences large deformations, its changing geometric configuration can cause the structure to respond nonlinearly. Nonlinear stress-strain relationships are a common cause of nonlinear structural behavior. Many factors can influence a material's stress-strain properties, including load history (as in elastoplastic response), environmental conditions (such as temperature), and the amount of time that a load is applied (as in creep response).

e) Surface-To-Surface Contact Elements

ANSYS supports both rigid-to-flexible and flexible-to-flexible surface-to-surface contact elements. These contact elements use a "target surface" and a "contact surface" to form a contact pair.

- The target surface is modeled with either TARGE169 or TARGE170 (for 2-D and 3-D, respectively).
- The contact surface is modeled with elements CONTA171, CONTA172, CONTA173, and CONTA174.

To create a contact pair, assign the same real constant number to both the target and contact elements. More details can be fined on defining these elements and their shared real constant sets in "surface-to-surface contact".

f) Steps in a Contact Analysis

The basic steps for performing a typical surface-to-surface contact analysis are listed. Each step is then explained in detail in the following sections.

- Create the model geometry and mesh.
- Identify the contact pairs.
- Designate contact and target surfaces.
- Define the target surface.
- Define the contact surface.
- Set the element KEYOPTS and real constants.
- Define/control the motion of the target surface (rigid-to-flexible only).
- Apply necessary boundary conditions.
- Define solution options and load steps.
- Solve the contact problem.
- Review the results.

g) Finite Element Method-Based Wear Simulation

So far none of the commercial FEA-based design and analysis software provides an integrated wear simulation tool. However, using the available contact analysis tools, indirect wear estimation approaches are proposed to estimate wear [13, 8]. Implementation of any such approach depends on the openness and the capability of FEA software to incorporate external algorithms. This section presents contact analysis in FEA and implementation of wear algorithm. Contact analysis in FEM is a nonlinear problem.

Contact stresses and contact pressures are the two main quantities sought in FEM-based wear simulation. The continuous and random dimensional change of wear surfaces poses a significant difficulty in sliding wear problems. Their shapes vary due to the sliding velocity, load, material parameters, and surface topographies, and will be changed as a result of the friction and wear. The important wear modeling task is the ability to obtain precise amount of worn material out of any sliding situation and for any geometry [7].

ANSYS, the commercial FEA software used for this research can handle several material and structural nonlinearities, i.e., plasticity, viscoelasticity, and friction. For contact problems, ANSYS can model contact condition with different types of contact element and present Lagrange multiplier, penalty function and direct constraint approaches. When meshing a model, the nodes on potential contacting surfaces comprise the layer of contact elements who's four Gauss integral points are used as contacting checkpoints [1].

h) Wear Simulation Algorithm

Contact analyses tools are used to solve sliding contact as a series of successive static load problems. After each sliding step nodal pressures at the contact nodes of the wearing member are extracted (recall the assumption made earlier that only softer of the two members would wear). The FEM based stepwise sliding wear calculation algorithm used in this research is presented.

Initially each node is moved individually, thus instigating the localized material removal. The distance moved by the contact node may not be uniformly distributed along the sliding surface. This not only leads to the prediction of height decays of the contact, but also indicates the approximate worn shape [13, 8].

However, after a few iterations, when the cumulative displacement of any contact node nears the element height, further movement of nodes destabilizes the FEA model. In this case a revised geometry of the worn contact has to be defined. The element height, thus, mentioned depends on this choice of FEA software, meshing size, and element types used in the model.

i) Input Parameters

- Element types: Slider-Contact-CONTA171, base-target-TARGE169
- Force= 143N
- Co-efficient of friction=0.14
- Young's modulus=0.8E5
- Density: Slider=1490 kgm^{-3}, Base=1400 kgm^{-3}
- Possion ratio: 0.3

j) Finite Element Model

Figure 12 shows the component model in ANSYS which is imported from CATIA and illustrates the FE model for one of the three detents depicted. To simplify the problem it is assumed that all three detents experience uniform and simultaneous wear. The problem is reduced to a two dimensional model with the assumption that wear would be uniform along the 3rd Cartesian dimension (depth). In Figure 12, slider and base are trapezoid and rectangle, respectively.

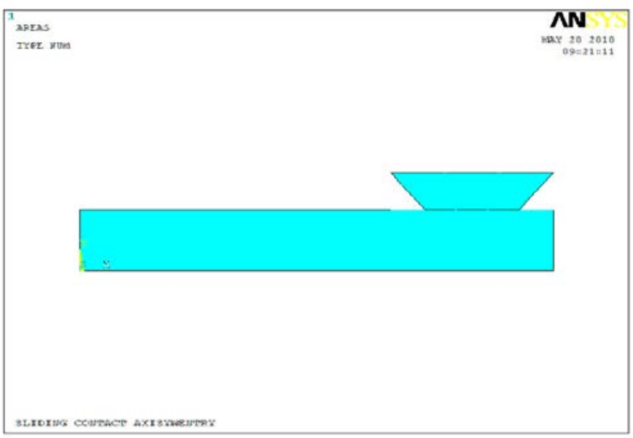

Figure 12 : Component model in ANSYS

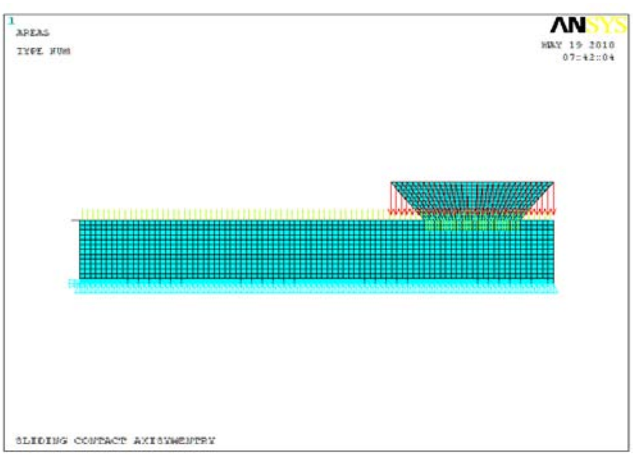

Figure 13 : It shows the finite element models in preprocessor stage

A uniform pressure is applied on top of the slider with displacement (sliding step) in x-axis. The sides of the base are constrained in all degrees of freedom to prevent rigid body motion. For the stability of surface-to-surface contact FEA model, it is mandatory that neither of the mating surfaces penetrate into each other. For this purpose ANSYS classifies the two surfaces as contact and target with specific element types assigned to each, namely CONTA171 and TARGE169.

Actual location of the contact depends on the geometry of the mating surfaces; ANSYS uses augmented Lagrangian formulation to find the contact regions. The model is limited to experience small deformations only. The structural equilibrium is found by incrementally changing the applied load. A converged solution is reached after a few Newton-Raphson iterations [1].

k) Sliding Step Size Determination

The model presented in Figure 14(a) is solved for different sizes of the sliding step. Internally each sliding step is divided into a number of sub-steps. The nodal pressure distribution for the contact nodes is plotted for each sub-step. It can be seen as the step size is increased the pressure distribution starts varying considerably. This behavior of FEA model affects the overall solution. Although a model solved with a smaller sliding step gives more accurate results, it comes at the expense of computational time. Therefore, the solution step is to be selected accordingly. In this case, the solution step of 0.1 mm was used.

l) Numerical Results

There are two key outcomes expected from an FEA wear analysis: height decay and worn geometry. Height decay over time gives an estimation of the component life, whereas the worn geometry gives an insight to the design's weak spots susceptible to wear.

Added to the above two factors, 'sliding contact wave propagation' over the sliding steps is also presented. To simulate the actual to and fro motion of the actual product, sliding distance was translated to repeated back and forward sliding strokes. The sliding stroke is FEA model illustrated in Figure 1 was solved for repeated sliding steps.

Due to the limited computational capability and development support from the FEA software used, we were not able to run the simulation for the complete number of sliding steps summing to the overall sliding distance of 400 meters. However, a reasonable accuracy was achieved with the assumption that the wear outcome remains unchanged for 100 successive sliding steps. At each 100 sliding step the cumulative height decay was incorporate in the FEA model and solved for next 100 steps.

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m) Contact Pressure Analysis

Pressure distribution and contact status for the first sliding step solution for the contact problems are illustrated in Figures 14(a) and 14(b). It can be seen the pressure is distributed evenly at the middle region of the contact whereas the edges have maximum pressure concentration. This evidences that wear would be initiating from the contact edges. ANSYS classifies the contact status as 'near contact' and 'sliding', which are denoted by different color in Figure 14(a). Figure 14 (a) shows that the full face of the slider is in sliding contact. This initial contact will be converted to unevenly distribute small contact regions after few steps of wear as illustrated in the following results. Subsequent to the first contact solution step mentioned above, the contact is solved for the second sliding step by incorporated wear calculated from the above solution. This is indicative of wear on both edges that conform to the conclusion from the previous step, i.e., wear would be initiated from the edges of the sliding contact.

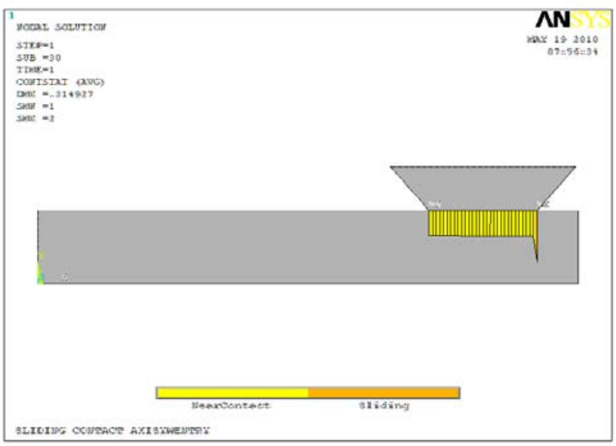

Figure 14 : (a) Contact status

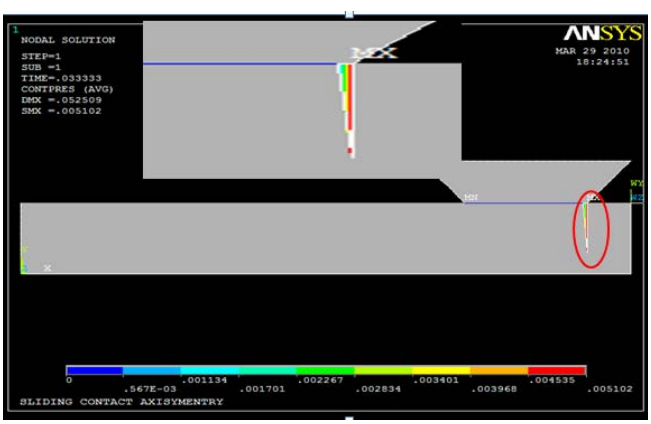

Figure 14 : (b) Pressure distribution

n) Contact Sliding Wave

Due to the elastic nature of polymers, the initially contacting surfaces do not maintain an absolute contact while sliding on top of each other The initially flat contact becomes a series of detachment waves also known as Schallamach waves moving along the contact zone during sliding [6, 13].

This phenomenon was observed during successive contact solutions. The oscillatory motion of the contact zone is now addressed. After incorporating first wear, the resulting contact is solved for the sliding step. Internal to the FEA software, each sliding step is divided into ten sub-steps. Analysis of the solution result at these sub-steps reveals the shifting of sliding contact zone along the face of the slider. This conforms to the wave phenomenon described above.

Using the ANSYS classification of contact status, we find that Figure 15 indicates the traveling of the actual contact zone along the face of the slider. Referring to Figure 14(b), the vertical line on the right indicates the starting datum for x-axis motion of the slider. A localized pressure distribution with the shape of two conjoined triangles for each sub-step indicates a very small contact detachment not physically visible on the scale of the drawing.

A contact separation travel opposite to the direction of the sliding can be seen in successive sub-steps 1, 5 and 10. Since the above data was obtained after incorporating a few iterations of wear, the wave encounters a cavity, resulting from the material removal, causing a contact gap terminating the wave in step 5. In the wave can be seen to follow a cyclic pattern in sub-step groups of {5, 10, 15} and {20, 25, 30}.

o) ANSYS Results

Figures 16 and 17 show the FEA of nodal pressure and cumulative cycle for proposed materials. Graph analysis the component wear rate with number of cycles.

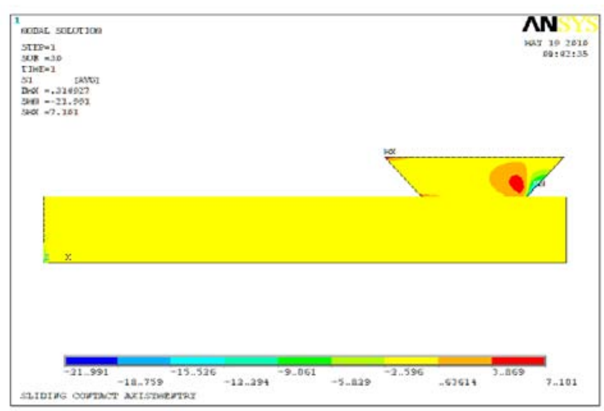

Figure 16 : Nodal pressures

The consolidated graph drawn by both experimental and ANSYS software readings is shown in Figure 17.

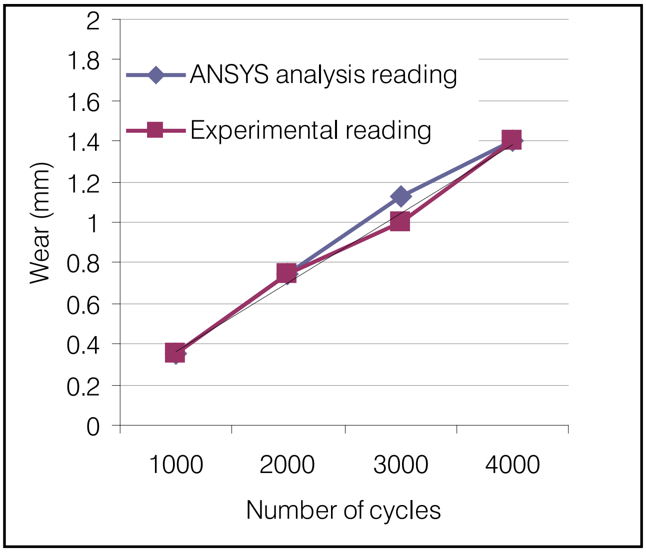

Figure 17 : Number of cumulative cycle for 0.314 mm

VI. Conclusion

For the slider material 43% glass fiber reinforced polyamide 66 resin gives the following results:

In ANSYS number of cycles=4016 for 1.4 mm

In experimental number of cycles=4100 for 1.4 mm

Nodal pressure=7.101N/mm^2

From the Figure 17 and result we concluded that contact analysis in ANSYS and experimentally pin on disc both of them, similar results are found which shows increasing in life cycle of the component by changing the material 43% glass fiber reinforced polyamide 66 resin for slider. The two important outcomes expected from a wear model from engineering standpoint are: change in dimensions and localized effects of wear. The FEA model presented addresses both aspects. Dimensional changes resulting from wear are seldom uniformly distributed; therefore any wear prediction model averages the changes in dimension across the contact in consideration. The FEA model can gives wear results at nodal level which can be averaged across the contact. The height decay results presented are obtained from averaging of nodal pressure. During the tests it was assumed that normal load is equally distributed to all three contacts.

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Burnishing Effects on Friction Stir Welding of Al-Alloy 7075 T6

By Rasheed Abdullah & Nabil Beithou
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Abstract- Burnishing process is widely used to produce excellent surface finish, hardness and compressive residual stresses by plastically deforming the workpiece surface for the various types of materials such as steel, copper, brones, aluminum and thier alloys. Many works have studied the effect of burnishing on surface characteristics of different materials. In this work the optimum parameters of burnishing process on Friction Stir Welded joints of Aluminum 7075 T6 alloy are investigated by testing the effect of different burnishing parameters i.e. table speed, burnishing force, and transverse feed rate on Friction Stir Welded joints and study the mechanical behavior before and after burnishing process. It has been found that good surface finish is achieved at low burnishing speed and transverse stroke with burnishing force around 200 N, high micro-hardness and high bending strength can be obtained at low burnishing speeds and low transverse stroke, with high burnishing force where as a high tensile strength is obtained at high burnishing speeds due to directional deformation of grains and the orientation of residual stresses.

Keywords: material properties, friction stir welding, burnishing of aluminum alloys, mechanical properties, burnishing parameters.

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BURNISHINGEFFECTSONFRICTIONSTIRWELDINGOFALALLOY7075T6

Strictly as per the compliance and regulations of:

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Abstract- Burnishing process is widely used to produce excellent surface finish, hardness and compressive residual stresses by plastically deforming the workpiece surface for the various types of materials such as steel, copper, brones, aluminum and thier alloys. Many works have studied the effect of burnishing on surface characteristics of different materials. In this work the optimum parameters of burnishing process on Friction Stir Welded joints of Aluminum 7075 T6 alloy are investigated by testing the effect of different burnishing parameters i.e. table speed, burnishing force, and transverse feed rate on Friction Stir Welded joints and study the mechanical behavior before and after burnishing process. It has been found that good surface finish is achieved at low burnishing speed and transverse stroke with burnishing force around 200 N, high micro-hardness and high bending strength can be obtained at low burnishing speeds and low transverse stroke, with high burnishing force where as a high tensile strength is obtained at high burnishing speeds due to directional deformation of grains and the orientation of residual stresses.

