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Highlights

- Review of Applications
- Design Optimization of Golf
- Reduction of Production Lead
- Fast Pyrolysis of Tectonagrandis

Discovering Thoughts, Inventing Future

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Reduction of Production Lead Time using Value Stream Mapping (VSM) Technique

By Mirza Md Sayeed Hasan , Anik Islam Nirjher & Antor Habib Chowdhury
Rajshahi University of Engineering Technology

Abstract- Value Stream Mapping (VSM) is a special type of flow chart that uses symbols known as "the language of Lean" to depict and improve the flow of inventory. In this research, process time and other unnecessary non value added activities of a battery manufacturing company have been reduced by using various lean manufacturing tools. The current situation is analyzed by showing a current state map. Then after using several lean tools, a future state value stream map has been showed. A different layout of the industry especially assembly section has been suggested. The layout of the assembly section is time wasting in current situation. They could reduce their overall production lead time as well as wastes by considering the suggestions about using lean tools and improved layout.

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REDUSCTIONOFPRODUCTIONLEADTIMEUSINGVALUESTREAMMAPPINGVSMTECHNIQUE

Strictly as per the compliance and regulations of:

Reduction of Production Lead Time using Value Stream Mapping (VSM) Technique

Mirza Md Sayeed Hasan [α], Anik Islam Nirjher [σ] & Antor Habib Chowdhury [ρ]

Abstract- Value Stream Mapping (VSM) is a special type of flow chart that uses symbols known as "the language of Lean" to depict and improve the flow of inventory. In this research, process time and other unnecessary non value added activities of a battery manufacturing company have been reduced by using various lean manufacturing tools. The current situation is analyzed by showing a current state map. Then after using several lean tools, a future state value stream map has been showed. A different layout of the industry especially assembly section has been suggested. The layout of the assembly section is time wasting in current situation. They could reduce their overall production lead time as well as wastes by considering the suggestions about using lean tools and improved layout.

I. Introduction

The first time that lean concepts were shown to the world was in the book "the machine that changed the world" which is a benchmark among craft production, mass production and lean production (Womack, Jones and Roos, 1990). The lean manufacturing system was built up between 1945 and 1970. After the Second World War, the Japanese economy had collapsed due to the shortage of raw materials, financial and human resources as well as an oil crisis. This research addresses the application of lean manufacturing concepts to the continuous production sector with a focus on the battery industry. The goal of this research is to investigate how lean manufacturing tools can be adapted from the discrete to the continuous manufacturing environment, and to evaluate their benefits on a specific application instance. Value Stream Mapping includes all the steps, both value added and non value added, required to take a product or service from raw material to the waiting arms of the customer. This enables to see at a glance where the delays are in process, any restraints and excessive inventory. Current state map is the first step in working towards ideal state for organization. VSM is primarily concerned with mapping the movement of information and materials through the value stream.

Our research objective is

- ➢ To reduce manufacturing lead time and wastes of a particular battery manufacturing company.
- ➢ To increase capacity of that battery manufacturing company. Many unnecessary times have been wasted in various industries. The focus of this research is to eliminate those unnecessary process times and reduce wastes of a particular battery manufacturing company. The main goal is to reduce these unwanted times of the production by using various lean tools. A different layout has been suggested considering various ergonomic and other factors to increase capacity of the overall industry.

Author α σ ρ: Rajshahi University of Engineering Technology.
e-mail: akibmirza93@gmail.com

II. Literature Review

The term value stream was first introduced in the book The Machine that Changed the World by Womack, Jones and Roos (1990), and further discussed in Lean Thinking (1996) by Womack and Jones. In a later book by Martin and Osterling, the authors defined: "a value stream is the sequence of activities an organization undertakes to deliver on a customer request." (Martin and Osterling, 2013). More broadly, value stream is the sequence of activities required to design, produce, and deliver a good or service to a customer, and it includes the dual flows of information and material." (Martin and Osterling, 2013). Value stream mapping in the manufacturing environment has been discussed since the technique was used at the Toyota Motor Corporation, and was known as "material and information flows." Toyota focuses on understanding the flow of material and information across the organization as a way to improve manufacturing performance. Ulf K. Teichgräber, Maximilian de Bucourt (2010) utilized VSM to eliminate non-value-adding (NVA) waste for the procurement of endovascular stents in interventional radiology services by applying value stream mapping (VSM). The Lean manufacturing technique was used to analyze the process of material and information flow currently required to direct endovascular stents from external suppliers to patients. Based on a decision point analysis for the procurement of stents in the hospital, a present state VSM was drawn. After assessment of the current status VSM and progressive elimination of unnecessary NVA waste, a future state VSM was drawn (Ulf K. Teichgräber, et al 2012). Krisztina Demeter, Zsolt Matyusz (2011) discussed how companies can improve their inventory turnover performance through the use of lean practices. However, there may be significant differences in inventory turnover even among lean manufacturers depending on their contingencies (Cox, A., 2002). Zoe J. Radnor, Matthias Holweg, Justin

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Waring (2012), adopted process improvement methodologies from the manufacturing sector, such as Lean Production. In this paper they report on four multi-level case studies of the implementation of Lean in the English NHS. Their results showed that the work generally involves the application of specific Lean 'tools', such as 'kaizen blitz' and 'rapid improvement events', which tend to produce small-scale and localized productivity gains. Although this suggests that Lean might not currently deliver the efficiency improvements desired in policy, the evolution of Lean in the manufacturing sector also reveals this initial focus on the 'tool level'. Bergmiller and McWright (2009) identified manufacturing firms who had implemented lean manufacturing and received one of lean's most distinguished awards, the Shingo Prize (The Shingo Prize for Operational Excellence, 2009). He found that these firms were significantly greener than a general population of other manufacturers in twenty five of twenty-six measures of green manufacturing. Bergmiller and McWright utilized an online survey tool in order to harvest information from Shingo award-winning manufacturers. The survey was divided into three sections, as follows: Status of their plant(s) environmental management system (EMS), Fourteen questions regarding the application of environmental waste techniques at the plant(s) and Ten questions about advantages/ disadvantages of the EMS at the plant(s).Sawhney, Teparakul, Aruna, and Li (2007) show the connection between lean manufacturing and the environmental movement stating that "it is natural that the lean concept, its inherent value-stream view and its focus on the systematic elimination of waste, fits with the overall strategy of protecting the environment", which they call Environmental Lean (En-Lean). The focus group reported that several green manufacturing metrics were more positive in lean manufacturing than batch-style manufacturing: Air pollution was lower in a cellular manufacturing scenario since exhaust and power consumption was less, employee's safety and health were better with an optimized plant layout, exposure to dangerous material was reduced by eliminating unneeded material transfers.Teresko (2004) made the connection between green manufacturing and the lean movement in his research into Bill McDonough's book "Cradle to Cradle". Teresko recites McDonough's statements that the goal of lean, when applied to a manufacturing facilities layout, is to "shrink-wrap a structure around an optimized process; including the entire external commercial environment in the optimized process, integrating all the manufacturing flows from global to national to submicroscopic levels". In the last several years, much research concerning applying techniques such as linear and non-linear programming, and discrete event simulation (DES) as lean tools has been conducted. Multiple authors cite the significant (positive) impact the application of these tools can have in conjunction with the more traditional tools as developed by Toyota (Marvel & Standridge, 2009; Maynard, 2007). Curry (2007) described how DES is used to "allow one to visually see and measure how processes perform over time, including materials, information and financial flows, and how probabilistic variables impact them". Additionally, Curry stated how DES is an extremely valuable compliment to value stream mapping (VSM) because VSM is inherently non-analytical and static in nature.