Keywords: material properties, friction stir welding, burnishing of aluminum alloys, mechanical properties, burnishing parameters.

I. Introduction

Friction Stir Welding (FSW) is a solid-state joining process used for applications where the original metal characteristics must remain unchanged as far as possible. This process is primarily used on aluminum and most often on large pieces which cannot be easily heat treated post weld to recover temper characteristics [1]. One of the key elements in the FSW process is the heat generated at interface between the tool and the work piece which is the driving force to make the FSW process successful. The heat flux must keep maximum temperature in the work piece high enough so that the material is sufficiently soften for the pin to stir but low enough so that the material dose not melts. The maximum temperature created by FSW process ranges from 80% to 90% of the melting temperature of the welding material as measured by Tang et al [2]. Welding of dissimilar metals leads to excessive wear of the rotating pin in a short duration.

The rotational speed has great effect on FSW, if the rotational speed is lower than the optimum value the pin wore out in a short time due to insufficient heat generation and insufficient plasticization of the laying surface, consequently a quarter of the weld interface may be welded, but if the rotational speed is faster than the optimum value pin rotation, oxidation may occur during the welding process; consequently the weld will be poor [3]. K. Kimapong and T. Watanabe, studied the FSW of Aluminum Alloy to Steel [4], they obtained the variation of the friction torque with both welding time and welding distance.

Burnishing is economically desirable, because it is simple and cheap process, requiring less time and skill to obtain a high-quality surface finish. There is an optimum burnishing speed, feed and burnishing force at which the best surface finish could be obtained, hardness, mechanical properties, fatigue life, and wear resistance [5]. At the begging of the plastic deformation zone the yield point is exceeded and cold flow takes place, after the material has been subjected to maximum compressive strain under the bottom of the ball it begins to elastically relive through the elastic recovery zone, finally exiting the area beneath the ball with a smooth surface and a significant value of compressive stresses [8]. In this study the Aluminum 7075 T6 alloy has been selected for the study because of its important use in several industries such as aircraft industry, the optimum parameters of burnishing process on FSW joints of Aluminum 7075 T6 alloy will be investigated by testing the effect of different burnishing parameters i.e. table speed, burnishing force, and feed rate on FSW joints and the mechanical behavior before and after burnishing process will be investigated.

II. Method: Tools and Experiments

In order to study the effect of ball burnishing process on FSW joints, an experiment of 5 steps had been established.

- First weld 2 plates of aluminum using FSW.
- Then Mill the surface of the welded joint to improve the surface quality.
- After that the welded joint will be burnished.
- Test the surface roughness, hardness, tensile and bending tests before and after burnishing process and compare.
- Establish the optimum parameters of the burnishing process on friction stir welded joints.

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AL 7075-T6 has been selected for this study because of its wide use in industry especially in aircrafts. Alloy 7075_sheet and plate have application throughout aircraft and aerospace structures where a combination of high strength with moderate toughness and corrosion resistance are required. Aircraft fittings, gears and shafts, fuse parts, meter shafts and gears missile parts, regulating valve parts, worm gears, keys, defense applications bike frames, all-terrain vehicle (ATV) sprockets [7].

To perform the tests, 40 specimens were prepared by cutting a sheet of 107 cm length, 112 cm width and 4 mm thickness to plates of 200 mm length and 100 mm width. The dimensions were selected to make it possible to carry put tensile and bending tests afterwards.

Table 1 : Physical and Mechanical properties of Al 7075-T6 [7]

Density	2.81 g/cm^3
Ultimate tensile strength	572 MPa
Tensile yield strength	503 MPa
Elongation at break	11% at 1.6 mm thickness
Modulus of elasticity	71.7 GPa
Shear modulus	26.9 GPa
Poisson's ratio	0.33
Fatigue strength	159 MPa
Machinability	70% 0-100 scale of aluminum alloys
Shear strength	331 MPa
Thermal conductivity	130 W/m-K
Melting toint	477-635 °C

The material chosen for the welding tool is alloy steel D2 due to its high hardness, wear resistance, and its excellent abrasion resistance, due to a large volume of carbides in the microstructure.

Table 2 : Alloy steel D2 chemical composition

Comp.	C	Cr	Mg	P	S	V	Si	Mo
Wt%	1.5%	11.0-13.0%	0.45%	0.030% Max	0.030%	1.0%	0.30%	0.7°

The welding tool was cut from 25 mm diameter bar (D2) for length 45 mm then the tool was machined on lathe machine to the dimensions shown in figure 1. The diameter and length of pin was chosen closely to the thickness of plate. The shoulder diameter is taken around three times of the pin diameter.

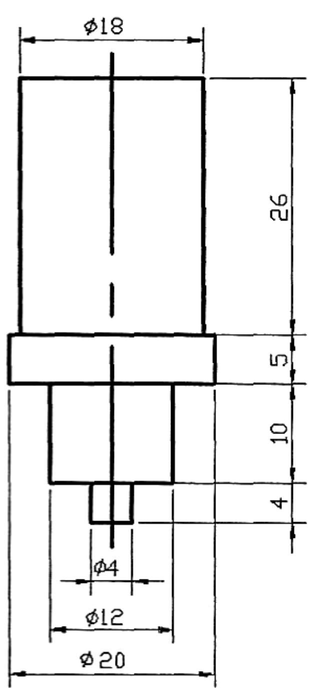

Figure 1 : Welding tool dimensions

The hardness of tool material was 27 HRC as received. For welding process the hardness was increased to 50 HRC by heat treatment. The heat treatment conditions were austenite temperature of 1030°'C, holding time 37 min, and quenching media was oil, tempering temperature 500°C and tempering time 120 min. The hardness 50 HRC was necessary to resist the friction between the pin and shoulder with butted surface.

The specially designed simple burnishing tool is shown in Figure 2. the tool is composed of several elements, each has a particular function. The burnishing action is carried out with a steel bearing ball having an outside diameter of 18 mm which is fitted to the tool shank with the help of the holder. Two bolts are used for locating and positioning the holder. The holder and the ball are moved into the desired position by compressive spring.

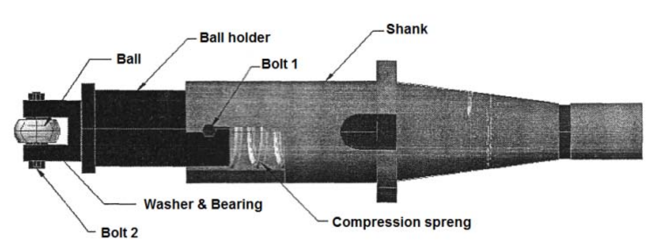

Figure 2 : Burnishing tool

The burnishing ball is a regular ball bearing made of chrome steel AISI 52100.

Table 3 : Chrome steel AISI 52100 chemical composition

component	C	Mn	Si	Cr
Wt%	1.00%	0.35%	0.25%	1.50%

The spring constant (K =28016.86 N/m) [8]. The burnishing force used in this study are 150, 200, 250 N.

A Lagun FU1 100 vertical milling machine Figure 3. was used for friction stir welding, surface milling, and burnishing processes. In this machine the main motion is provided to the tool (CW rotary motion), while the feed motion is provided to the table (liner motion). Rotational speed range is (35- 800 rpm), and the feed range is (10-660 mm/min).

Figure 3 : The used milling machine

The measurement of roughness in the present work was accomplished using a Surfcorder SE 3500 Surface Tester. The Vickers microhardness test was employed in the present work. The sample testing in this test was carried out using a digital microhardness tester model HWDM-3, provided with a precision microscope that has a magnification of 400X. The tensile test was conducted on universal material strength tester model Galdabini QUASAR 100. The bending test was conducted in Jordan University on a hydraulic universal material strength tester model GUNT Hamburg WP 310.03.

III. Results and Discussions

The forty specimens were welded by FSW process resulting in 20 welded specimens, two of which were kept for comparison, and the other 18 specimens were subjected to burnishing under different conditions.

Friction stirs welding Process Parameters, tool rotation speed 700 rpm; and table speed is 40 mm\min. the burnishing process parameters are Burnishing Force N, Table Speed mm/min, and Transverse Feed, mm/stock.

a) Roughness Test

Surface roughness values (Ra) were measured before and after burnishing process, the Ra value of the unburnished surface was measured to be 1.55 μm. Figure 4. shows the effect of burnishing force on the surface roughness for low and high table speeds. It is clear from the figure that the surface roughness is much better under low table speeds and transverse strokes, both increasing the transverse stroke and table speed badly affect the surface roughness of the welded specimens.

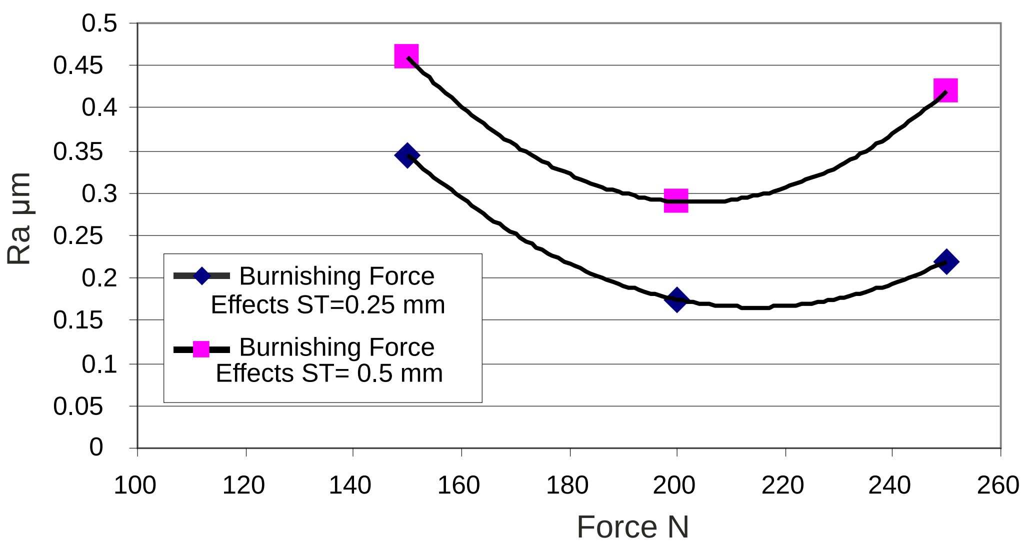

Figure 4 : (a) The effect of burnishing force on the surface roughness under low table speed (=40 mm/min)

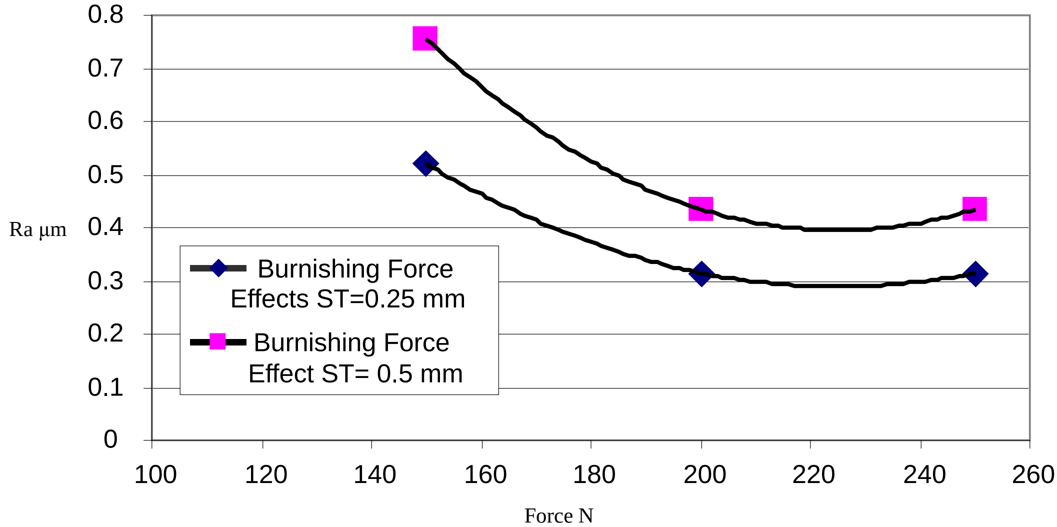

Figure 4 : (b) The effect of burnishing force on the surface roughness under high table speed (=120 mm/min)

The optimum surface roughness was obtained around 200 N burnishing force, which should be related to the welding material properties.

b) Hardness Test

To observe the effect of the burnishing force, table speed and transverse stroke distance on the welding zone hardness, the hardness values before and after burnishing were measured. The microhardness values for the specimens before burnishing were almost the same and the mean value was calculated to be (77 HV) which is used as initial microhardness value. The hardness of the burnished specimens were measured under different conditions and the results are shown in figure 5.

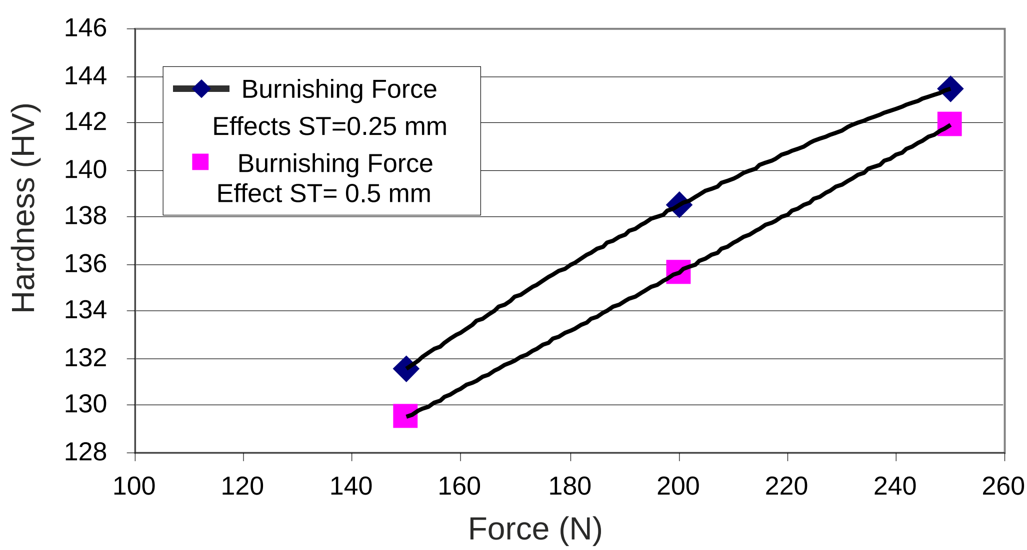

Figure 5 : (a) The effect of burnishing force on the Surface Hardness under low table speed

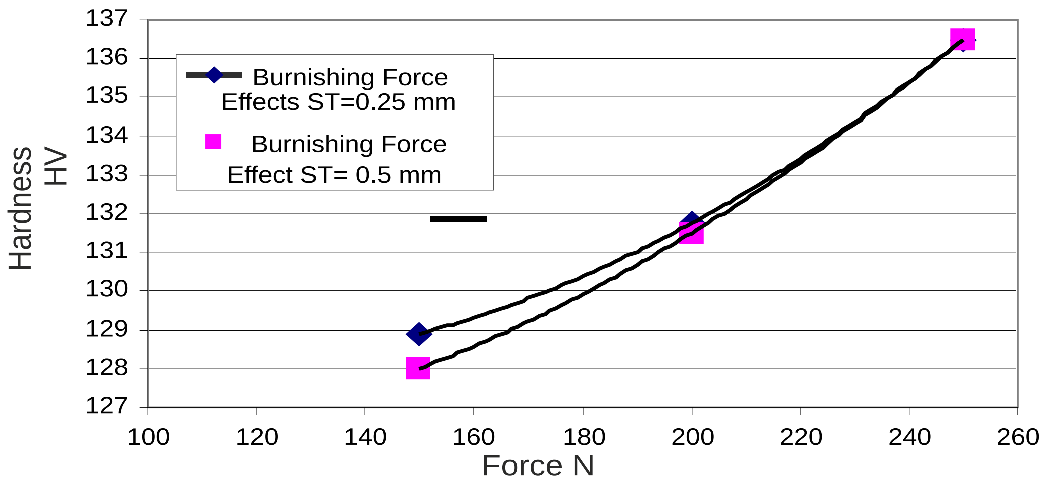

Figure 5 : (b) The effect of burnishing force on the Surface Hardness under high table speed

Figure 5. shows that the microhardness of the specimens increases with increasing the burnishing force due to the plastic deformation and strain hardening of the welding material, on the other hand the transverse stroke distance does not show any significant effect on the specimens which is expected as the burnishing force is constant and the table speed is fixed.

c) Bending Test

During the bending test the bending load (kN) against bending deflection (mm) was recorded on a chart, from which the yield bending load and deflection were determined. The same procedure was done for each test. This yield value was equivalent to 0.2% of total deflection. Figure 6. summarizes the results of bending stresses with respect to other burnishing parameters. The Figure . shows the effect of burnishing force on the bending stress, as expected the bending stresses increases as the burnishing force increases, this obviously improves the welding bending property. The table speed and the transverse stroke distance did not affect the bending stress in a clear way, more investigations are required to be able to judge about the effect of the table speed and transverse stroke distance.

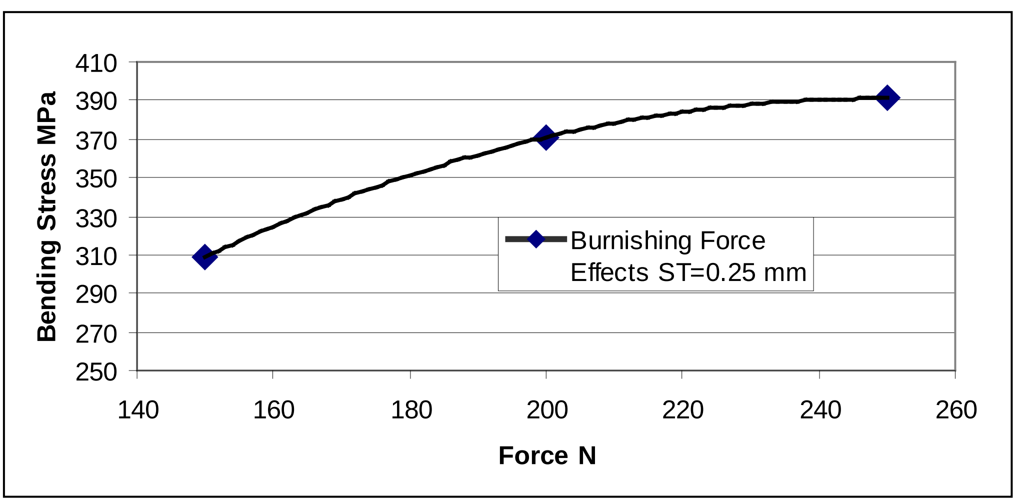

Figure 6 : The effect of burnishing force on the bending stress

d) Tensile test

For tensile testing of the specimens, the specimens were prepared with the suitable dimensions, and subjected to the tensile force, during the tensile test tensile load and deformation were recorded, from these data the yield tensile corresponding elongation were determined. Figure 7. shows the effect of the burnishing force on the tensile stress.

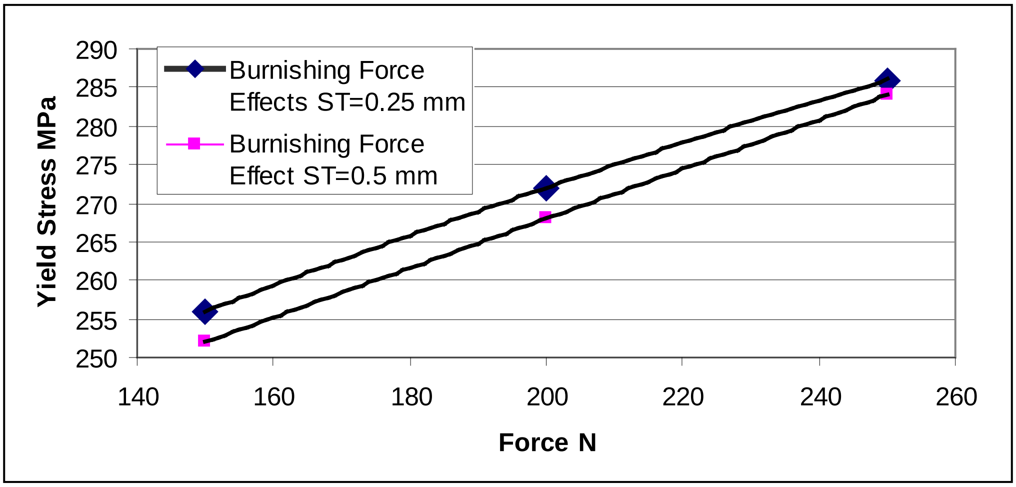

Figure 7 : (a) The effect of burnishing force on the bending stress at low table speed

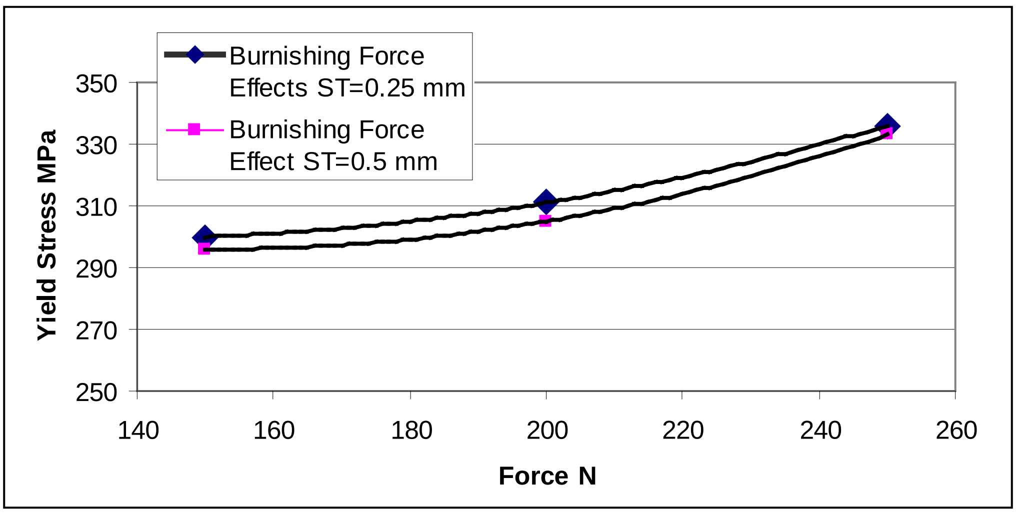

Figure 7 : (b) The effect of burnishing force on the bending stress at high table speed

Once more figure 7. (a and b) show that the increase in burnishing force leads to an increase in the tensile stress.

IV. Conclusions

The experimental results presented in this work generally reveal that the surface roughness, microhardness, bending and tensile stresses of aluminum alloy 7075-T6 joints were affected by the variation of the burnishing parameters i.e. transverse stroke, machine table speed, and the burnishing force. The surface roughness improved by reducing the peak to valley height. As the ball rolls on the surface of the FSW joint, the metal plastically deformed the surface hardness of the FSW joint is also increased by increasing burnishing force. Both tensile and bending strengths are increased as a result of the formation of residual compressive stresses due to the ball pressure applied to the work piece surface.

From the results obtained the optimum surface roughness was achieved at low burnishing speed (40 mm/min), medium burnishing force (200N) and low transverse stroke (0.25 mm/stroke). The high micro hardness, bending strength were achieved at low burnishing speed (40 mm/min), high burnishing force (250N) and low transverse stroke (0.25 mm/stroke). The high tensile strength was achieved at high burnishing speed (120 mm/min) and high burnishing force (250N), where the burnishing transverse stroke did show a significant affect on the tensile strength.

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A New Expression of the Curve S-N in Fatigue based on the Concept of the "Weakest Link" of Weibull

By N. Ngarmaïm, B. Tikri, B. Bassa, N. Kimtangar, F. Pennec & J-L. Robert
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Abstract- A new expression of the SN curve based on the concept of "weakest link" is proposed. It is a probabilistic model introducing a new parameter Nc, the number characteristic of cycles corresponding to the failure probability equal to 1. His confrontation with the terms of the curve most used SN, particular those Basquin, the Wöhler and the Stromeyer, the fatigue tests and martensite steels P22O 100C6 data provided errors of about 5% maximum for models Basquin, Wöhler and that proposed. Expression takes into account the volume of the Seine part of the test, which will help explain the number variations of cycles for a given level of stress. The search for a correlation relationship between the fatigue limit σ^D and the breaking strength R_m will help prevent the fatigue life of the work-hardened materials.

GJRE-A Classification : FOR Code: 091399

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Strictly as per the compliance and regulations of:

A New Expression of the Curve S-N in Fatigue based on the Concept of the "Weakest Link" of Weibull

N. Ngarmaïm [α], B. Tikri [σ], B. Bassa [ρ], N. Kimtangar [ω], F. Pennec [¥] & J-L. Robert [§]

Abstract- A new expression of the SN curve based on the concept of "weakest link" is proposed. It is a probabilistic model introducing a new parameter Nc, the number characteristic of cycles corresponding to the failure probability equal to 1. His confrontation with the terms of the curve most used SN, particular those Basquin, the Wöhler and the Stromeyer, the fatigue tests and martensite steels P22O 100C6 data provided errors of about 5% maximum for models Basquin, Wöhler and that proposed. Expression takes into account the volume of the Seine part of the test, which will help explain the number variations of cycles for a given level of stress. The search for a correlation relationship between the fatigue limit σ^D and the breaking strength R_m will help prevent the fatigue life of the work-hardened materials.

I. Introduction

The static essay, serving to determine the ultimate resistance to break, may be considered as a very particular case of a essay of fatigue, the number of cycles with break was equal at the most to 1. This ultimate resistance with break is the minimal value in which the break of the material occurs in a certain way.

The problem of dispersal of the trial results, as well in statics (for the determination of the ultimate resistance with break) that in fatigue (for the determination of the number of cycles with break or for the determination endurance limit) is the consequence of the structural heterogeneity of the defects since the elaboration of material [1]-[11]. The density of these defects vary from specimen to another, yet all taken from the same sample. In the case of fatigue, for a given stress level σ_i, one can also observe a dispersion value of the number of cycles to failure N_i [12]-[13]. The number of cycles to failure is related to the material structure and thus the defects that contain. That these defects are difficult to measure, it is advisable to use as a random variable [12], for a given stress level, the number of cycles to failure to explain the existence of defects by a probabilistic approach. We rely on the concept of the "weakest link" Weibull to formulate a new expression of the SN curve can take into account the actual volume of a flawless material considered. In the absence of a means of assessing defect in the structure, the results for two types of materials are comparable with those of Wöhler and Basquin. A simulation made by the variation of the tensile strength of a material that shows this new expression for describing the fatigue behavior of a hardened material.

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II. Concept of "Weakest Link" Weibull

According to this concept, for juxtaposed volumes, subjected to monotonic loading, the failure of one is independent of the other, if one of the volumes fails, the system is considered failed [14]. The survival probability of a system consisting of n elements (or volume) is given by:

$$R_n = 1 - e^{-\int f dv} \tag{1}$$

Where f is the probability density of failure and dv is the elementary volume constituting the reference volume V.

III. Specification of the Probability Density Function f

We will consider as a random variable the number of cycles to failure for a given stress level by the fact that the number of cycles determines the fatigue. Dependent on the dispersion, the number of cycles is a variable representing statistically the stress applied from the viewpoint fatigue (damage to a given level of stress). We will consider the failure probability density f as a function of number of cycles to failure; it is given in the following form:

$$f(N) = \beta N^m \tag{2}$$

Where β is a parameter to be determined, and the module m, within the meaning of Weibull [14].

The parameter β can be determined when we know a characteristic value of the number of cycles N_c to a level corresponding stress. At this number of cycles N_c characteristic density of default probability take the value 1. It then pulls:

$$\beta = N_c^{-m} \tag{3}$$

or,

$$f(N) = \left(\frac{N}{N_c}\right)^m \tag{4}$$

In this case, the probability of survival given equation (1) becomes:

$$R_n = 1\text{-}e^{-\int\left(\frac{N}{N_C}\right)^m .dv} \tag{5}$$

IV. Proposal for a New Expression of the S-N Curve

It is obvious that there is a relationship between the probability of failure P (function the number of cycles) and the level of responsible of this fatigue failure stress. We admit that there is a function g dependent on the characteristics of fatigue σ^D and static R_m linking the probability of failure P stress responsible for this failure.

Since σ^D and R_m are constants for a given material, then g is a constant function. A simple relation linking the stress at failure probability is that the stress is proportional to the probability of failure; with as the proportionality coefficient function g. This relationship is expressed by :

$$\begin{aligned} \sigma &= g\left(\sigma^D, R_m\right) P(N) \\ &= g\left(\sigma^D, R_m\right)\left[1\text{-}R(N)\right] \end{aligned} \tag{6}$$

ie, from (5):

$$\sigma = g\left(\sigma^D, R_m\right) e^{-\int\left(\frac{N}{N_C}\right)^m .dv} \tag{7}$$

For a tension loading when the load is uniform, the expression (7) becomes :

$$\sigma = g\left(\sigma^D, R_m\right) e^{-V\left(\frac{N}{N_C}\right)^m} \tag{8}$$

Thus, two limiting cases are possible according to the value of the stress σ:

- For $\sigma = R_m$, ultimate resistance to break, $N = 0$, the relation (8) becomes:

$$R_m = g\left(\sigma^D, R_m\right) \tag{9}$$

- For $\sigma = s^D$, endurance limit, $N = N^D$, the relation (8) becomes :

$$\sigma^D = g\left(\sigma^D, R_m\right) e^{-V\left(\frac{N^D}{N_C}\right)^m} \tag{10}$$

ie,

$$g\left(\sigma^D, R_m\right) = \sigma^D e^{V\left(\frac{N^D}{N_C}\right)^m} \tag{11}$$

The equality of two expressions g, given by equations (9) and (11) gives R_m depending on σ^D

$$R_m = \sigma^D e^{V\left(\frac{N^D}{N_C}\right)^m} \tag{12}$$

The expression of the S-N curve in tension given by equation (8) becomes :

$$\begin{cases} \sigma = R_m e^{-V\left(\frac{N}{N_C}\right)^m} \\ \text{ie} \\ \sigma = \sigma^D e^{V\left\{\left(\frac{N^D}{N_C}\right)^m - \left(\frac{N}{N_C}\right)^m\right\}} \end{cases} \tag{13}$$

V. Experimental Study of the New Expression

To validate the sensitivity of the proposed fatigue behavior of a material model for V = 1, we have experimental data from two types of materials: steel martensite P220 and 100C6. A comparative study is made, from these data, with models of the most utilized S-N curves [15]-[16] such that Basquin, the Wöhler and the Stromeyer :

$$\begin{cases} \log(N) = -a_B \log(\sigma) + b_B & : \text{Basquin} \\ \log(N) = -a_W \sigma + b_W & : \text{Wöhler} \\ \log(N) = -a_S \log(\sigma - \sigma^D) + b_S & : \text{Stromeyer} \\ \log(N) = a_N \log\left\{\log\left(\frac{R_m}{\sigma}\right)\right\} + b_N & : \text{proposed} \end{cases} \tag{14}$$

Where, for the proposed model $\begin{cases} a_N = \frac{1}{m} \\ b_N = \log(N_C) \end{cases}$

The curves parameters are determined for each fatigue testing each of the two steels result, by the method of least square.

a) Test Data

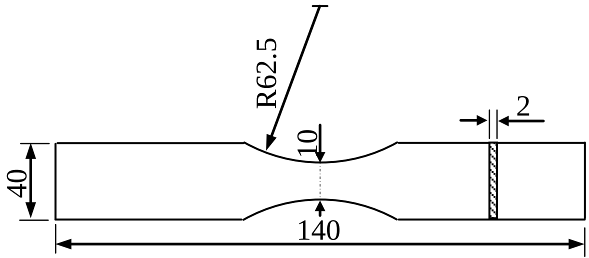
i. *P220 Steel*

The data are taken from the steel work performed LaMI (Laboratory of Mechanics and Engineering) in order to investigate the influence of cutting processes on the fatigue behavior of parts. Two procedures were used, laser and shears, it, with several execution qualities (good, standard and bad) corresponding to different sets of machines settings. Table.1 gives the geometry of the specimen and the fatigue test at constant amplitude tension-compression alternating statement.

Table 1 : Specimen geometry and fatigue testing of the P220 cut steel with the standard laser process result

Material: P220
Type of sollicitation: tension-compression at constant amplitude
Solicitation frequency: 20Hz

Dimensions and shape of the specimen



□ (MPa)	344	321,8	319,9	319,8	311,5	311,1	310	309,5	290	280	275	270	235
N	10596,5	296828	281248	320467	371162	305503	204238	309191	520089	662397	3909947	5335707 (*)	7522596 (*)

(*) no rupture

ii. *Martensite Steel 100C6*

The tableaux.2 and 3 below give, respectively, the chemical composition and the fatigue test result of the 100C6 steel [11].