III. Methodology

To implement a VSM various steps can be followed. Our goal was to find out different types of wastes from the job floor and reduce the cycle time. To achieve our goal we implement the steps shown in following figure:

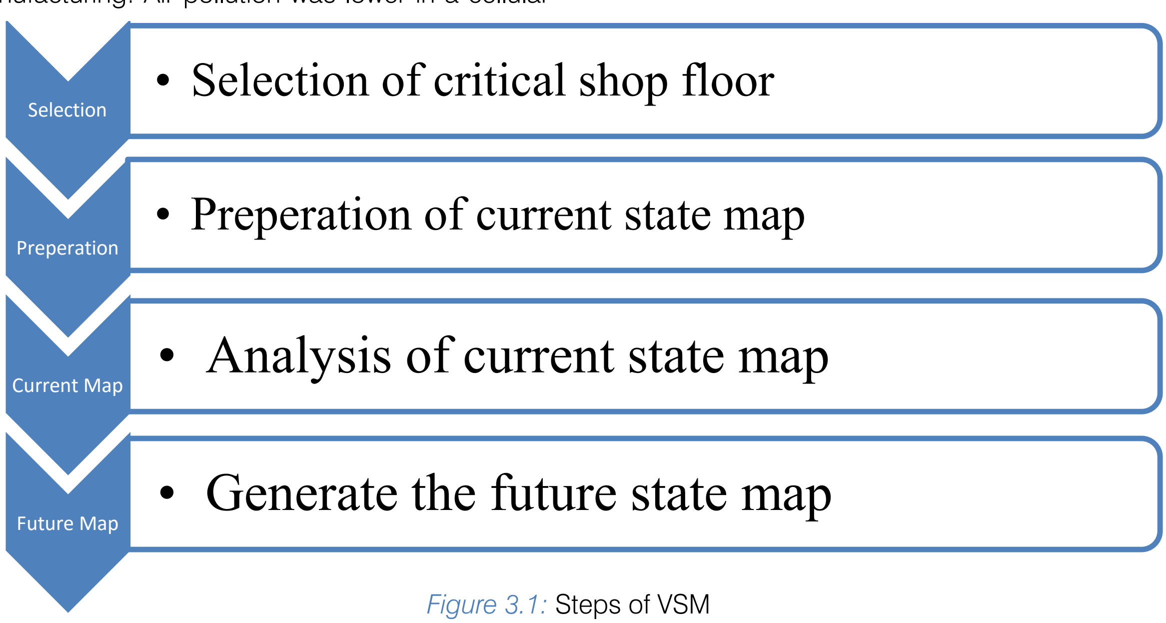

Figure 3.1: Steps of VSM

IV. Data Collection

In Rahimafrooz Battery LTD (RBL) current condition of the production system is very efficient than any other battery companies in our country. The main raw materials for their production are Lead and Poly propylene. The 80% leads are coming from the used batteries which were sold out at the market. There are mainly five job floors, where different types of manufacturing process are being held to produce batteries. Some important information collected to generate current state map of RBL are given below:

a) Job Floor 1- Lead Preparation Plant

Rotary Furnace:

Daily hard lead production rate: 10 metric ton /day
Cycle time: 2 hours

Alloy pot:

Process time: 16-30 hours
Total worker Number: 40 / shift

b) Job Floor 2- Plate Preparation Plant

Grid Casting:

Machine no: 9
Capacity: 10000 pcs/ shift
Aging time: 72 hours

Oxide mixing:

Machine no: 2
Capacity: 14.5 metric ton/day
Aging time: 48 hours

Pasting:

Machine no: 2
Capacity: 75000 pcs /shift (machine-2) and 55000 pcs /shift (machine-1)

Curing chamber:

Machine no: 8
Capacity: 48000 pcs /machine

Formation:

Machine no: 11
Capacity: 12000 pcs / day
Circuit no: 12
Drying:

For positive dry oven:

Machine no: 2
Capacity: 48000 pcs / machine
Processing time: 8-12 hours

For inert gas oven:

Machine no: 1
Capacity: 55000 pcs / day ; Processing time: 85 minutes

Part process under IGO:

Machine no: 4
Capacity: 15000 pcs / day
Processing time: 11 minutes
Total worker number for this section: 55 / shift

c) Job Floor 3- Plastic Molding Section

Machine no: 8 / shift
Amount of polypropylene: 1 ton / shift
Number of workers: 12 / shift

d) Job floor 4- Small Parts Casting Section

Machine no: 4
Number of workers: 6 / shift
Capacity: 1500 pair / shift (lead pot)
Amount of lead: 189 kilograms

e) Job floor 5- Assembly Section

Number of workstation: 1(for N50)
Number of workers: 33-36 / shift
Processing time: 4-5 minutes
TAKT time = Available time to production / required units of production

V. Future State Map Generation

As seen in the figure the current state VSM is displayed. From the figure it can be observed that hard lead produced in the Lead recycle plant is internally supplied to the Plate preparation plant, Small parts casting section and Plastic molding section. Daily production of different batteries from these three sections is supplied to the Assembly line section. We have calculated total value added time from collecting cycle times of each plant. The total value added time for N50 standard dry cell automotive battery is 303.424 seconds. The calculation of daily production of N50 battery is given below:

The daily production hour = 2 shifts = 16*60*60= 57600 seconds
Cycle time for producing one N50 battery = 303.424 seconds
The daily production rate = 190 pcs / day; Shift time = 8 hours
Monthly production rate = 190 * 30 = 5700 batteries