Table 2 : Chemical composition (% by mass) of the martensite steel 100C6

Martensite steel 100C6								
Si	Mn	P	S	Cr	Cu	Ni	Mo	O
0,242	0,339	0,012	0,008	1,461	-	0,147	0,032	-

Table 3 : Fatigue test of martensite steel 100C6 result

Matereal: martensite steel 100C6 (E=210GPa, R_m=2300MPa, σ^D=850MPa et N^D=6.0265x10^9cycles).
Solicitation frequency: 20KHz

Fatigue test results

σ (MPa)	975	960	950	940	930	900	890	880	870	860	850
Nmoy. x10^6	0,1183	0,1019	0,1639	9,806	167	466	664,4	542,1	990,75	1853,3	6026,5

The value of the ultimate resistance to break R_m of the steel P220 is between 600 and 800 MPa, it will take three values in this range for the simulation thus allowing to highlight the sensitivity of the proposed model.

b) Comparison

The comparison will be made by tracing curves in the plane (log (σ), log (N))). Parameter values, determined by the method of least squares, corresponding to different models, given by Equations (14), for the two steels, are given in the following Table.4 :

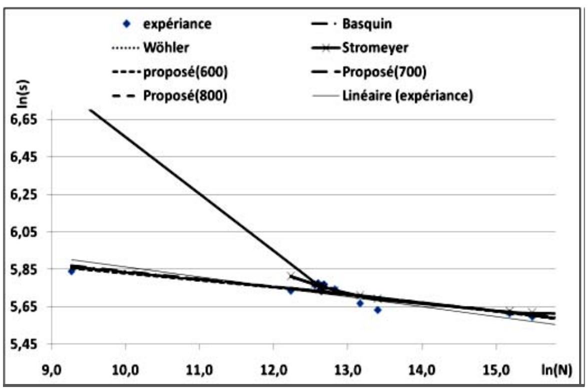
Table 4 : Value of parameters of the models used for the two steels

P220 steel	
Model	Parameters
Basquin	a_B=23.66 ; b_B=148.2
Wöhler	a_W=0.078 ; b_W=36.65
Stromeyer	a_S=1.52 ; b_S=17.73
Proposed Model	R_m=600MPa; σ^D=271.24MPa; m=0.062; N_c=214037564;
	a_N=16.13; b_N=19.18
	R_m=700MPa; σ^D=271.57MPa; m=0.051; N_c=15622128; a_N=19.61; b_N=16.56

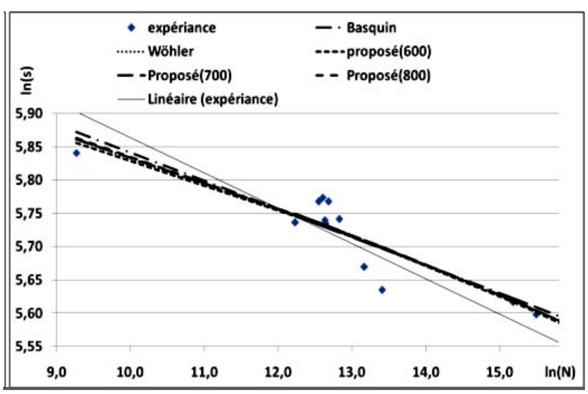
	R_m=800MPa ; σ^D=271.76MPa ; m=0.044; N_c=925359 ; a_N=22.73; b_N=13.74
Matensite steel 100C6	
Model	Parameters
Basquin	a_B=94.2 ; b_B=659.3
Wöhler	a_W=0.10 ; b_W=111.5
Stromeyer	a_S=4.02 ; b_S=32.2
Proposed Model	R_m=2300MPa ; σ^D=863MPa; m=0.0115; N_c=3.47x10^{10} ; a_N=86.96; b_N=24.27

VI. Results and Discution

- P220 steel



(a)



(b)

a) The four models and the linear trend of the experiment;

b) Models Basquin of Wölher those proposed and the linear trend of the experience.

Figure 1 : SN curves in the plane (ln (σ) ln (N)) of the models studied for P220 steel

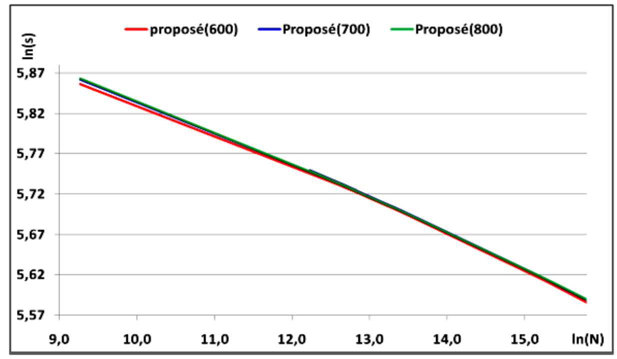
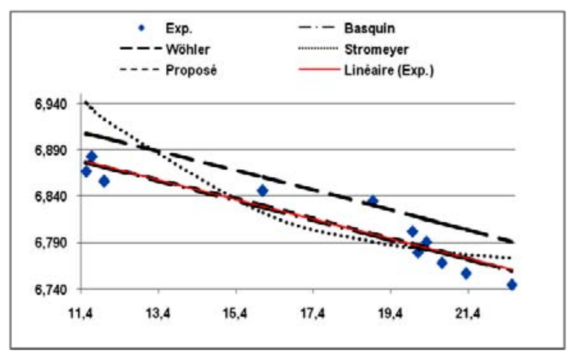


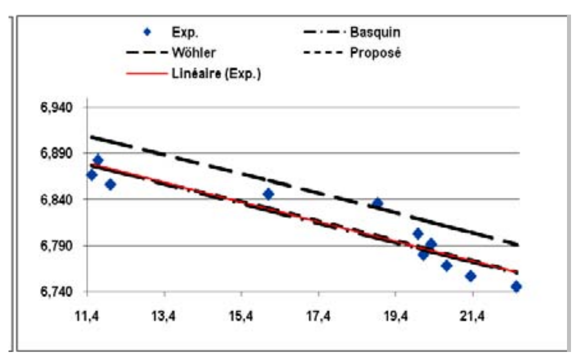
Figure 2 : Sensitivity of proposed model with the values of R_m

Here we can see clearly that the SN curve model Stromeyer is not linear and strongly deviates from the experimental curve in the oligocyclic domain (Figure.1.a). Basquin, Wöhler curves and that proposed for different values of R_m approximate linear trend given by experience. We find a correlation between the last three curves (Figure.1.b), the relative error on the stress values provided for by these curves do not generally exceed 5% compared to the values of the experiment.

- 100C6 steel



(a)



(b)

a) The four models and the linear trend of the experiment;

b) models Basquin of Wölher, he proposed and the linear trend of the experiment.

Figure 3 : SN curves in the plane (ln (σ) ln (N)) of the models studied, for steel 100C6

Basquin models and the proposed are approaching significantly from the linear trend of the experiment while that of Stromeyer does not follow this trend for large values of the constraint (figure.3.a). Wohler model, meanwhile, is shifted in translation relative to this trend (figure.3.a and b). The relative error on the values of constraint provided by the curves Basquin of Wölher and that proposed not exceeding 5% there too compared with the values of the experiment.

VII. Conclusion

The sensitivity of the proposed model to the values of R_m, is reflected in an angular shift in direction of rotation hands of a watch while R_m increases (figure.2). The limit of σ^D fatigue increases substantially, but the value of the number of cycles N_c dimunie characteristic significantly well as the modulus value m while R_m increases, the appreciable increase in the endurance limit with that of the breaking strength reflecting the inflection the S-N curve traced in the plane (σ; N), thus modifying the scope of limited field of fatigue.

The proposed model introduces a new parameter, the number of cycles characteristic N_c for which the failure probability density function takes the value 1and therefore the smallest number of cycles which the rupture occurs with certainty. It takes also into account the volume of the material. All the calculations are done by taking V=1. To take into account the defects can be considered as a fraction V corresponds to useful volume of the material constituting the piece to explain the variations of cycles number to failure for a given level of stress. The model allows, given its sensitivity to the change R_m, to track the fatigue behavior of work hardened materials, a phenomenon for which the value of its breaking strength R_m varies notably.

VIII. Acknowledgement

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Review of Stress Analysis of Connecting Rod using Finite Element Analysis

By Swatantra Kulkarni, Ashwani Mishra, Himanshu Arora, Rajinder Singh, Prabhjot Singh & Ramanpreet Singh
Lovely Professional University, India

Abstract- Connecting rod is one of the important components of the whole engine assembly as it acts as a mediator between piston assembly and crankshaft. Also it faces a lot of tensile and compressive loads during its life time. So, a detailed analysis is the need of hour. For quick, better and accurate analysis CAD and FEA have proved very useful. This paper presents review on account of the developments done in the field of analysis, weight and cost reduction opportunities and better materials for connecting rod.

Keywords: finite element analysis, connecting rod, composite material, optimization, modelling.

GJRE-A Classification : FOR Code: 290501

REVIEWOFSTRESSANALYSISOFCONNECTINGRODUSINGFINITEELEMENTANALYSIS

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Review of Stress Analysis of Connecting Rod using Finite Element Analysis

Swatantra Kulkarni [α], Ashwani Mishra [σ], Himanshu Arora [ρ], Rajinder Singh [Ѡ], Prabhjot Singh [¥] & Ramanpreet Singh [§]

Abstract- Connecting rod is one of the important components of the whole engine assembly as it acts as a mediator between piston assembly and crankshaft. Also it faces a lot of tensile and compressive loads during its life time. So, a detailed analysis is the need of hour. For quick, better and accurate analysis CAD and FEA have proved very useful. This paper presents review on account of the developments done in the field of analysis, weight and cost reduction opportunities and better materials for connecting rod.

Keywords: finite element analysis, connecting rod, composite material, optimization, modelling.

I. Introduction

A connecting rod (Fig.1) acts as a link between the piston assembly and crankshaft thereby converting the reciprocating motion of piston into the rotary motion of crankshaft.

Around the globe connecting rod is produced in large quantity and furthermore it works under high tensile and compressive loads. So a connecting rod should be designed in such a way that it can withstand high stresses that are imposed on it. So its analysis is necessary.

It has mainly three parts namely- a pin end, a shank region and a crank end. Pin end is connected to the piston assembly and crank end is connected to crankshaft.

However the stress analysis can be performed easily by modelling it in any CAD software and analysing it by using FEA.

Discovering new techniques and methods for weight and cost reduction can definitely increase the engine performance and economy, thereby decreasing the inevitable centrifugal and inertial forces.

Moreover a search for new material can also be made for better results.

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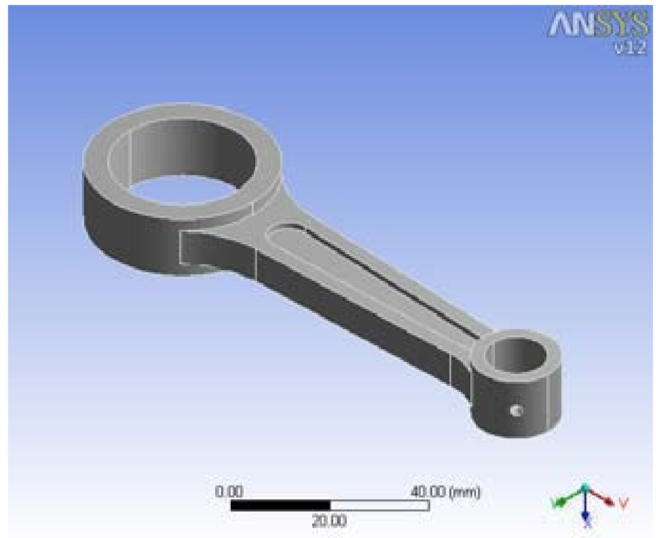

Figure 1 : Model of connecting rod in ANSYS

II. Literature Review

Anusha B et al. (2013) carried out the analysis and comparison of the cast iron connecting rod and structural steel connecting rod.Pro/E was used to model the rod and ANSYS Workbench was used for analysis. Hero Honda Splendor was taken as case study. However 3.15MPa of pressure was applied at piston end. Big end was kept fixed. It was observed that stresses induced in structural steel connecting rod were lesser than cast iron connecting rod and structural steel connecting rod showed improved results than connecting rod of other material. Moreover design was obtained safe for both materials. Finally it was recommended to use structural Steel connecting rod.

Anusha B. et al (2013) took Hero Honda Splendor connecting rod as case study. For investigation purposes 3.15MPa of pressure was applied at piston end. Big end was kept fixed. Pro/E (Creo Parametric) was used to model the rod and ANSYS was used for its analysis. As a result piston end was identified as the region under maximum stresses.

Rao G N M (2013) compared genetic steel, Aluminum, Titanium and Cast Iron for weight reduction opportunities of a connecting rod. Firstly load analysis was carried out then FEA and optimization were performed. After comparing the results, the study discovered that genetic steel connecting rod showed less deflection and stress as compared to other materials like Titanium, Cast Iron and Aluminum.

Pathade V.C. et al. (2013) used three methods for performing the stress analysis of connecting rod. The three methods were Finite element analysis, photoelasticity and theoretical method. For analysis through experimental method (photoelasticity) the casting of photoelastic sheet using Resin AY103 and Hardener HY951 was done and then model of photoelastic sheet was prepared. In FEA, Pro/E was used to model the rod and ANSYS Workbench 11.0 was used for analysis.The results from all the three methods were investigated and it was found that effect of stress concentration exists at both ends and it was found negligible in the middle portion of connecting rod. Moreover, small end was observed to be under more stresses than big end.

Prakash O. et al. (2013) carried out the case study of the connecting rod of Universal Tractor (U650). They re-optimized the connecting rod. Furthermore they also performed static and fatigue analysis. CATIA was used to model the rod and ANSYS V12 was used for its analysis. Critical areas were improved. Optimization led to the decrease in weight by 5gm and hence decreased the inertial and centrifugal forces.

Sarkate T. S. et al. (2013) took a case study of alloy aluminum 7068 and AISI 4340 alloy steel. Static analysis and comparison of both the above materials were performed. Pro/E Wildfire 4.0 was used to model the rod and ANSYS V12 was used for its analysis. As a result of analysis 63.95% weight of the rod was lowered and a decrement in stresses by 3.59% was identified with aluminum 7068 alloy.

Singh R (2013) took two materials for connecting rod–one was isotropic and other was orthotropic and carried out linear static stress analysis using Finite Element Analysis. The isotropic material was steel and orthotropic material was E-glass /Epoxy. CATIA V5R10 was used to model the rod and MSC.PATRAN was used for its analysis. The comparison indicated that E-Glass/ Epoxy showed a 33.99% stress reduction and 0.026% reduction of displacement. Furthermore, Mesh TET 10 was suggested for better results.

Vazhappilly C V et al. (2013) discovered weight and manufacturing cost reduction opportunities by taking into account the recent developments in several fields like finite element modeling techniques, optimization techniques, and developments in production technology etc. Additionally it also accounted the importance of CAD and FEA for the optimization purposes.

Kumar et al. (2012) used CAE tools for performing the optimization of connecting rod's parameters. Pro/E was used to model the rod and ANSYS Workbench 11.0 was used for its analysis. Static FEA was performed. Load was applied on big end and small end alternatively. As a result the piston end was observed to be subjected to maximum stresses. However the study suggested that by modifying design parameters, improvement in the existing results can be achieved. Furthermore increase in the material near the piston end was suggested to reduce the stresses and use of other materials like C-70 steel for the optimization was suggested.

Pal et al. (2012) used FEA for design evaluation and optimization purpose of connecting rod. Pro/E Wildfire 4.0 was used to model the rod and ANSYS V12 was used for its analysis.The study resulted in a reduction of weight by 0.477g and small end was observed under maximum stresses. It was concluded that change in design parameters can yield better results and increase in material in the stressed region can reduce stresses. Fatigue strength was identified as important parameter during designing and optimization purposes.

Pathade V.C. et al. (2012) performed theoretical as well as finite element analysis of I. C. Engine's connecting rod. Big end was kept fixed. Different loads were applied at small end. The rod was modeled in Pro/E and ANSYS was used for its analysis. As a result it was concluded that small end of connecting rod was observed under more stresses than big end.

Ranjbarkohan et al. (2011) carried out a case study of Nissan Z24 engine. Kinematic and kinetic analysis of slider-crank mechanism and stress analysis of connecting rod of Nissan Z24 engine was performed. Modeling was done in Solid Works and ANSYS software was used for analyzing purpose. Additionally the simulation of engine was performed in MSC/ADAMS/engine software. It was concluded that pin end faced maximum tensile stress. Moreover fatigue analysis of connecting rod was also recommended.

Thomas et al. (2011) inspected fatigue life of heavy duty application's connecting rod and observed that shot peening increased the fatigue life of connecting rod by 72% and thus shot penning was suggested for improving fatigue life cycles of connecting rod.

CIOATĂ et al. (2010) carried out the static analysis of connecting rod's foot. The rod was modeled in Autodesk Inventor Software and analyzed in ANSYS V11. It was identified that 0.036mm deformation of foot of connecting rod was obtained with FEA and 0.073mm was obtained with classical method. Furthermore the use of CAD software and software for finite element analysis was given due importance.

Shenoy P.S et al. (2005) worked for the optimization of steel forged connecting rod to discover weight and cost reduction opportunities. The study discovered that crackable forged steel (C-70), if used in place of forged steel connecting rod, can reduce the production cost by 25% and weight by 10%. It was also observed that the shank region possesses maximum margin for weight reduction. Moreover it was also recommended to consider fatigue strength during designing.

III. Conclusion

For the stress analysis of the connecting rod, it can be easily modeled in any CAD software like CATIA, Pro/E etc. and then it can be analyzed in any FEA software like ANSYS. With FEA we can get accurate results. It has been observed that small end is exposed to maximum stresses whereas the middle region of rod is subjected to negligible stresses.

Moreover better results can be achieved with changed or better design parameters and for reducing stresses we can increase the material at the small end. But this can increase the inertial and centrifugal forces. Moreover we can remove some material from the shank portion as it is observed as the greatest region for weight reduction.

Additionally fatigue strength is an important parameter to be considered while designing and optimizing and fatigue analysis should be performed. However it has been found out that shot peening can improve the fatigue life of connecting rod.

Additionally it has been found out that structural steel connecting gives better results as compared to cast iron connecting rod and Aluminum 7068 alloy performs better than AISI 4340 alloy whereas Genetic steel proves to be best when compared with Titanium, Cast Iron and Aluminum.

However by choosing different materials like E-glass/Epoxy, a composite material, C-70 steel etc. significant improvement can be obtained.

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High Technology Product Producing Factory Optimization with Buffers

By Prashobh Karunakaran

Abstract- This research is timely because many High Technology Product Producing Factories (HTPPF) are still following the trend of factories that produces the likes of canned food or even cars where all machines are jointed from start to end. Many HTPPF have not realized that improvements to product must be done every day to keep market share. And to perform research continuously, buffers in-between production machines are absolutely necessary. The absence of such buffers has caused a many hard disk manufacturing factories to close down especially in the Japan, Korea and Taiwan (notably Sony, NEC, Matsushita, Samsung and Trace). These factories were leaders in joining up production lines from start to end; but discovered that it led to a disadvantage in their ability to perform the necessary continuous improvement in product quality and capacity. Decision makers in these factories thought that a dedicated research line is all that is needed for research. This paper explains why a dedicated research line is not the answer to the needs of a HTPPF. Currently 90% of hard disks are produced by Western Digital and Seagate, with Toshiba having 10% market share. Western Digital and Seagate were slow in automating production lines which benefitted them in their research capability.

Keywords: automation, buffers, factory, optimization.

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HIGHTECHNOLOGYPRODUCTPRODUCINGFACTORYOPTIMIZATIONWITHBUFFERS

Strictly as per the compliance and regulations of:

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I. Introduction

Buffers in-between production machines enables research initiatives in production machines. The main reason why researchers prefer to perform hypothesis test on the production lines rather than on a dedicated research line is the empirical fact that in HTPPF, upon start-up of a line there is a yield drop and this yield stabilizes to the normal high value only after a few hours but can even take a day or two. This work was done mostly in computer hard disk factory but the same scenario is reported in the silicon chip industry. Therefore upon startup of a research line, a researcher may have to wait for up to two days before even a small change in say one chemical in the long production line can be tested. This discourages researchers from using the research line. Comparatively in a production line where the yield is already at around 98%, a small change in chemical in one particular machine in the long line can more easily be deciphered at the final test machine. Also if production lines are used as test beds many lines can be used at once, so more samples and controls can be taken. Research lines are still available for major changes especially where big electromechanical changes to machines are involved, but for quick validation of results, the running production line is preferred [1]. This author had fourteen years of working experience in the Western Digital hard disk factory in Sarawak, Malaysia, where research is done every day to improve the Key Quality Characteristics (KQC) of hard disks.

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II. Litreature Review

Initially a review of how manufacturing started and how it ended up in the current state was studied. Manufacturing started with Custom Manufacturing. In Custom Manufacturing, a carpenter made furniture, a cobbler made shoes and a tailor made clothes. These people had all the skills required to make the entire product. Today, special projects like spacecraft, special furniture, special clothing and specialty robots made by research organizations are still custom manufactured. As demand grew these skilled craftsmen could not meet the increasing demand of the people so Intermittent Manufacturing was developed. This is a set of small factories where products were made in batches like a batch of ten brooms at a time. The parts for a product are made at a time. Say ten wooden rods are turned from the raw wood. Then ten bottoms of the brooms are cut to shape from the raw wood. Then the ten bottom of broom are drilled with holes. Then the holes of the ten bottom of broom are stuffed with the plastic brushes to make the final broom. Continuous manufacturing was first developed in the Ford Motor company. There was a continuous demand for the Ford Model T cars so a conveyor system was developed where workers added parts to the cars at each station [2].

That was the beginning of the human drudgery of performing repetitive tasks like machines in factories. Instead of manufacturing say only ten brooms at a time, a continuous output of brooms are manufactured. At each workstation a particular task is performed to make the broom. Workers at each station are trained to accomplish their task as quickly as possible. Today most consumable products are manufactured in this way except that human are often replaced by robots [3]. The next manufacturing system is called Flexible Manufacturing System (FMS) where computer and communication technology is increasingly utilized. In a FMS, products are manufactured in lots but the process is continuous and highly automated and generally controlled by a central computer. FMS is a group of computer-controlled independent machines linked by material handling systems that are able to produce a variety in types and quantities of products. All the machines are controlled by a central computer running a Human Machine Interface (HMI) software which normally includes a SCADA (supervisory control and data acquisition) system. Often there are no humans even at the HMI computer. Many HTPPF management mistakenly believe that is the ultimate trend and work toward automating everything without buffers, thus hampering research initiatives. A HTPPF needs continuous research and only humans can do this. If the whole factory is already like a machine, humans cannot make changes easily. They cannot even access the machines because factory robots can harm them. Many HTPPF and not designed with the researchers' access in consideration. Researchers have to stop the whole factory or at least a whole production line to test out a hypothesis.

Since factories are increasingly being automated, details of the latest available robots and capabilities were also studied. The available configurations of robot arms are SCARA (four axes robots - Selection Compliance Assembly Robot Arm), Vertical multi-joint (six axes robot or articulated), Cartesian coordinates (two axes also known as Linear Module). Cylindrical coordinates (two linear axes plus one rotating axes) and Spherical coordinates (one linear axis plus two rotary axes).

Most of the testing used in this work is at the University Malaysia Sarawak laboratory which has five Adept robots of various configurations. The Adept Cobra i600 is a SCARA robot. It is the first Adept robot with the amplifier unit built into the robot arm. So it is not far off to place the PLC and everything the robot needs in the arm. The head of Adept robots in Singapore stated that it is just a matter that no one demanding for it so far [4]. Robots can change End-Effectors which are like changing fingers according to the type or shape of the product it will pick up. The Teach Pendant of the robot is used to move the end-effector to the product being processed and then this location is stored as a variable (like X) with the instruction: "here X". Later to move to this particular location, the instruction used is: "move X". The teaching of the location of the product must be extremely accurate because sometimes the robot arm have to move to this particular point to pick up the product for 24 hours a day and for many months after the initial teaching [5].

Major developments in factory machinery especially to prepare for future product generations are slow due to the huge capital invested in existing HTTPF machines and the large amount of capital such industries generate. The view that a process that is still generating big income requires no update is what kills big companies. The huge scale at which a HTPPF can be is best depicted by the largest, located in Shenzhen, China. This factory named Foxconn utilizes about a million workers to create revenue of US$94 billion in 2011 [9]. With such big money and number of employees, the resistance to major changes to cater for future generation of products is much greater. Foxconn is mostly an assembly factory but there are lots of avenues of improvements to make such a factory more efficient. Continuous research can be done aided by buffers in the production line.

A general view is that big companies with highly educated people cannot make major mistakes. A classic example to counter this is IBM. IBM invented the hard disk and was the main hard disk manufacturer in 1994 when it started to change the hard disk media from Al-NiP to glass. IBM was so confident that this is the direction to take that they shut down all their Al-NiP plants while the rest of the hard disk industry stuck with Al-NiP. The reason why glass was thought to be superior was that it was better able to handle head crashes onto the disk. If the head crashes onto the Al-NiP, it will cause a ripple just as when a stone is thrown into a calm lake. This ripple destroys lots of data [6].

The problem is that there is a huge data base on metallurgy developed since mankind started making swords while glass is a relatively new material. Therefore while Al-NiP factories were able to continually increase data capacity of their hard disk, IBM struggled. The Al-NiP factories also later developed systems that prevented the heads from ever contacting the disk via various sensors placed within the hard disk. As an example when a laptop is falling down, the head will move up over the disk, just as weight decreases in an elevator that moves down. A sensor is placed to detect this and the head is instructed by the software to immediately move completely off the disk. With sensors like this Al-NiP hard disk manufacturers claim their hard disk can take a falling force of nine g-force. This practically nullifies the advantages of using glass to make the disk in the hard disk [6].

Another major issue was that glass cannot dissipate heat generated as the disk spins below the head, while the AL-NiP disk can dissipate it via the hub which clamps onto the disk. From the hub heat is transmitted to the relatively big surface area aluminum body of the hard disk.

Heat destroys magnetic data storage. Magnetism occurs when electrons in domains within magnetic materials, like iron spin in the same direction. Heating a magnet will make electrons spin clockwise in one domain and anticlockwise in another and so forth. This in effect will turn the material back from a magnet to iron. The end result of this wrong decision by IBM researchers is that they had to sell off the entire hard disk manufacturing division [8].

III. Methodology and Results

The methodology and results for this work was done via data collection and empirical observations at the Western Digital hard disk manufacturing plants in Sarawak and Johor, Malaysia and also the laboratory at University Malaysia Sarawak.

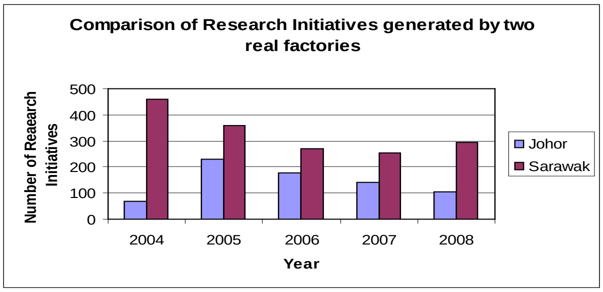

Figure 1 : A comparison of Research initiatives generated by two factories, the Western Digital factory in Sarawak (with buffers in-between machines) and Johor (with no buffers in-between machines), Malaysia

Data was collected of the rate of research activities for the Western Digital (WD) factory in Johor, Malaysia which is fully automated without buffers, versus the WD factory in Sarawak, Malaysia which has humans operating the buffers in-between automated production machines. The results are depicted in Figure 1. In the current hard disk industry, companies are still bent on full automation (without buffers) neglecting the above data; the exception being WD and Seagate which in recent years are following the Sarawak factory model. It is not the human factor in these buffers that enabled the Sarawak WD factory to have superior research but the fact that researchers can stop production lines due to these buffers. Humans in these buffers cause lots of defects as they handle ever increasingly sensitive hard disk media. The aim of this work is to automate this buffer so that researchers can more easily perform their tests.

The logic of managers of HTPPF in justifying fully automated production lines without stoppable buffers is that research can be performed on the dedicated research lines. But empirical observations made at the Western Digital factory in Sarawak showed that researchers tend to avoid the dedicated research lines and prefer to use the production lines to perform their tests because of the following factors:

a) Faster manpower turnover in a research line. A research line of production machines need a whole team of technicians to operate and maintain. Researchers will find it hard to justify financing this team to top management who tend to value short term or quarterly financial gains. This research team could be idle for days in-between research activities and this could be frowned upon by the rest of the production staff, especially during performance reviews which will eventually lead to employees deserting the research teams.

b) The current process must be stabilized before introducing a change. An empirically observed situation is that unfailingly, a newly started production machine will always have more defects, especially mechanical defects and particles than a line which has been running for a few hours. It might take even a full day for yield to go back to 98-99% after Preventive Maintenance (PM). Engineers in factories are still baffled by this empirical observation which goes against logic because machines which just went through PM have new parts and a thorough cleaning of the machine is always done after PM. In fact people in charge of PM in factories are often blamed for this issue. This is especially the case if the management does not have a technical background. Management can be engineers without much hands-on practice of non-engineers.

The most probable cause is not the mechanical parts but the fact that the stirred up chemicals in a machine that has been running for some time is more conducive for the process than chemicals that have been stagnant for a day or more. One of Western Digital's (formerly Komag) factory in Japan, concluded that even if the inner circumference of the pipes are clogged with coagulated chemicals, the process is still stable unless these pipes are disturbed by the PM, which dislodges particles from the inner circumference of the pipes. The PM for the pipes involves pumping either hydrogen peroxide (H2O2) or nitric acid (HNO3), (depending on if the process chemical is acidic or alkaline respectively) in the pipes for a duration of one to six hours (minor or major PM respectively). It is for this reason that PM on the pipes was not done for this Japanese factory. Instead all the pipes are changed after a certain span of time.

c) Other than chemicals in pipes, HTPPFs uses other OSRM (Operation Supplies Required Materials) which includes filters, liquid abrasives and specially built porous pads that hold the liquid abrasives required to polish the computer hard disk media. All these OSRM do not function optimally if they are not wet or used over a few hours. Settlement or coagulation will occur in these OSRM which impacts yield.

d) More samples of the test can be carried out in production lines. A researcher can test out an idea on say five production machines and take another five lines as controls. With more samples the conclusion can be more accurate than using just a research line. The overall change in the quality of the resulting product due to the incremental research change on the product is often very small and deciphering a conclusion of it's impact to final yield is quite difficult. So the more samples and controls there are, the easier the research objectives are achieved.

e) Researchers will eventually have to justify cost like everyone else. They have to plan their annual budgets. Starting up a huge research line for a tiny molarity change in one of the chemicals used in the production will definitely be very expensive and hard to justify at the end of the financial year especially if the results do not positively improve product quality. The cost includes employee compensation, increasingly expensive chemicals, electricity and extra Clean Room expenses. Clean Room expenses include electricity and HEPA (High Efficiency Particulate Absorption) filters and ROI (Return On Investment) of building the extra cleanroom. Considering all this justification to financially impatient managers will result in scientist performing less research. Researchers should not be expected to achieve a positive result for every hypothesis they made.

Considering all these potential problems of running a newly started production line, researchers tend to prefer performing their test on production lines which are continuously running every day for 24 hours. Note HTPPF run production 24 hours because settlements and coagulations of chemicals will not allow production to stop. Therefore because of the cost implications (and therefore management approvals) of performing even a small test, buffers between production machines in HTPPF are a necessity.

Other than aiding research initiatives, buffers will enable maintenance to be carried out more easily. Say a small pneumatic cylinder is faulty in one machine in a long production line. Buffers will enable the maintenance crew to stack up products in the buffer and repair the pneumatic cylinder. Without the buffer the whole production line will have to be stopped to repair this small pneumatic cylinder.

Throughput improvements of a particular machine within a long line can also be made easier with buffers within production machines. Say an engineer designed a throughput improvement for one machine within a long production line. If there are no buffer in-between machines, the throughput improvement cannot be utilized because all machines in the line must be synchronized. On the other hand with a buffer, improved throughput of one machine translates to a larger buffer before the next machine, while waiting for engineers to design throughput improvements for the next machine and so forth.

Another justification for a buffer is that it enables running multiple products. For example, with buffers products can skip one machine in a long production line. Perhaps customers have requested for such product for a lower end application. By the same token buffers can enable a higher end product as the product goes through an extra machine or two for a high end military application for example.

To enable an automated buffer the first design was a robot installed upon an elevator in-between HTPPF machines. As mentioned previously humans in buffers do not specifically enable research but a stoppable buffer does. Humans actually tend to create handling defects to the increasingly sensitive hard disk media; as the data stored on it increases at an exponential rate. So automation need to be designed such that the buffer can be stopped by researchers without human handlers.

The disks are placed in RFID coded cassettes and stacked on three layered tunable shelves. The reason for three layers is the standard dimension of floor to roof in a hard disk factory and the size of an off-the-shelve, six-axis factory robot. For this buffer to have more layers the robot arm must be custom built. The robot moves up and down with the help of a ball screw. Moving robots up and down on a ball screw system has never been done before [4] because factory robots have facilities going up to it.

Currently most factory robots have a CPU and an amplifier to amplify the signals coming out of it before it goes into the robot arm. Currently one Adept robot, the Adept Cobra i600P has the amplifier unit built onto the robot arm. But it is possible to build-in both the CPU and the amplifier into the robot arm [4]. The facilities required are power wires, signal wires and pneumatic pipes.

Wireless power is a recent advance developed at MIT (Massachusetts Institute of Technology) [7]. Basically a normal 50 or 60 Hz power transformer already has wireless power transfer between two coils separated by a paper. If the frequency is increased to the megahertz range, the separation of coils can be up to many meters.

As for the wireless signals to the robots, Wireless transmission has long been around as in cell phones but has not been implemented for factory robots, mainly due to concerns of hackers penetrating the factory robots. Therefore to communicate signals wirelessly to factory robots, security software must be sourced or developed from established suppliers (like McAfee).

For the electro-pneumatic system within the robot arm, Clean Dry Air (CDA) supply can be sent to the robot arm by installing a small pump with a filter at the robot arm itself. And this pump runs on wireless energy from the base at the bottom. Figure 2 and Figure 3 shows a Solid Works picture of the automated buffer.