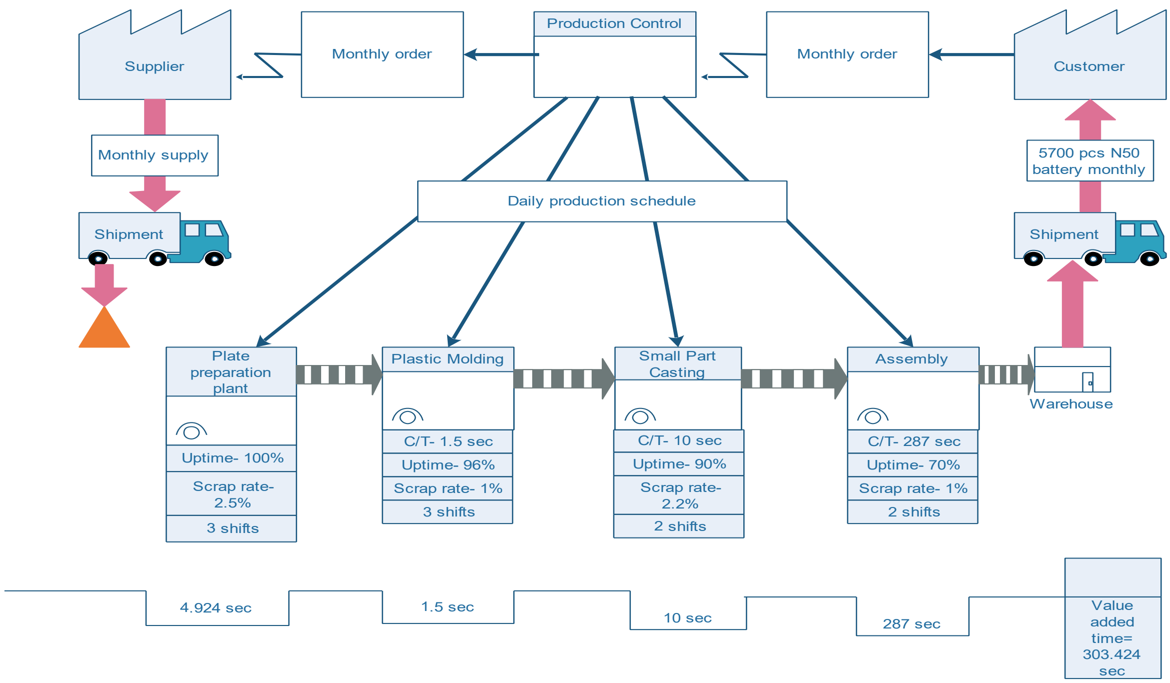

Figure 5.1: Current state map of RBL production system for N50 battery

Future state map gives us the view how a manufacturing plant can operate in improved design comparing to the current situation. Improved stage of information flow, material flow and time flow are displayed in the future state map. Various lean tools to reduce waste throughout the manufacturing plant have been displayed. Raw materials are supplied from local suppliers or imported from abroad. Lead recycles plant supplies lead to the plate preparation, plastic molding and small parts chamber in the assembly section. Plate preparation plant and plastic molding sends plates and plates and boxes to the assembly section.

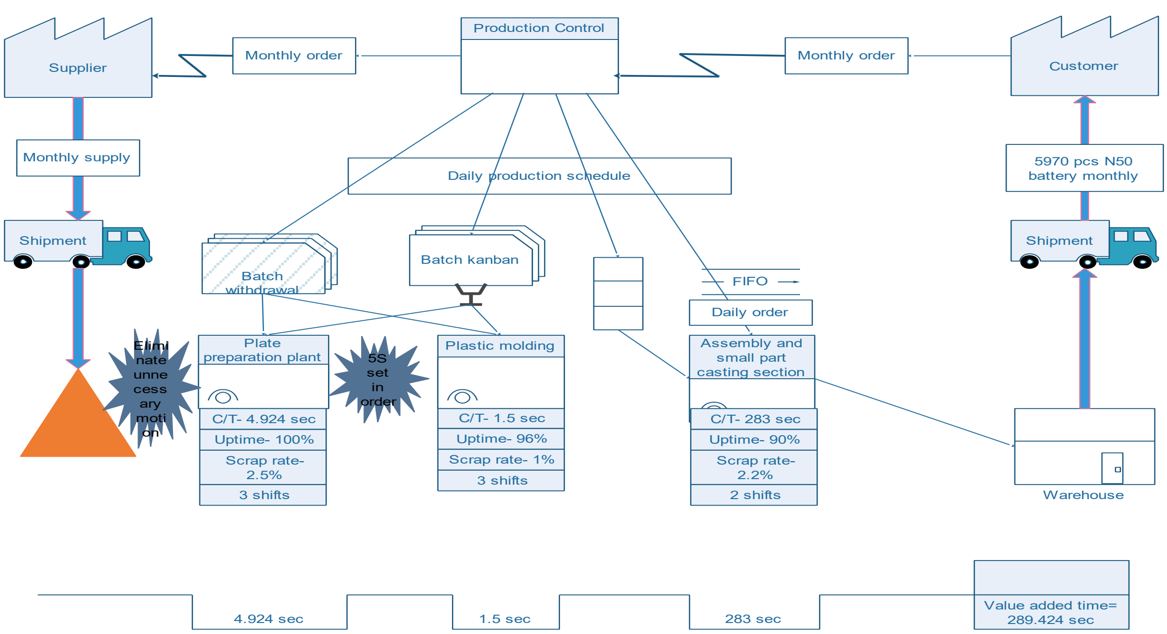

Figure 5.2: Future State Map of RBL to Manufacture N50 Battery

In Future State Map we suggested- Kanban, Kaizen, 5S From the future state map, we can calculate the daily production rate of N50 standard automotive dry cell batteries. Cycle time of each process can be recorded. The calculation is given below:

Total process time = 4.924 + 1.5 + 283 = 289.424 seconds Total production time = 16 * 60 * 60 = 57600 seconds (two shifts)

Per shift = 8 hours

Daily production of N50 automotive batteries = 199 pcs / day

Monthly production of N50 automotive batteries = 199 * 30 = 5970 batteries

We have applied lean manufacturing concept “kaizen” on plate preparation plant and “5S” on plastic molding section. The use of “5S” can ensure improved service and safety and efficiency. 5s is a part of kaizen. Sorting and set in order can ensure better discipline in the use of the equipment. Kanban system can also be used for better information flow. Kanban is Japanese for “visual signal” or “card. Batch production kanban and withdrawal kanban are two types of kanban system. The main function of a withdrawal Kanban is to pass the authorization for the movement of parts from one stage to another. The primary function of the production Kan-ban is to release an order to the preceding stage to another. The primary Function of the Production Kan-ban is to release an order to the precending stage to build the lot size indicated on the card. The production Kan-ban card should have the following Information materials required as inputs at the preceding stage parts required as inputs at the preceding stage information stated on withdrawals Kan-ban. Various lean tools to reduce waste throughout the manufacturing plant have been displayed in future state map. Withdrawal kanban and batch production kanban cards are displayed in the map. Production control section controls better information flow and control information using these kanban cards. Production control then suggests assembly section to apply “FIFO’ or first in, first out methods. Kaizen burst icon signals elimination of unnecessary motion in plate preparation plant and application of “5S” in plastic molding section. We reduce 4 minutes in assembly and small part casting section from 287 to 283 seconds by using FIFO method and safety stock. We have reduced almost 10 second in small part casting and plastic molding section by using 5s and withdrawal Kanban and batch Kanban. We also use withdrawal and batch Kanban in plate preparation plant.

VI. Result Analysis

Waste findings are Motion, Ergonomic factors, Transportation & Waiting By applying the improvements, lead time will be reduced. The improvements are shown in the Improvement Chart below-

Table 1: Improvement Chart of N50 Battery

Parameters	N50 Battery
Current Process time	303.424 seconds
Improved Process time	289.424 seconds (4.61%)
Current Daily production	190 pcs / day
Improved Daily production	199 pcs / day
Current Monthly production	5700 pcs
Improved Monthly production	5970 pcs (4.52%)