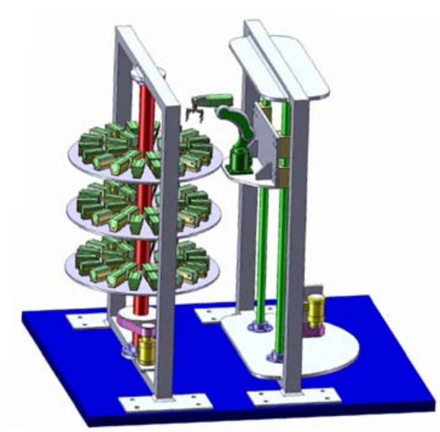

Figure 2 : The design of the buffer system in-between machines (Solid Works software sketch) which will facilitate research initiatives in HTPPF

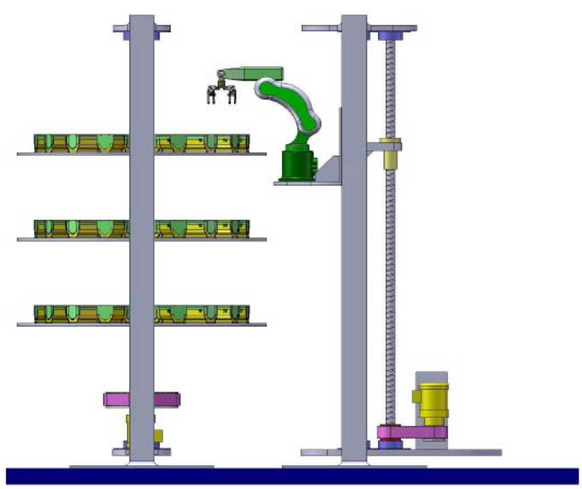

Figure 3 : Side view of the automated buffer

Once the automated buffer has been designed, there is a need to design a better way to stop the production machines. Researchers need to be able to stop production machines upon getting an inspiring idea without causing damage to products. Currently when a researcher stops the production line it is quite messy, with products being manually placed in temporary storage containers (if wet) or in cassettes on carts while the researcher makes the changes. This current system requires lots of human handling and therefore damage to the products. Quality personnel or managers will be shocked to see the avenues for damage to the highly sensitive products as they just pass by a production line being stopped by researchers. So a novel machine stopping method was designed specifically to cater to the needs of researchers within HTPPF.

The designed improved stopping device called Machine Stop (MS) has three modes of stopping. If Button I pressed, the machine will stop with memory i.e. stopping just like an EMO (Emergency Machine Off) does, but the machine has memory of last positions before stopping. This is enabled with the help of the recently available encoders with battery backup. Thus the robot will not need to do a "homing" upon startup. Homing need to be done if encoders are without battery backup so that the main controlling computer knows exactly where its' parts are.

If Button II pressed, the stopping will occur after finishing the current process. Say a machine has nine processes and the researcher may want to stop it after the second process to test an idea, so the button II must be pressed during the second process.

If Button III is pressed, all the existing products from the machine will be cleared before stopping. To enable these modes of stopping all the actuation of production machines must be changed from electro-pneumatics to battery-backed-up-encoder servo motor as depicted for a cleaning machine in Figure 4. In a high level portion of the program there is a continuous monitoring for button I, II or III being pressed by a researcher. If I is pressed for example, the program counter jumps to a sub-routine to stop the machines and record all the encoder positions of all the servo motors.

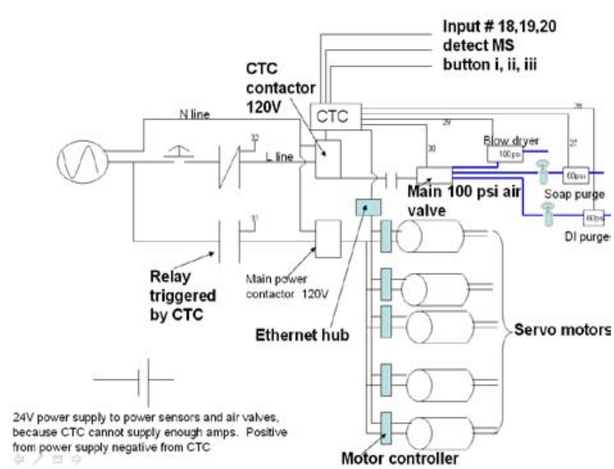

Figure 4 : A disk cleaning machine wiring schematic to enable Machine Stop (MS). The bigger bold letters represent changes

IV. Justification for Automation

With all these innovation implemented, the factory will have less manpower. There is therefore a need to justify advancing automation in factories as there are some who claim that such advances will take away jobs from the workforce. But paradigm shifts need to be made to view these automations as instruments that can liberate factory workers from the inhuman drudgery of pick and place jobs. Peering into human history will reveal that it was never natural for humans to be doing repetitive jobs for eight to twelve hours each day. Currently factory workers keep performing their jobs for the financial benefits they gain, the money is the shackle that keeps them almost as slaves to their jobs [10]. This prevents them from having the normal human intuition to help improve their surroundings. Their tight work schedule prevents them from developing skills that can enable them to earn a living in other ways. Factory work should be relegated to the machines. Foxconn factory is the largest private sector employer in China. In 2010, 14 suicides occurred in the factory and the factory actually installed nets to catch people falling down [9, 10]. Margaret Heffernan studied the problems in Foxconn and found that while it is the most modern factory in the world, economic needs have resulted in the management squeezing the workers of every last bit of energy. The workers are monitored constantly to ensure they are as efficient as possible. Basically management in this factory are watching over their human workers as any diligent management will watch over a factory robot to ensure it is positively earning for the factory. Often they do this without the concern or respect a football or basketball coach has over their players. Thereby the workers feel squeezed of every ounce or dedication they can provide and this sometimes leads to suicides. Workers were initially enticed to work in the factory on the first day by higher salaries and the possibilities of ending up as an entrepreneur like Bill Gates or Steve Jobs [11]. Only later they will find out they will have to be the agile robots that scientist and engineers have not yet been able to create (at the cost of their salaries) [12]. Workers join these factories in the hope of achieving their dream of financial success but more often than not they exhaust their human capacities instead. By the time they are retrenched (which is common) they realize what a foolish mistake it was to spend 10-17 years specializing in a skill within a HTPPF which cannot be utilized outside the factory. A worker who initially opted to be a construction laborer, a grass cutter, an electrician or a farmer will have more chance of continually upgrading their skills and eventually using these skills to better their financial status. The chances are higher for a construction worker to end up owning a construction company, a grass cutter to end up owning a landscape business or an electrician to end up owning an electrical installation business, than a Foxconn worker ending up owning a HTPPF.

Industrialist and job seekers have to come to terms with the fact that, with today's international market place, customers from a rich or poor country will not purchase an inferior human-labor made product, while a superior quality and cheaper, robot-made part is next to it. People will only purchase the optimum product to suit their finances and needs and not to satisfy some patriotic ideal. It is therefore imperative that competition will cause the human-labor intensive factories to eventually shutdown. When this happens, the only factory where a human can get employed will be as researchers at automated factories, which are producing high quality products at the lowest cost. Thus to increase employment, industrialists need to use automated machines and processes to find a niche in the international market. By slowly building up this niche with higher quality and precision, they will increase employment. Eventually HTPPF will be populated only by researchers or other highly technical skilled workers, most probably all degree holders [12].

V. Conclusion

The main hypothesis of this research is that buffers in-between production machines will enable HTPPF to innovate and thereby keep market share. The proof for this is the empirical observation that researchers in the WD factory in Sarawak prefer to use production lines to test their hypotheses. Also the chart Figure 1 indicates that the WD, Sarawak factory, which has manually operated buffers in-between machines, has a greater rate of research compared to the WD, Johor factory where all machines are jointed up.

The other data is the empirical observation that HTPPF that do not have the understanding that buffers are important are losing market share or have closed down especially in Japan, Korea and Taiwan. These factories automated and joined up all machines without buffers because it is the trend in all industries to do so. Top management tend not to be the most technical people in the factory some are non-engineers or engineers who skipped the hands-on work and rose into management. In the hard disk industry a company that cannot make the transition from one level of hard disk capacity to the next, say from 80GB to 120 GB per platter, can close down within a quarter or two.

In many of these failed HTPPF, top management reasoned out that dedicated research production lines is all that is needed to perform research, but as empirically observed, the research lines are frequently left unused in HTPPF, unless there are major changes to the product. A majority of the changes to product quality are small and can best be performed upon a production line.

VI. Future Work

Having used the WD factory as a research laboratory, four future works is suggested for improving the production flow in HTPPF.

The first is a better statistical software coupled with easily placed sensors to enable factory engineers to more easily trace yield detractors within HTPPF. Statistics used in factory are gradually developed and improved in the production of products but as life spans of high technology products decreases the statistical methods used should be as made as easy to use as possible.

The second improvement is a similar statistical software coupled with sensors to trace less than optimum operation of machines. For example a vibration sensor can detect a faulty bearing before the problem escalates to the destruction of an induction motor. This will reduce down time of machines, increase yield and bring down overall production cost of the HTPPF.

The third improvement should be to bring down prices of ultrasonic sensors, which are installed outside pipes to detect flow rates within it. Current propeller and ball flow-rate sensors are becoming too inefficient and sources of contamination in HTPPF. As chemicals used in HTPPF gets purer to cater to the ever increasing capacity in smaller spaces, required in products (like hard disk), contamination from propeller flow meters becomes unbearable. Furthermore, while installing propellers flow sensors, pipes need to be cut which will contribute to the contamination of chemical lines. Propeller and ball flow meters currently used in HTPPF tend to stop working after a while as sedimentation of the chemicals or even the extreme pH levels of these chemicals prevent their optimum functioning.

A fourth improvement is the more extensive use of fiber optic sensors. Fiber optic sensors can recently measure most physical properties ranging from strain pressure, temperature all the way to pH of chemicals [13]. These sensors are also non-reactive to most chemicals and withstand extremely high electromagnetic surroundings. So research should be advanced in this field to bring down cost to affordable ranges for use in HTPPF.

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Thermal Characterization of Neem and Cork Wood Polyacrylonitrile Composites

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Abstract- Wood polyacrylonitrile composite (WPC) from neem and cork woods were synthesized. The process was carried out through benzoyl peroxide(0.05mol/l) catalyzed impregnation polymerization of acrylonitrile 2mol/l, 4mol/l, 6mol/l into neem and cork woods in benzene medium at 75+-10c.The properties of WPC over untreated wood was evaluated. Loading of PAN into cork woods as ascertained through TGA, DTGA and DTA as well as Scanning Electron Microscopy (SEM) was found to increase the resistance against thermo-oxidation of WPCs in comparison to untreated wood.

Themogravimteric analysis (TGA) is one of the techniques used to determine the thermal properties of wood.Wood polyacrylonitrile composite (WPC) from, mango and cork wood was synthesized. The process was carried out through benzoyl peroxide (0.05mol\l) catalyzed impregnation polymerization of acrylonitrile, 4mol/l, 6mol\l into cork wood and mango wood in benzene medium at 75+-10c. The properties of WPCs over untreated woods were evaluated in terms of Thermo gravimetric analysis (TGA) in Nitrogen. Thermo gravimetric analysis were improved with impregnation of polyacrylonitrile. Impregnation of polyacrylonitrile (PAN) into, mango, cork woods were confirmed through scanning electron microscope. In the present research effects have been made to develop such polyacrylonitrile impregnated composites in Benzene medium having improved thermal stability for there commercial exploitation for desirable purposes.

Keywords: benzoyl peroxide, polyacronitrile, impregnation.

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THERMALCHARACTERIZATIONOFNEEMANDCORKWOODPOLYACRYLONITRILECOMPOSITES

Strictly as per the compliance and regulations of:

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Dr. Mohammed Abid Ali [α] & Dr. VVS. Kesava Rao [σ]

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Keywords: benzoyl peroxide, polyacronitrile, impregnation.

I. Introduction

Wood polymer composites (WPCs) results from the polymerization of liquid monomers already impregnated in wood. In principle WPCs should display super mechanical properties; dimensional stability to chemical degradation and less moisture absorb temperature than non-impregnated wood. A number of wood preservatives developed during those wood treatment processes and are under continuous demands which can develop the modified wood materials with improved mechanical strength, thermo-oxidative stability and resistance biodegradation for the better outdoor applications. Polymerization of polyacrylonitrile into poplar wood has also been reported and the composites indicated excellent moisture resistance and thermo oxidative stability [1, 2]. Temperature affects physical, structural properties of wood. Several affects have been made to establish the relationship between temperature and thermal stability of wood [3, 4, 5, 6]. The physical and mechanical properties of wood may be improved by preparing composites of wood with vinyl monomers [7]. Reinforcement of several monomers like styrene, methyl methacrylate has provided substantial thermal stabilities to different types of woods [8, 9]. However, since most vinyl monomers are non-polar; there is little interaction between these monomers and hydroxyl groups of the cellulose fibers. Wood, a renewable resource and naturally occurring material abundantly available has a wide range of applications as construction material, pulp, paper, fire board products as well as source of energy and as raw materials for various industrially important chemicals. Considerable work has been done on the modification of wood [10], [11]. Meyer (1981) reported that wood treated with vinyl type monomer followed by curing (radiation or catalyst) significantly improves the moisture resistance, hardness etc. The advantage of impregnation at normal conditions is the large quantities of samples of various sizes and shapes can be conveniently impregnated compared to vacuum impregnation [9]. Thermo gravimetric analysis (TGA) is one of the major thermal analysis techniques used to study the thermal behavior of carbonaceous materials. The rate of weight loss of the sample as a function of temperature and time is measured to predict thermal behavior of the materials. Thermal analysis as TG has become the polymer characterization method the most frequently used. The TGA is particularly more adopted for mass variation study. In this work, we studied the process of degradation of wood poly acrylonitrle composites. Compressive strength of impregnated eucalyptus wood specimens is greater than that of non impregnated ones indicating that monocomponent polyurethane resin can be considered for impregnated impregnating wood [12]. In thermo gravimetric list thermal decompositions of rice husk floor from room temperature to 350^{0}C was similar to that of wood floor. Thus rice husk floor was thought to be a substitute for wood floor in agricultural lignocellulosicfiber-thermoplastic composites in the aspect of thermal decomposition [13]. Physical and mechanical grown A auriculiformis of three different ages (8,12,13 years) from sirsi, Karnataka indicate that the wood can be used for tool handles in workshops and factories and agricultural sectors, light packing cases[14].

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The mechanical stability of cedar wood samples were increased by using P (AGE/AN), P (AGE/MMA) copolymers. [15]. Polymerization of polymethyl methacrylate and acrylonitite into Block Berry Wood has also been reported and composites indicated excellent wear stability and thermo oxidation stability [16]. Polymerization of acrlonitrile into Indian Cork wood has also been reported and composites indicated excellent compressive resistance and thermal stability[17].

II. Experimental Procedure

a) Materials

All the chemicals and solvents (AR) were purchased from M/S SDFCL Chemicals Ltd; Mumbai. The monomer acrylonitrile was purified by extracting it with aqueous NAOH (10%) to remove inhibitor contents fallowed by repeated washings with distilled water. The fraction at 78^0 C was used for the impregnation polymerization reaction. Other chemicals and solvents were used without further purification.

b) Sample Preparation

Wood specimens were prepared as per IS: 1708-1986.The moisture content of wood was deduced according to ASTMD1037-72a and was found to be 12.75%.

c) Impregnation Procedure

The Benzene solution of acrylonitrile at concentration of 4M, 6Moles and Benzene solution of benzoyl peroxide at0.05M have also been prepared. Samples were then placed into an impregnation chamber. Extra loads were applied on the samples before impregnation so that no flotation occurs. The appropriate monomer system was then introduced through a dropping funnel and the specimens were left immersed while atmospheric pressure was reached and allowed to stand for up to 24H (ASTMD-1413-61). Treated wood specimens were then wrapped in commercially available Al foil and cured in oven at 95^0C for 2H to induce the impregnation polymerization reaction. Impregnation of polyacrylonitrile into neem, and cork woods was confirmed through scanning electron microscopy.

Figure 1 : Polymerization Process

III. Measurement of Loss of Mass

a) Charecterization Method

The DTG-TGA- DTA examines the process of weight changes as a function of time and temperature and other environmental conditions that may be created that may be created with in the instrument. In its simplest form, TGA measurements are made by heating the sample at constant rate in a prescribed atmosphere. W=f (Tor t). Thermo gravimetric analysis of polymers and their composites were carried out to assess the thermal and oxidation stability of the samples. The equipment specifications are: Model: TG/DTA6200. Temperature range: 5-600^0 C heating rate: 10^0C/min. The thermal stability of wood and related WPCs are usually measured through simultaneous Differential thermo gravimetry-Thermogravimetry-differential thermal analysis (DTG-TG-DTA).

b) Scanning Electron Microscope (SEM)

Electron micrographs of Cork wood &their Polyacrolonitrile (PAN) reinforced wood composites were scanned on HITACHI 3400N SEM. The morphologies of composites were studied in view to get a clear understanding about the affinity of polyacrylonitrile (PAN) with their respective woods.

IV. Results and Discussion

a) Thermal Analysis of Neem wood poly acrylonitrile composites

TG/DTA model thermal analyzer has been employed to study thermo gravimetry analysis of untreated wood and its polyacrylonitrile (PAN) wood composites in the atmosphere of nitrogen. 5 mg-20 mg masses of samples were analyzed. The sample was placed in a little cup made of aluminum hanging from a micro balance. The variation of the mass of the sample cans allows drawing the TG thermo grams. TG scans were exploited to evaluate the range for various decomposition stages electron micro graphs of woods and their reinforced wood composites were scanned on HITACHI 3400N SEM. TG data has been used to study the weight loss in Neem wood and related composites at the various temperatures range 0-600ºC. TG profile indicate the Thermo gravimetric analysis of wood started at 255ºC with –2.6% weight loss. A weight loss in Neem wood was recorded in temperature range 255ºC-314ºC with 15.7% weight loss which was further intensified at 383ºC with 37.4 % weight loss recorded. The first and second DTA endotherms have represented the crystallization temperature T_c at 81.7ºC and oxidation temperature T_{ox} at 371.7ºC. Similarly the maximum T_{max} and final T_f at decomposition were recorded 79.4ºC and 361.4ºC respectively from DTG endotherms. Thermo gravimetric analysis of Acrylonitrile impregnated wood composites with concentration of 2M started at 255ºC with 2.9% weight loss. A weight loss in Neem wood was recorded in temperature range 255°C-314°C with 14.4% weight loss which was further intensified at 383°C with 45.9% weight loss recorded. The first and second DTA endotherms have represented the crystallization temperature T_c at 80.01°C and oxidation temperature T_{ox} at402.8°C .Similarly the maximum T_{max} and final T_f at decomposition were recorded 77.6°C and 366.1°C respectively from DTG endotherms. Thermo gravimetric analysis of Acrlonitrile impregnated wood composites concentration of 4M started at 255°C with 2.3% weight loss. A weight loss in neem wood was recorded in temperature range 255°C-314°C with 15.4% weight loss which was further intensified at 383°C with 40.1% weight loss recorded. The first and second DTA endotherms have represented the crystallization temperature T_c at 72.9°C and oxidation temperature T_{ox} at 374.5°C .Similarly the maximum T_{max} and final T_f at decomposition were recorded 66°C and 361.7°C respectively from DTG endotherms. Thermo gravimetric analysis of Acrlonitrile impregnated wood composites concentration of 6M started at 255°C with 3% weight loss. A weight loss in Neem wood was recorded in temperature range 255°C-314°C with 16.4% weight loss which was further intensified at 383°C with 34.9% weight loss recorded. The first and second DTA endotherms have represented the crystallization temperature T_c at88.2°C and oxidation temperature T_{ox} at 352.5°C .Similarly the maximum T_{max} and final T_f at decomposition were recorded 86.7°C and344.9°C respectively from DTG endotherms.

TG-DTG-DTA-scans were exploited to evaluate the ranges for various decomposition stages. (Graph Fig. 2 to Fig. 13).

b) Thermal Analysis of cork wood poly acrylonitrile composites

TG/DTA model thermal analyzer has been employed to study thermogravimetry analysis of untreated wood and its polyacrylonitrile (PAN) wood composites in the atmosphere of nitrogen. 5 mg-20 mg masses of samples were analyzed. The sample was placed in a little cup made of aluminum hanging from a micro balance. The variation of the mass of the sample cans allows drawing the TG thermograms. TG scans were exploited to evaluate the range for various decomposition stages electron micro graphs of woods and their reinforced wood composites were scanned on HITACHI 3400N SEM. TG data has been used to study the weight loss in cork wood and related composites at the various temperatures range 0-600°C. TG profile indicate the Thermo gravimetric analysis of wood started at 255°C with 1.4% weight loss. A weight loss in cork wood was recorded in temperature range 255°C-314°C with 16.8% weight loss which was further intensified at 383°C with 36.7 % weight loss recorded. The first and second DTA endotherms have represented the crystallization temperature T_c at 71.4°C and oxidation temperature T_{ox} at 393.3°C. Similarly the maximum T_{max} and final T_f at decomposition were recorded 70°C and 339.9°C respectively from DTG endotherms. Thermo gravimetric analysis of Acrylonitrile impregnated wood composites with concentration of 2M started at 255°C with 2.2% weight loss. A weight loss in cork wood was recorded in temperature range 255°C-314°C with 15.0% weight loss which was further intensified at 383°C with 41.9% weight loss recorded. The first and second DTA endotherms have represented the crystallization temperature T_c at 77.1°C and oxidation temperature T_{ox} at 372.3°C .Similarly the maximum T_{max} and final T_f at decomposition were recorded 74.5°C and 353.6°C respectively from DTG endotherms. Thermo gravimetric analysis of Acrlonitrile impregnated wood composites concentration of 4M started at 255°C with 2.0% weight loss. A weight loss in Cork wood was recorded in temperature range 255°C-314°C with 16.1% weight loss which was further intensified at 383°C with 36.4% weight loss recorded. The first and second DTA endotherms have represented the crystallization temperature T_c at 82.4°C and oxidation temperature T_{ox} at 402.9°C .Similarly the maximum T_{max} and final T_f at decomposition were recorded 77.3°C and 349.3°C respectively from DTG endotherms. Thermo gravimetric analysis of Acrlonitrile impregnated wood composites concentration of 6M started at 255°C with 2% weight loss. A weight loss in cork wood was recorded in temperature range 255°C-314°C with 15.7% weight loss which was further intensified at 383°C with 37.5% weight loss recorded. The first and second DTA endo therms have represented the crystallization temperature T_c at 78.2°C and oxidation temperature T_{ox} at 400.1°C. Similarly the maximum T_{max} and final T_f at decomposition were recorded 73.2°C and 351.8°C respectively from DTG endotherms.TG-DTG-DTA-scans were exploited to evaluate the ranges for various decomposition stages. (Graph Fig.14 to Fig.10).