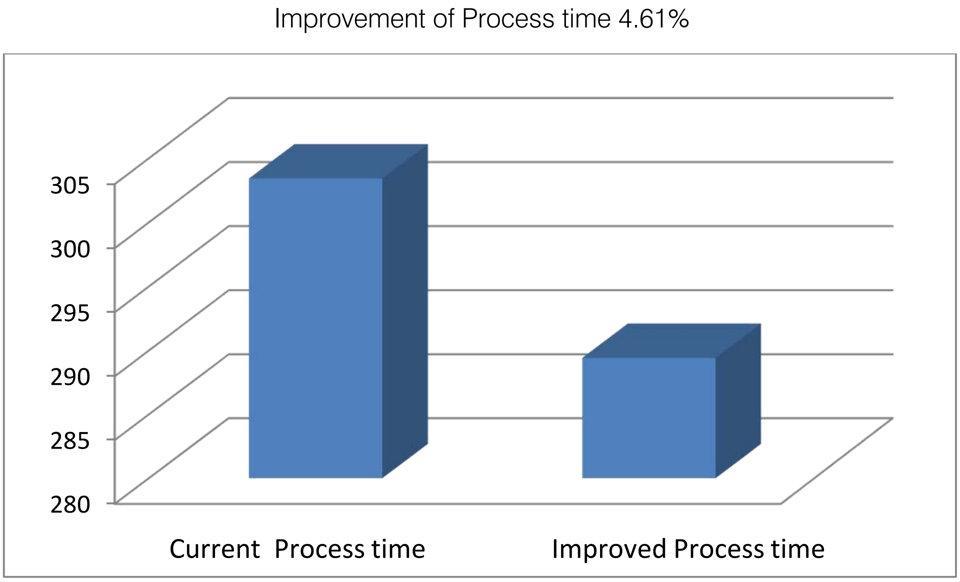

Figure 6.1: Improvement of Process Time for N50 Battery

This graph contains two bars representing the current Process time and future Process time comparison. The current Process time is 303.424 seconds and the improved Process time reduced to 289.424 seconds. The future state map will improve the Process time by 4.61%.

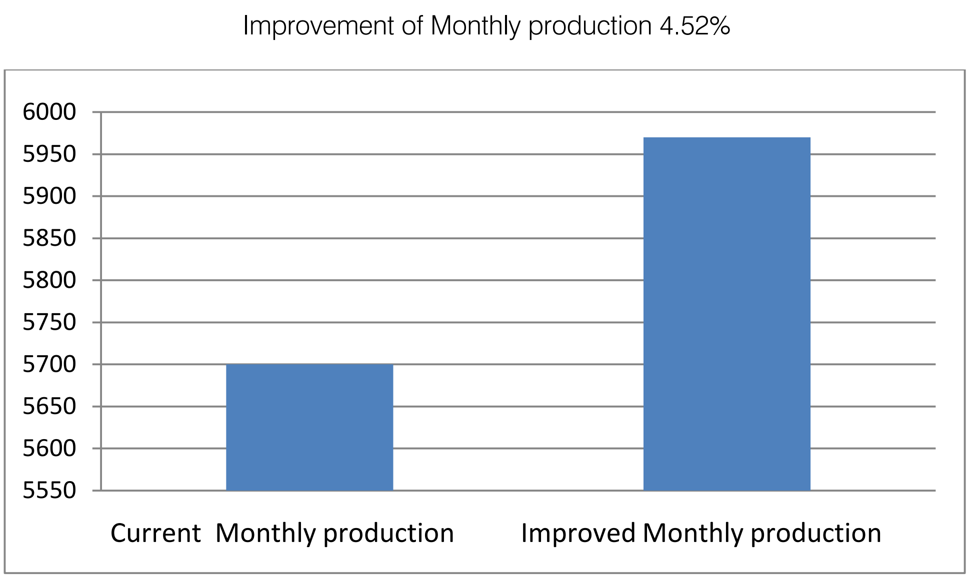

Figure 6.2: Improvement of Monthly production for N50 Battery

This graph contains two bars representing the current Monthly production and future Monthly production comparison. The current Monthly production is 5700 pcs and the improved Monthly production increased to 5970 pcs. The future state map will improve the Monthly production by 4.52%.

VII. Conclusions

The main focus of this research is to reduce the overall lead time and wastes of Rahimafrooz batteries limited (RBL). This paper has suggested a different layout of the assembly section of that particular industry. Value stream map is used in the current situation. Applying lean tools such as kaizen, kanban and 5S turn out to be helpful for better material and information flow throughout the production system. Small parts casting and assembly process joining in two workstations parallel can reduce overall value added time. Thus, daily producing more products and fulfilling customer order in satisfactory manner. Rahimafrooz can reduce their unnecessary non value added activities and ultimately reduce the overall lead time of the process by overall improved layout.Value stream mapping has been indicated as one of the best tool for lean production implementation in a facility. A battery manufacturing plant (RBL) is a complex process. Different types of batteries such as N70, N150, NS40, PCM 15, N100, and N120 all are assembled in the same workstation. For this thesis work, N50 dry cell automotive battery has been selected. Lead recycle plant, plate preparation plant, plastic molding section are all complex manufacturing plants. Value stream map has proven to be effective to analyze RBL's current production state and thus recommendations are suggested.

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A Review of applications and Developments of Biomechanics in Sports

By Koustav Kanjilal & Sudipto Shekhor Mondol
Heritage Institute of Technology

Abstract- Sports biomechanics is an analysis of sports' activities and professional athletes in general. It can plainly be called the Physics of Sports. In this sub division of biomechanics, the principles of mechanics are incorporated to gain a better insight of athletic performance via computer simulation, mathematical modelling and measurement. This paper briefly describes about the various methods in which biomechanics has enabled the athletes to perform better while being safe.

Keywords: biomechanics, sports mechanics, clap skates, long jump, prosthetics.

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AREVIEWOFAPPLICATIONSANDDEVELOPMENTSOFBIOMECHANICSINSPORTS

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A Review of applications and Developments of Biomechanics in Sports

Koustav Kanjilal [α] & Sudipto Shekhor Mondol [σ]

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Keywords: biomechanics, sports mechanics, clap skates, long jump, prosthetics.

I. Introduction

Biomechanics can be defined as the study of the structure and function of biological entities by application of biological principles coupled with the principles of mechanics. Basically it serves to unify two vastly different disciplines – biology and mechanics. It also utilizes the concepts of physics, aerodynamics and material sciences among other subjects. In biomechanics, the human body is analogously treated as a mechanical system i.e. the concept of links, degrees of freedoms, equilibrium of forces, etc. can be applied to a living body as it can be applied to any inanimate object. For example, the human body has 244 degrees of freedom. There are 230 joints in the body, most of which have 1 degree of freedom (exception – hips and shoulders that have 3 degrees of freedom), so in totality, there are 244 degrees of freedom controlled by 630 muscles. These concepts are very pivotal in the making of prosthetics, orthotics and building humanoids.

II. Major Subdivisions

a) Soft Body Mechanics

Soft Body Mechanics deals with the motion and properties of deformable objects.

b) Kinesiology

It is the combination of kinetics and physiology. It governs the physiological, mechanical and psychological mechanisms of living bodies. Application areas include strength and conditioning of athletes and refinement of sport exercises.

c) Allometry

This subject deals with the relationship of body size to shape or in scientific terms it deals with the statistical shape analysis. Study of insect species is conducted by utilizing its principles.

d) Orthotics and Prosthetics

Orthotics are externally applied systems that support a deformity or deficiency of a subject. They are used to restrict movement in a particular direction or assist movement in a particular direction. Prosthetics are artificial limbs that help a subject to perform normal human functions which would otherwise not have been possible due to its absence.

e) Ergonomics

It deals with the reduction of injuries in the workplace, thereby creating an environment of maximum comfort and ease which in turn optimizes their workplace efficiency. For example, the ideal distance between a person's sight and the computer screen on which they work should be 26 inches. There should provisions on the chairs so that the person can rest their arms, the computer screen should me moveable so as not to strain the person's neck.