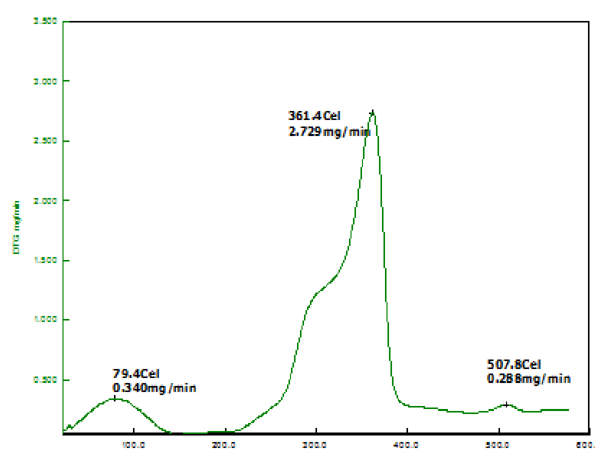

Figure 2 : D TG for Untreated neem wood

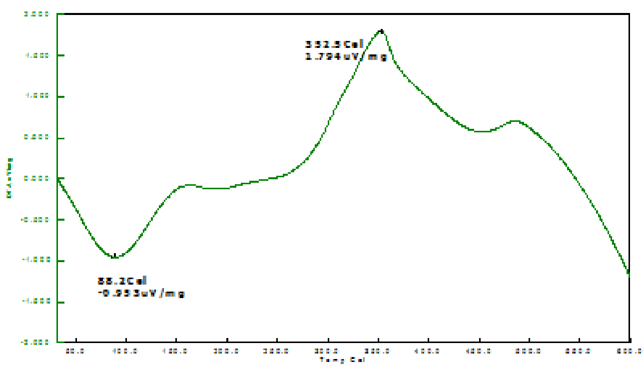

Figure 3 : D TA for Untreated neem wood

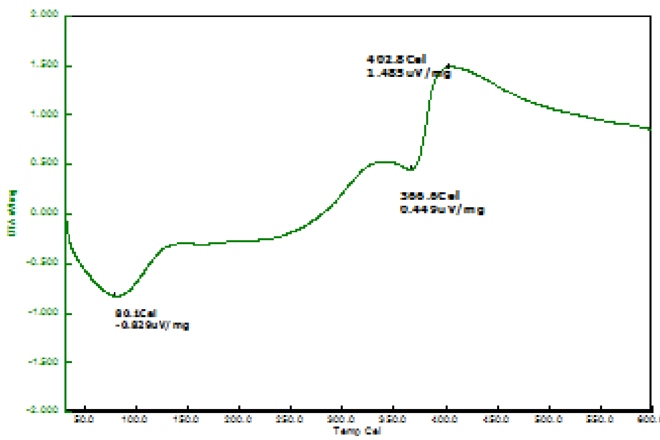

Figure 4 : TGA for Untreated neem wood

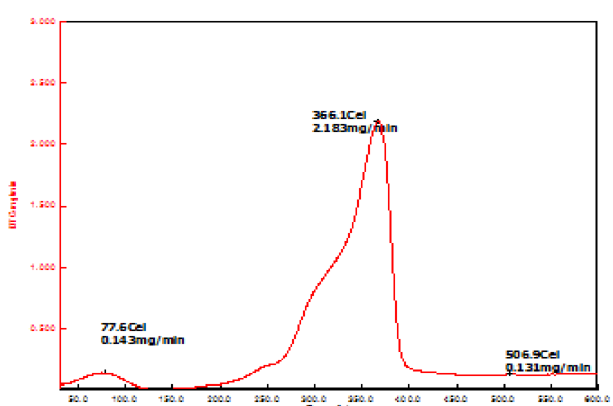

Figure 5 : DTG curve for Acrylonitrile of 2 Mconcentrated treated neem wood

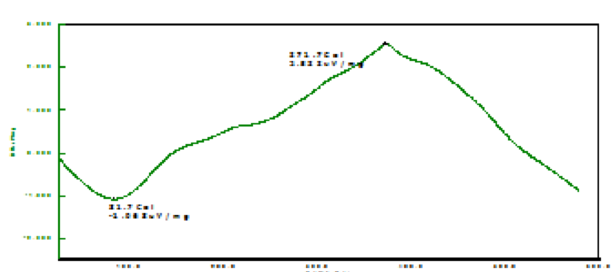

Figure 6 : DTA curve for Acrylonitrile of 2 Mconcentrated treated neem wood

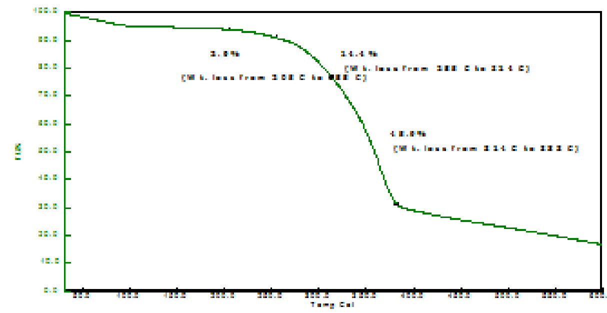

Figure 7 : TGA curve for Acrylonitrile of 2 Mconcentrated treated neem wood

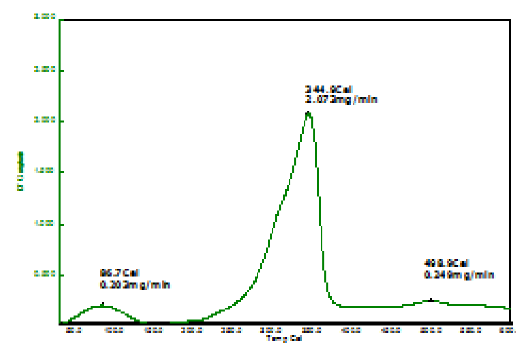

Figure 8 : DTG curve for Acrylonitrile of 4 Mconcentrated treated neem wood

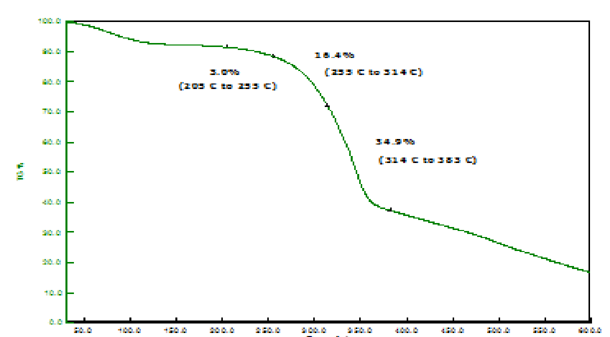

Figure 9 : TGA curve for Acrylonitrile of 4 Mconcentrated treated neem wood

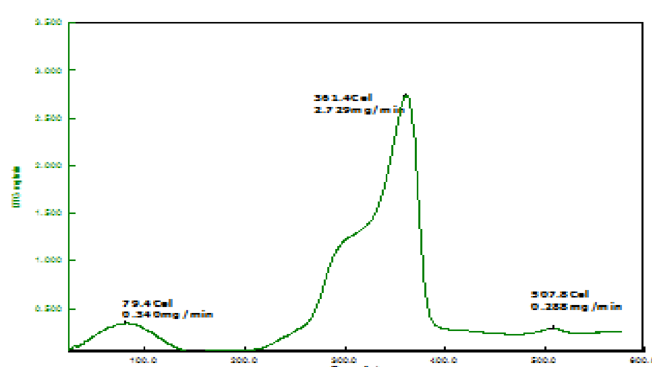

Figure 10 : DTA curve for Acrylonitrile of 4 Mconcentrated treated neem wood

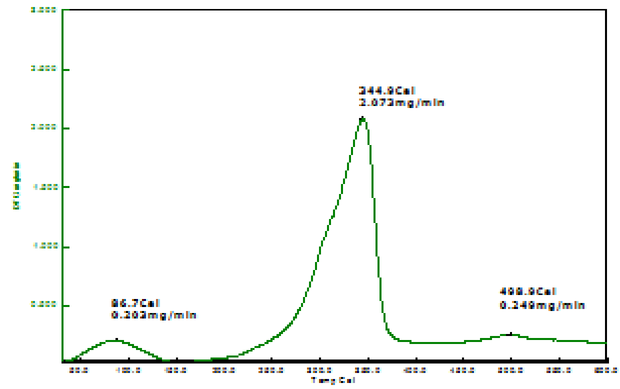

Figure 11 : DTG curve for Acrylonitrile of 6 Mconcentrated treated neem wood

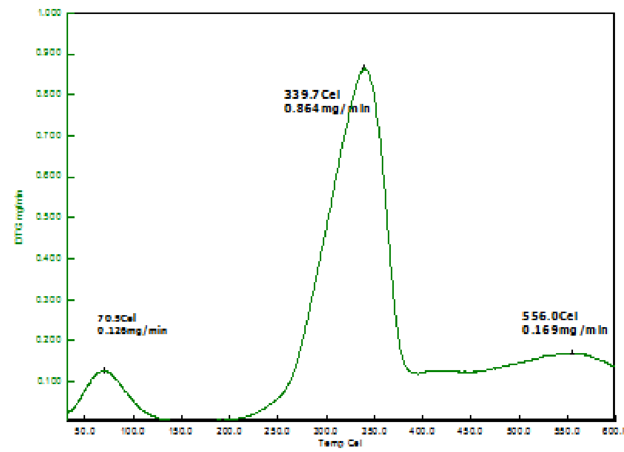

Figure 15 : D TG for Untreated cork wood

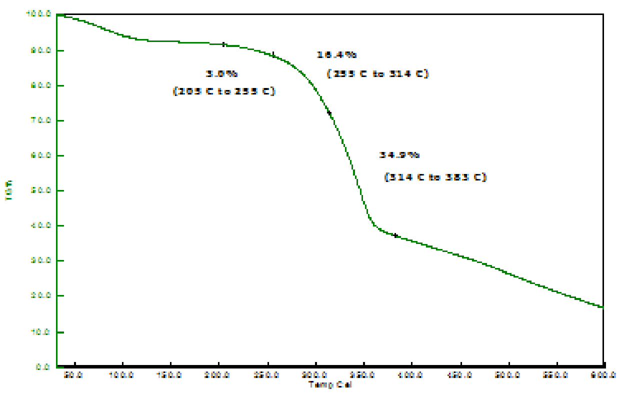

Figure 12 : TGA curve for Acrylonitrile of 6 Mconcentrated treated neem wood

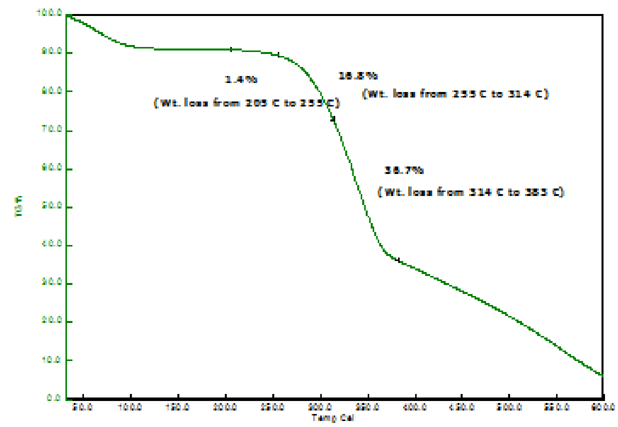

Figure 16 : TGA for Untreated cork wood

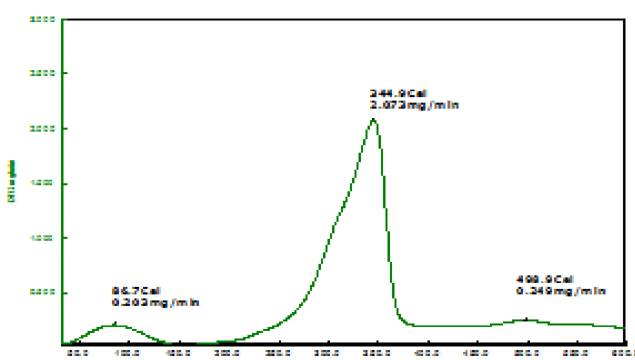

Figure 13 : DTG curve for Acrylonitrile of 6 Mconcentrated treated neem wood

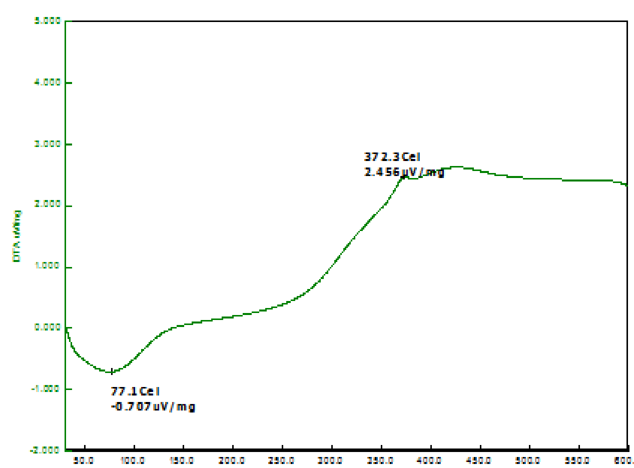

Figure 17 : DTA curve for Acrylonitrile of 2M concentrated treated cork wood

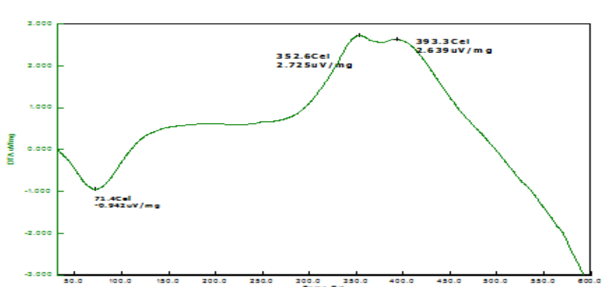

Figure 14 : DTA for Untreated cork wood

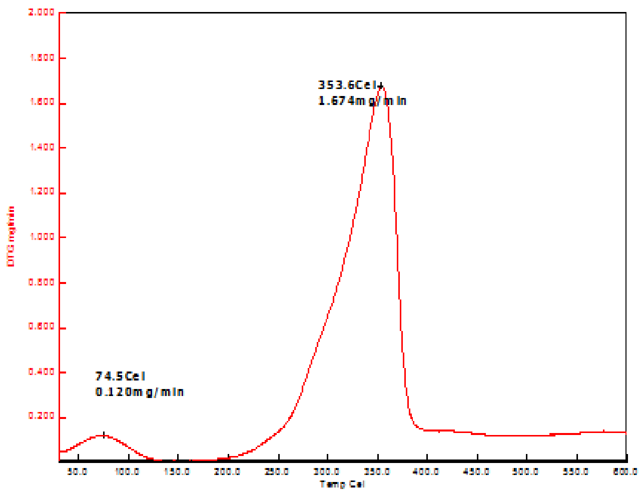

Figure 18 : DTG curve for Acrylonitrile of 2M concentrated treated cork wood

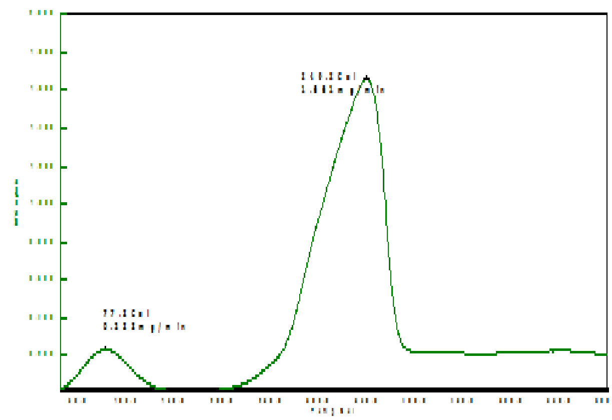

Figure 21 : DTG curve for Acrylonitrile of 4M concentrated treated cork wood

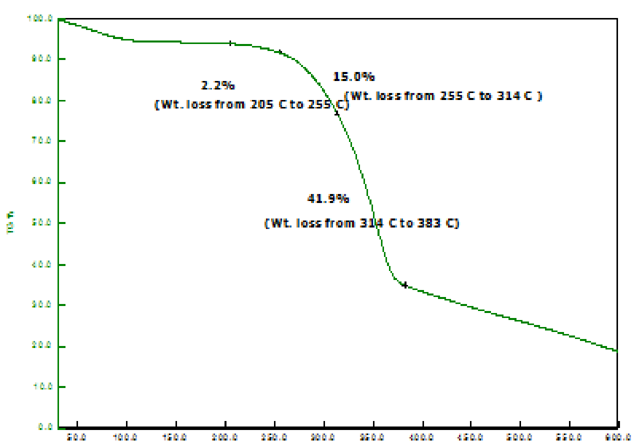

Figure 19 : TGA curve for Acrylonitrile of 2M concentratedtreated cork wood

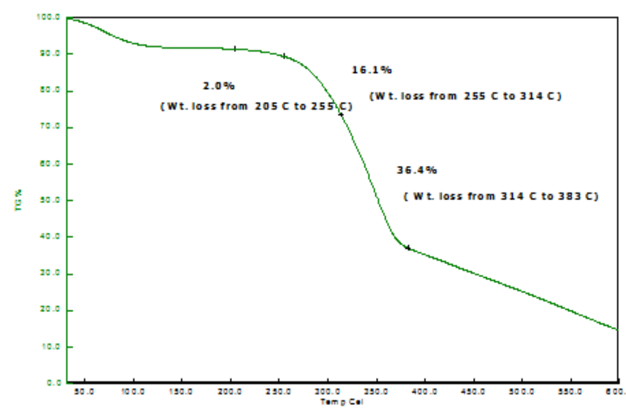

Figure 22 : TGA curve for Acrylonitrile of 4M concentrated treated cork wood

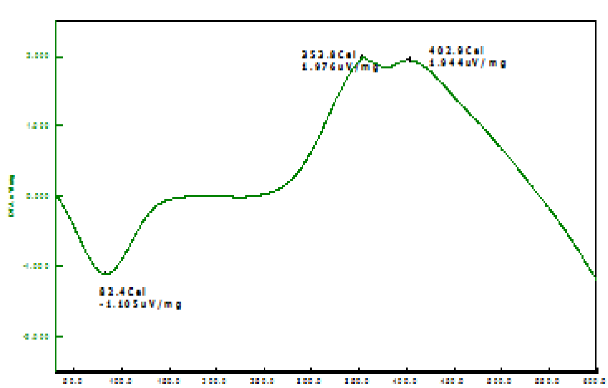

Figure 20 : DTA curve for Acrylonitrile of 4M concentrated treated cork wood

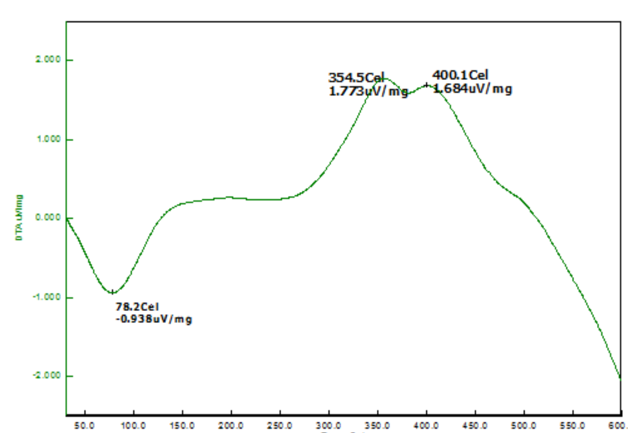

Figure 23 : DTA curve for Acrylonitrile of 6M concentrated treated cork wood

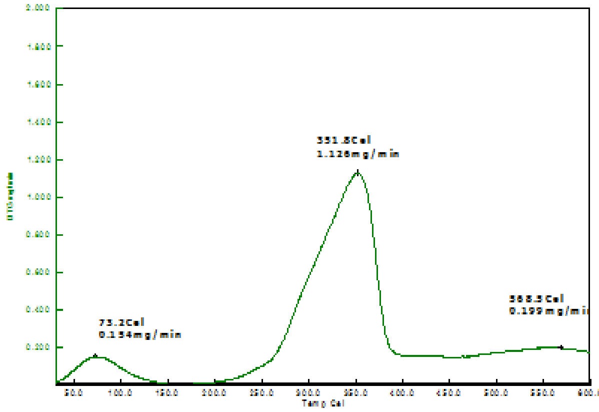

Figure 24 : DTG curve for Acrylonitrile of 6M concentrated treated cork wood

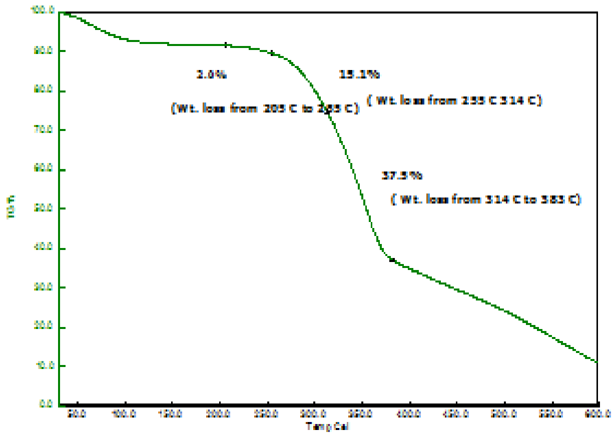

Figure 25 : TGA curve for Acrylonitrile of 6M concentrated treated cork woo

c) Scanning Electron Microscope (SEM)

SEM test is a type of electron microscope that images the sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography. Scanning electron microscopic analysis cork wood specimens examined the surface topology of untreated and treated Wood specimens. The pore size of the material was continuously affected by increasing the extent of Acrylonitrile reinforcement. The analysis of microscopic structure of non-impregnated cork wood samples compared with the samples impregnated with Poly Acrylonitrile monomers shown in Fig. 26 to Fig. 33.

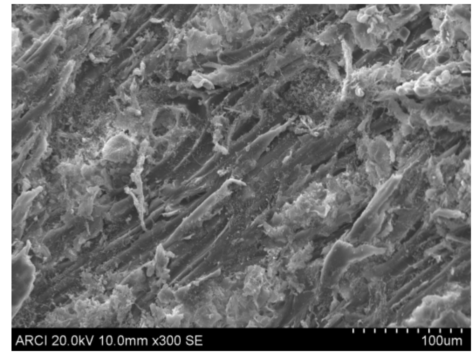

Figure 26 : Microscopic view of untreated neem wood

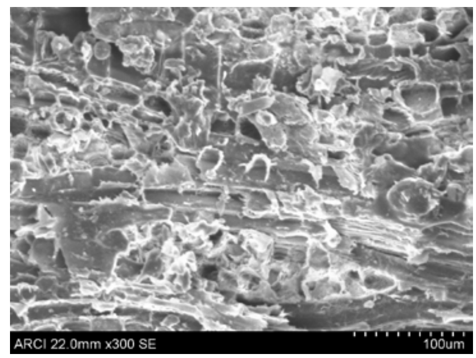

Figure 27 : Microscopic view poly acrylonitrile affinity

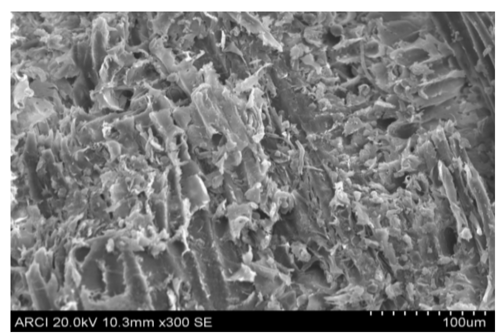

Figure 28 : Microscopic view poly acrylonitrile

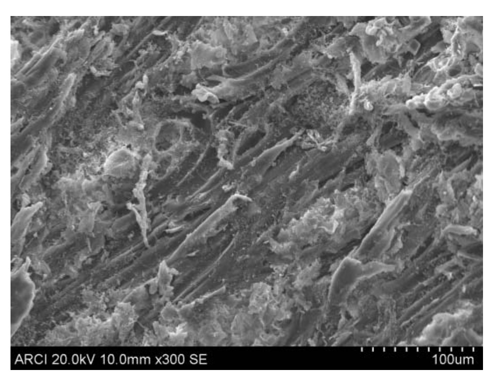

Figure 29 : Microscopic view poly acrylonitrile affinity of 6M concentration treated neem wood

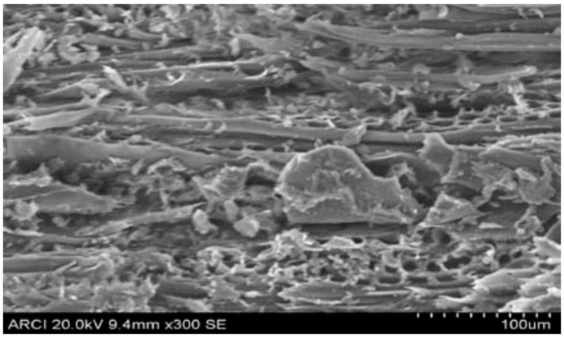

Figure 30 : Microscopic view of untreated cork wood

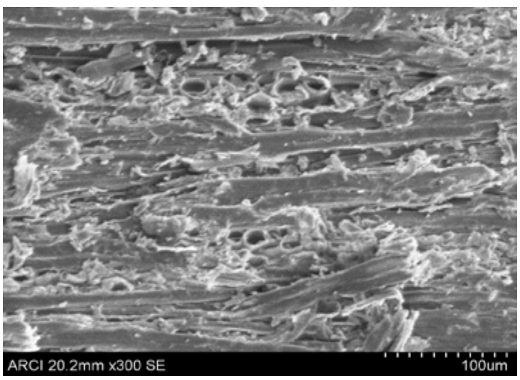

Figure 31 : Microscopic view poly acrylonitrile affinity of 2M concentration treated neem wood

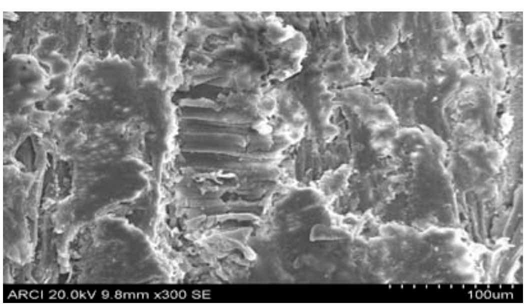

Figure 32 : Microscopic view poly acrylonitrile affinity of 4M concentration treated neem wood

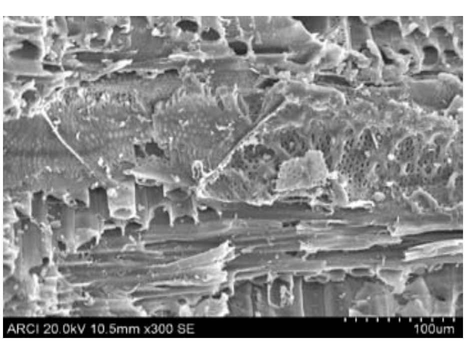

Figure 33 : Microscopic view poly acrylonitrile affinity of 6M concentration treated cork wood

V. Conclusions

Results of these tests demonstrated that the Thermal properties of impregnated wood specimens are greater than that non impregnated ones. It is concluded that thermal data presented in this paper that thermal stability of Polyacrylonitrile (PAN) Reinforced composites was improved in comparison to untreated neem and cork woods. Scanning microscope (SEM) indicated non-uniform distribution of polyacrylonitrile into wood lumens. It is concluded that observations that thermal stability of low grade woods can incorporated for its vertesile scientific and technological applications by selecting appropriate combinations of the monomer and catalyst along with their respective concentrations. Results of these tests demonstrated that the Thermal properties of impregnated wood specimens are greater than that non impregnated ones.

It is concluded that thermal data presented in this paper that thermal stability of Polyacrylonitrile (PAN) Reinforced composites was improved in comparison to untreated cork and neem woods. Scanning microscope (SEM) indicated non-uniform distribution of polyacrylonitrile into wood lumens.

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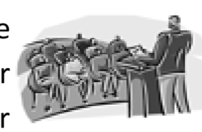

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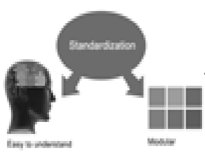

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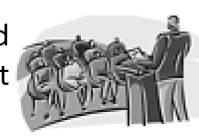

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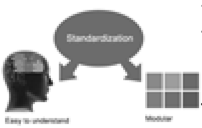

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To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

4. MANUSCRIPT'S CATEGORY

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

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All manuscripts submitted to Global Journals Inc. (US), ought to include:

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Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

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The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

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Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

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Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

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TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

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7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

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11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

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Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
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- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

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- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

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This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
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