III. Applications in Sports

a) Improvement of movement techniques involved in athletic performances

The fundamental aspect of any sport is movement and through effective gait analysis optimization of musculoskeletal functions is highly possible. It not only improves the performances of the athletes but also helps in their career longevity and reduction of injuries. In this case, I have proceeded to show how the high jump technique has evolved over the years leading to a gradual increase in the world record heights.

Author α σ: Department of Mechanical Engineering, Heritage Institute of Technology. e-mails: Koustav942@gmail.com, sudiptoshekhor.mondol.me17@heritageit.edu.in

Figure 1: Scissors Technique

(Courtesy of The 1908 London Olympics Gallery By Stan Greenberg)

Figure 2: Eastern Cut-Off

(Courtesy of German Federal Archive)

Figure 3: Straddle Technique

(http://m.eb.com/assembly/87963)

Figure 4: Fosbury Flop

(http://thinklink.in/richard-douglas-fosbury)

In the above four figures the gradual evolution of the high jump technique is shown. Figure 1 denotes the earliest technique, known as the scissors technique. The main advantage of the scissors technique was that parts of both legs are well below the level of the bar at the peak of the jump. This increases the height of the pelvis and consequently the height of the bar that can be cleared. The world record was set at 1.97 m. Figure 2 shows the next technique that came about, known as the eastern cut-off. In this technique the body is in the horizontal position at the peak and thus the pelvis is lifted higher than in the scissors technique. But the main disadvantage of this technique is that it requires tremendous flexibility. The world record was set at a rather modest 2.01 m. Figure 3 shows the straddle technique in which the athlete cleared the bar face down. Parts of leg and pelvis is higher and effective bar clearance is more. The athlete cleared the bar by virtue of the angular momentum generated due to movement of hip and lower back. The world record increased from 2.01 m to 2.13 m and finally to 2.28m. The technique's main drawback was that it depended very much on the strength of the athlete and caused a burnout. Figure 4 shows the current technique that has completely dominated the sport since its inception. The Fosbury Flop has now emerged as the most successful of the 4 techniques. The athlete arches back in this case, thus the bending lifts the belly higher than all the previous techniques. For this reason the present world record has shot up to 2.45m.

Explanation: The sport of high jump is based on two simple principles:

a) To lift the C.M. of the human body as high as possible.

b) To keep the C.G.of the human body as low as possible.

In Figs. 1, 2, 3 and 3 the C.M. of the athlete is over the bar. The height of C.M. in descending order in the four figures are as follows–Figure 4 >Figure3 >Figure2 >Figure 1. Due to arching backwards in case of Fosbury Flop the pelvis is lifted higher than all the 3 other techniques. The effectiveness if the Fosbury Flop technique in lifting the pelvis over the bar causes the effective bar clearance to increase. In case of C.G., in Figures 1, 2 and 3 the C.G.s of the athletes are over the bar but in Figure 4 the C.G. is well below the bar because of the 140 degree arched configuration of the body. If the C.G. is lower the energy required to generate the jump will also be lower leading to performance of successive jumps effectively.

The effect of C.G. can be seen from the equation,

$$1/2\ mv2 = mgh$$

1/2 mv2 is the kinetic energy generated before take-off. mgh = the potential energy of the athlete at the peak position where velocity is zero;

i.e. at the peak height kinetic energy is converted into potential energy. Here, h is the height of the C.G. of the athlete. So evidently, lower value of h will require a lower value of kinetic energy.

b) Improvement of interface between the athlete and environment

With the application of biomechanics the interface between the athlete and his environment can be made significantly congenial for him. The improvement of ice skates used for ice skating is testament of this fact.

Figure 5: Clap Skates

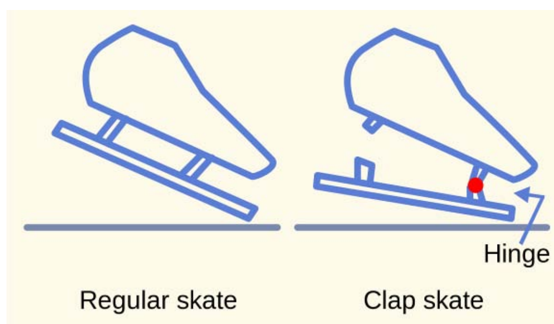

Figure 6: Regular Skate vs Clap Skate

(Drawn by Branko, vectorized by Mysid)

Figure 6 shows the regular skates that were prevalent in the ice skating circuit before clap skates (Figure 5) were introduced in 1998. Clap skates proved highly beneficial and completely dominated the ice skating circuit since.

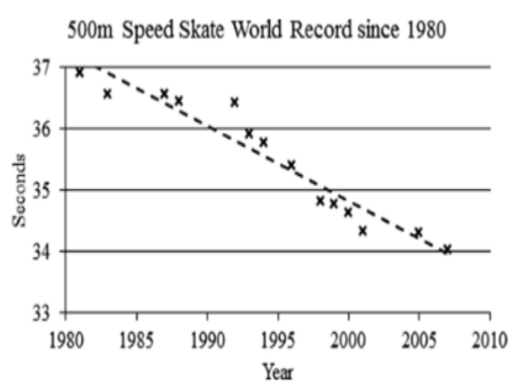

Figure 7

(http://researchgate.net/)

The graph above shows the influence of clap skates since its introduction in 1998. The dotted line represents an average or mean graph of the time vs year. After 1998, the cluster of 'x' marks are well below

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the dotted line, indicating that as the years have progressed the time required in 500m speed skating has decreased considerably, which proves the effectiveness of the clap skates.

Explanation: The regular skates used to amplify plantar flexion of the feet by which the toe would strike the ground in an inclined position while the heel remained raised. Ankle flexion causes forces of the order of 1000 KPa to act on the ground thereby causing the skates to dig into the ground and cause accidents or loss of time/momentum. The regular skates being hinged at both ends the leg would come off the ice long before the back leg was fully extended, thereby maximum utilization of the elastic potential energy generated at the knee was not possible. It also caused muscular fatigue. The clap skates being unhinged allows longer strides and greater ground clearance because the back leg can come off the ice yet the skates can remain fully in contact with the ice. The spring provided at the front suppresses plantar flexion of the foot by recoiling it, thereby the forces generated due to plantar flexion are minimized.

Figure 8: Hinge of a clap skate
(Picture taken by Cassi Saari)

The edges of the blades are also rounded off so to decrease stress concentration and effectively manoeuvre around tight corners. It has been found that 5% more power is utilized by clap skates than the regular skates.

c) *Development of sport specific equipments*

Various sports are played on grass turfs (or plastic pitches) like football, rugby union, rugby league, etc. Yet in spite of the similarities of conditions the demands and dynamics of the sports vary from one to the other. Here comes the need for development of sport specific equipments.

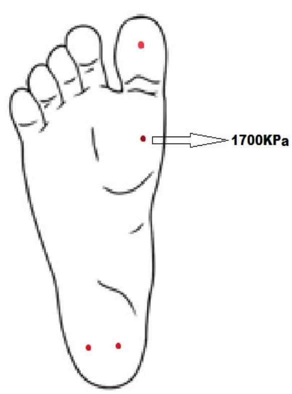

Figure 9: Stress Concentration on a footballer's foot

The above figure shows the stresses that are developed on the foot of a professional footballer. Highest stresses are recorded in the ball of the foot as shown (1700 KPa). These soaring stresses are tremendously detrimental for the health and career longevity of the footballer. Therefore in case of football boots polyfoam urethane is provided in that section to minimize the build-up of such high stresses. But at the same time one may argue that for a game like rugby union which involves a lot of running like football, normal football boots would suffice for the rugby players. But in reality it is not so.

Figure 10: Direction of force on a rugby player's foot
(https://www.flickr.com/photos/phillygryphons/771273148/sizes/l/)

In the above figure if this particular position in rugby union is concerned where the arrows indicate the maximum stresses being developed at the ankle of the player. So rugby players have a cushioning and ankle protection provided in their boots and not on the ball of the toe.

d) Development of prosthetics

The area of prosthetic development has improved manifold by the application of biomechanical principles. People who are differentially abled can now rub shoulders with the best able-bodied athletes because of the advancements and availability of a wide variety of prosthetics.

Figure 11: Pistorius' running blades
(Shaun Botterill, Getty Images)

Figure 11 above shows the running blades by Oscar Pistorius. They are known as Flex Foot Cheetahs and are now developed by an Icelandic Company called Ossur. These blades act as a spring and a shock absorber. As the unit is compressed on impact, the energy is stored and the stress is absorbed within it, which eventually propels the athlete forward. They are made of layers of carbon-fibre – mainly 30-90 layers depending upon the athlete's weight and the impact levels to which he will subject them to. The apex of the J-curve is fitted with more layers of carbon-fibre to resist high stress and those in need of greater flexibility are fitted with less. Vertical forces generated at the heel contact are stored and translated into linear motion. It benefits more natural gait and reduced walking effort. Deflection of carbon-fibre heel and forefoot components are proportional to the user's weight and impact levels. It optimizes walking efficiency.

However, the Cheetah returns only 80% of the energy stored during compression which is a far cry from the 249% a normal able bodied runner's foot and ankle system delivers. Oscar Pistorius has to generate twice the amount of power from his hips and gluteal muscles than a normal sprinter.

IV. Developments

There has been a lot of activity in the field of biomechanics particularly in the last 20-30 years. A brief illustration of some of them have been described below:

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a) Improvement of scrimmaging

The International Rugby Board have funded a research programme for the improvement of scrummaging in the sport. The research is being conducted at the University of Bath, England where researchers are trying to minimize the forces on the necks and spinal cords of players in the game. Peak engagement forces have been recorded at 16.5 kN (men's elite international level) to 8.7 kN (women's elite international level). The new research has refined the technique of scrummaging whereby they have decreased the forces by 25% in elite level competitions. Yet, this has not been declared as the finished product and continuous research is still going on.

b) Swimgear improvement

SPEEDO's Aqualab in Nottingham, England has developed a new set of swimsuit and swimgear. The latest swimsuits compresses the swimmer's body into a streamline tube, traps air to add buoyancy. It has vertically stitched or ultrasonically welded seams to reduce drag.

c) Artificial Muscles

University of Texas is in the process of making artificial muscles from carbon nanomaterials. These artificial muscles can contract about 30000% per second while an ordinary muscle contracts about 20-40% per second.

d) Reactive padding

University of Delaware are developing a new kind of reactive padding that seeks to significantly reduce the impact stresses and harmful injuries like concussion. In the initial stages of research Kevlar was used because of its lightness and durability.

Besides these there have been many more developments like the developments of various softwares like SIMM, Quintic Biomechanics V26, etc.

V. Conclusion

The future of Biomechanics looks even brighter than it was a couple of decades back. The 18th World Congress on Biomechanics is to be held at Dublin in 2018. The University of Omaha in Nebraska has developed a $6 million stand-alone facility specifically for Biomechanical research which is also the first of its kind research facility in the world. These examples and many more bear witness to the fact that this subject will only flourish in the future. This in turn will cause tremendous advancements in the field of sports biomechanics, development of sports equipment and injury management and might someday lead to the development of the perfect athlete.

VI. Acknowledgment

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NOMENCLATURE

C.G.	Centre of Gravity
C.M.	Centre of Mass
m	Mass
v	Velocity
g	Acceleration due to gravity
h	Height
KPa	Kilo pascal
KN	Kilo Newton
SIMM	Software for Interactive Musculoskeletal Modeling

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Experimental Study of MRR, TWR, SR on AISI D2 Steel using Aluminium Electrode on EDM

By Sidhant Gupta, Dr. S.K. Jain & Gurpinder Singh

Ambala College of Engineering and Applied Research

Abstract- This paper depicts the experimental study of the input parameters of EDM i.e. current, pulse on time and pulse off time on output parameters material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR). The workpiece materials selected was AISI D2. The aluminium used as tool electrode and EDM oil as dielectric fluid. Taguchi, method was used to perform experiments, L9 orthogonal array was applied using MINITAB software. Signal to Noise (S/N) ratio and ANOVA were employed for parameter optimization and to achieve max MRR, min SR and TWR. The results indicate that the most prompting factor for MRR is Pulse off time. For TWR, the most influencing factor is current. For SR, the most prompting factor is pulse on time. Optimization is done by using Taguchi method on MINITAB 17 software.

Keywords: electric discharge machine, aluminium electrode, ss316, aisi d2 steel, minitab.

GJRE-A Classification: FOR Code: 290501

EXPERIMENTALSTUDYOFMRRTWRSRONAISID2STEELUSINGALUMINIUMELECTRODEONEDM

Strictly as per the compliance and regulations of:

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Sidhant Gupta [α], Dr. S.K. Jain [σ] & Gurpinder Singh [ρ]

Abstract- This paper depicts the experimental study of the input parameters of EDM i.e. current, pulse on time and pulse off time on output parameters material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR). The workpiece materials selected was AISI D2. The aluminium used as tool electrode and EDM oil as dielectric fluid. Taguchi, method was used to perform experiments, L_9 orthogonal array was applied using MINITAB software. Signal to Noise (S/N) ratio and ANOVA were employed for parameter optimization and to achieve max MRR, min SR and TWR. The results indicate that the most prompting factor for MRR is Pulse off time. For TWR, the most influencing factor is current. For SR, the most prompting factor is pulse on time. Optimization is done by using Taguchi method on MINITAB 17 software.

Keywords: electric discharge machine, aluminium electrode, ss316, aisi d2 steel, minitab.

I. Introduction

Electric Discharge Machine (EDM) is a non-traditional machining process. It has number of applications in die making, punches and molds industry. It also finds application in manufacturing of finished parts in automobile, also in manufacturing of surgical components. In EDM, electric spark is produced between workpiece and electrode and due to this spark material gets eroded from workpiece and tool electrode [1]. So this process can be successfully employed to materials which are electrically conductive. Hardness, shape, toughness and brittleness don't cause any restrictions [2]. In die sinking EDM, the shape which is to be produced on workpiece, the tool should be replica of that shape. Both tool electrode and workpiece are dipped in a dielectric fluid like EDM oil, Kerosene etc. The workpiece and electrode are placed at a very close distance and it depends on operating conditions and called as spark gap [3]. Modern era of EDM, i.e. from 1995 to till date. Many new aspects has been developed, namely micro-machining by EDM and dry EDM i.e. EDM without dielectric fluid. Now a days EDM is most acceptable technique for MRR [3]. For micro machining, ultrasonic vibration method is apt, dry machining is economical and water EDM is safe and conductive working environment, Powder mixed EDM is concerned more on improving surface quality [4]. The viability of machining Tungsten carbide ceramics by EDM with a graphite electrode using Taguchi method is studied and concluded that the current mainly effects the EWR and SR. The pulse duration is the most influencing factor for MRR [5]. For machining of tungsten carbide, graphite electrode gives the maximum MRR with comparison to copper and copper tungsten electrode [6]. The study of MRR by copper and graphite electrodes of different diameter is performed on XW42 tool steel. Copper is apt for roughing process, while graphite electrode is apt for finishing [7]. Copper, copper alloys and graphite has a problem of low wear resistance. A new composite ZrB2-Cu is developed to get an ideal combination of wear resistance, electrical and thermal conductivity. This composite demonstrates more MRR with less TWR than copper tool [8]. When manufacturing deep slots in low machinability materials, EDM may be the only method [9]. Investigation is done on SS 316L using compressed air as dielectric and copper electrode as tool [10]. MRR is primarily influenced by peak current and EWR is primarily influenced by peak current trailed by pulse on time [11]. For MRR, using copper as electrode input current & duty cycle is more dominant. Pulse on time and duty cycle for EWR, duty cycle and pressure for surface roughness [12]. EDM parameters using grey relational analysis on AISI SS (202), parameters mainly discharge current, and pulse off time and pulse on time [13].The effect of abrasive mixed dielectric on AISI D3steel is studied. At 6 g/ltr of concentration MRR is maximum. EDM (Abrasive mixed) outcomes in 58% more MRR as compared to traditional EDM [14]. Experiments were performed to determine factors effecting SR using brass, copper and aluminium as electrodes on Mild steel [15]. Aluminium yielded highest MRR followed by copper.

For present work, studies are conducted on AISI D2 steel using aluminium electrode to determine the MRR, TWR and SR and optimum values are predicted using MINITAB 17.

II. Workpiece and Electrode Material

AISI D2 steel is used mainly in die and mould making industry. Now a days dies are of very complicated shape so to achieve that kind of shape, non-conventional machining methods are employed because it cannot be achieved by conventional methods.

Author α: Mechanical Engineering, Ambala College of Engineering and Applied Research, Haryana,India. e-mail: siddhantguptag2@gmail.com
Author σ: HOD Mechanical, Dean of Academics, Ambala College of Engineering and Applied Research, Haryana, India.
e-mail: sk.jain117@yahoo.com
Author ρ: Asst. Prof., Mechanical Engineering, Ambala College of Engineering and Applied Research, Haryana, India.
e-mail: gurpindersinghsarwara@gmail.com

Table 1: Chemical composition of AISI D2 steel

Composition of AISI D2								
C	Mn	Si	C_r	Ni	Mo	P	S	Fe
2.11%	0.3531%	0.48%	12.88%	0.1547%	0.4312%	0.0181%	0.0127%	Balance

Aluminium is silvery white, soft, non-magnetic, ductile material. Aluminium and its alloys are vital to aerospace industry. Aluminium is capable of super conductivity. Aluminium find its application in electrical transmission lines for the purpose of power transmission. Melting point of aluminium is 933.47 K and density 2.70 g/cm3, electrical conductivity 3.50×107 S/m.

Figure 1: Machined AISI D2 workpiece and aluminium electrode

III. Evaluation of Parameters

a) *Evaluation of MRR*

MRR is articulated as the ratio of the difference of weight of the work piece before and after machining to the machining time. MRR is measured in mg/min.

MRR= (Mi-Mf)/t

Whereas,

Mi = Weight of work-piece before machining i.e. initial weight

Mf = Weight of work piece after machining i.e. final weight

b) *Evaluation of TWR*

TWR is articulated as the ratio of the difference of weight of the electrode before and after Machining to the machining time.

EWR =Ei-Ef /t

Whereas,

Ei = Weight of electrode before machining.

Ef = Weight of electrode after machining.

c) *Signal to noise (S/N) ratio*

The main objective of the study is to examine the effect of aluminium as electrode on AISI D2 steel. Signal to Noise (S/N) ratio is selected as larger is better for MRR, smaller the better for SR and TWR.

S/N ratios are defined as:

Larger is better = -10 log (MSDHB)

Where MSDHB=$1/r\sum_{i}^{r} = (\frac{1}{y_i^2})$

r = the number of tests in a trial

y_i = observed value of response characteristics

For material removal rate (MRR) the S/N ratio is larger is better.

Where,

MSDHB = Mean Square deviation for higher the better response.

Smaller is better = -10 log (MSDLB)

Where,

MSDLB=$1/r\sum_{i=1}^{r} = (y_i^2)$,

r = the number of tests in a trial

yi = observed value of response characteristics

For Tool wear rate (TWR) the S/N ratio is smaller is better.

Where

MSDLB = Mean Square deviation for smaller the better response.

d) *Design of Experiments*

Experiments In present study, Taguchi method was used to design the experiments. For optimization of system, Taguchi Technique reduces the trial of experiments to get only the necessary trial of experiments so there will be no repeated trials and it's done using DOE. Three parameters viz., pulse on, current and pulse off were chosen as control parameters and apiece parameter has three levels shown in table 2. L_9 orthogonal array was used to design the experiments shown in table 3. To obtain accurate results, each experiment was performed three times and there mean value is taken for optimization.

Table 2: Parameter Selected and their levels

S. No.	Input Parameters	Level		
		1	2	3
1	Current (A)	6	8	10
2	Pulse On (Ton)	50	100	150
3	Pulse Off (Toff)	6	8	10

Table 3 showing the values of material removal rate, tool wear and Surface roughness. MRR and TWR are measured in grams. SR is measured in microns using surface roughness tester. Experiments were executed three times to get the accurate results.

Table 3: Observation Table

Serial No	Current Ip, A	Pulse on Ton, µs	Pulse off Toff, µs	Material removed			Tool Wear (grams)			Surface roughness		
				MRR1	MRR2	MRR3	TWR1	TWR2	TWR3	SR1	SR2	SR3
1	6	50	6	0.1195	0.1232	0.1211	0.0268	0.0234	0.0274	4.534	4.243	4.432
2	6	100	8	0.3411	0.3144	0.3356	0.0411	0.0489	0.0477	5.133	5.698	5.443
3	6	150	10	0.72	0.7329	0.7469	0.03	0.0392	0.0342	6.149	5.745	6.253
4	8	50	8	0.36	0.3713	0.3675	0.0769	0.0648	0.0698	4.378	4.135	4.051
5	8	100	10	1.0166	1.0087	1.021	0.06	0.0567	0.0622	7.297	7.546	7.069
6	8	150	6	0.2031	0.1967	0.2104	0.0269	0.0212	0.0287	6.488	6.143	6.376
7	10	50	10	0.7	0.6934	0.7062	0.133	0.1411	0.1369	6.045	6.316	6.431
8	10	100	6	0.5166	0.5251	0.5286	0.05	0.0478	0.0493	6.618	6.754	6.552
9	10	150	8	0.57	0.5772	0.5658	0.05	0.0478	0.0493	7.661	7.211	7.521

Table 4 shows the values of SN ratio and means values. SN ratio is calculated using formula given in section 3.3.

Table 4: Observation table

S.no	MRR		TWR		SR	
	SNRA1	MEAN1	SNRA1	MEAN1	SNRA1	MEAN1
1	-18.3271998	0.12126667	31.72510106	0.02586667	-11.0588253	3.572
2	-9.63634552	0.33036667	26.73957182	0.0459	-14.7229144	5.4463333
3	-2.69768287	0.73326667	29.20061811	0.03446667	-15.3648633	5.864
4	-8.72620694	0.36626667	23.01473492	0.0705	-11.6965016	3.8433333
5	0.13270037	1.01543333	24.48398351	0.05963333	-14.4654947	5.2876667
6	-13.8428249	0.2034	31.76799737	0.0256	-16.3816835	6.592
7	-3.10042071	0.69986667	17.263058	0.137	-13.8691362	4.9363333
8	-5.62398705	0.52343333	26.18865056	0.04903333	-16.5331788	6.7086667
9	-4.86816042	0.571	26.18865056	0.04903333	-16.5012866	6.6843333

Table 5 shows the response table values for current, pulse on and pulse off for material removal rate. Table 6 shows the values for Surface roughness and Table 7shows the corresponding values for tool wear rate.

Table 5: Response table for MRR

Response Table for MRR						
	Response table for S/N ratio			Response table for Means		
Level	Current	Pulse On	Pulse off	Current	Pulse on	Pulse off
1	-10.22	-10.051	-12.598	0.39	0.3958	0.2827
2	-7.479	-5.043	-7.744	0.5284	0.6231	0.4225
3	-4.531	-7.136	-1.888	0.5981	0.5026	0.8162
Delta	5.69	5.009	10710	0.2031	0.2273	0.5335
Rank	2	3	1	3	2	1

Table 6: Response table for SR

Response Table for SR						
	Response table for S/N ratio			Response table for Means		
Level	Current	Pulse On	Pulse off	Current	Pulse on	Pulse off
1	-13.72	-12.21	-14.66	4.961	4.117	5.624
2	-14.18	-15.24	-14.31	5.241	5.814	5.325
3	-15.63	-16.08	-14.57	6.11	6.38	5.363
Delta	1.92	3.87	0.35	1.149	2.263	0.3
Rank	2	1	3	2	1	3

Table 7: Response table for TWR

Response Table for TWR						
	Response table for S/N Ratio			Response table for Means		
Level	**Current**	**Pulse on**	**Pulse off**	**Current**	**Pulse on**	**Pulse off**
1	29.22	24	29.89	0.03541	0.07779	0.0335
2	26.42	25.8	25.31	0.05191	0.05152	0.05514
3	23.21	29.05	23.65	0.07836	0.03637	0.07703
Delta	6.01	5.05	6.24	0.04294	0.04142	0.04353
Rank	2	3	1	2	3	1

IV. Results and Discussions

Figure 4, 5, 6 shows the main effects plots for S/N ratio and Mean of means For MRR, TWR and SR respectively. Optimization is established on selecting the values from plots depending upon S/N ratio requirement. From table 5, means graph is drawn and displayed in fig 4. For S/N ratio we always take maximum value irrespective of smaller the better or larger is better. For mean of means, we select maximum values for optimization if S/N is higher the better and we take minimum value if it is smalleris better.

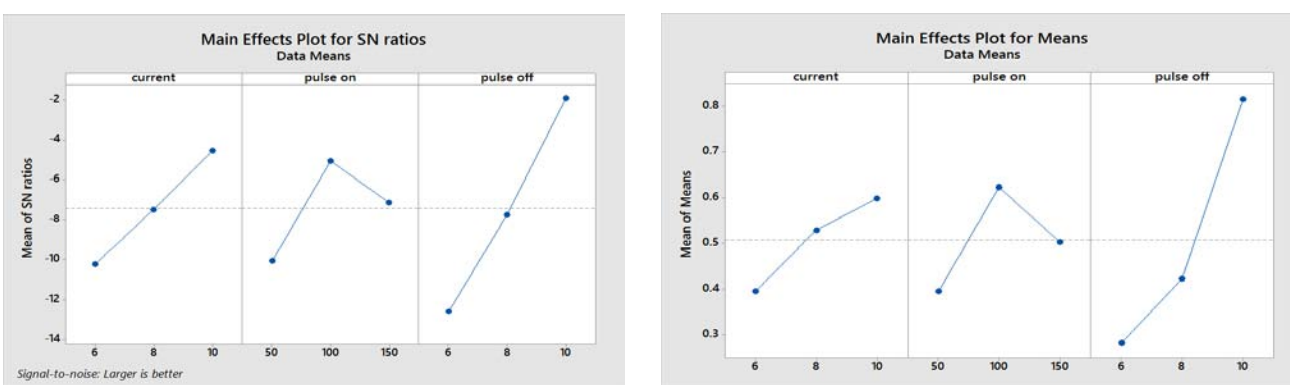

Figure 4: Mean effects plots for MRR

Graph displayed in figure 5 is made using table 7. For TWR, S/N ratio is smaller the better. So for SN ratio graph we take maximum values and for means we take minimum values for optimization.

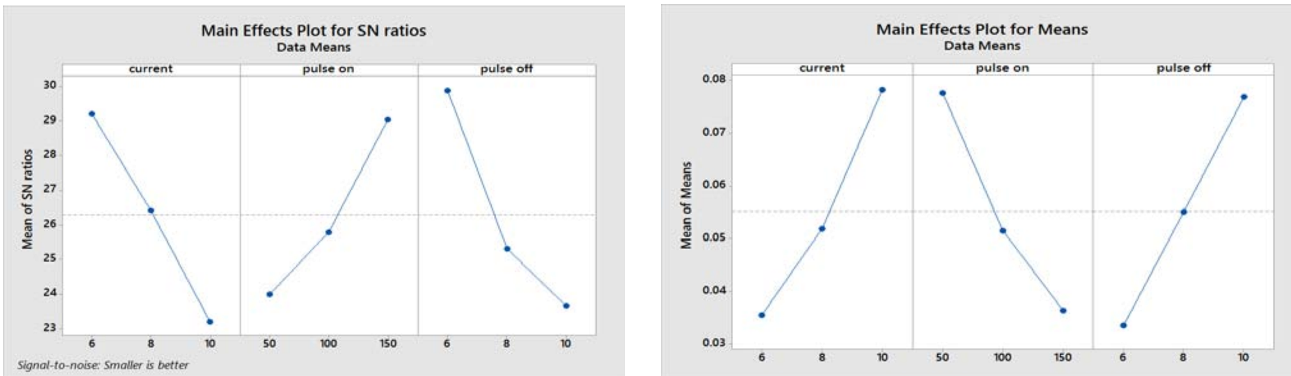

Figure 5: Mean effects plots for TWR

Graph displayed in figure 6 is made using table 6. For SR, S/N ratio is smaller the better. So for SN ratio graph we take maximum values and for means we take minimum values for optimization.

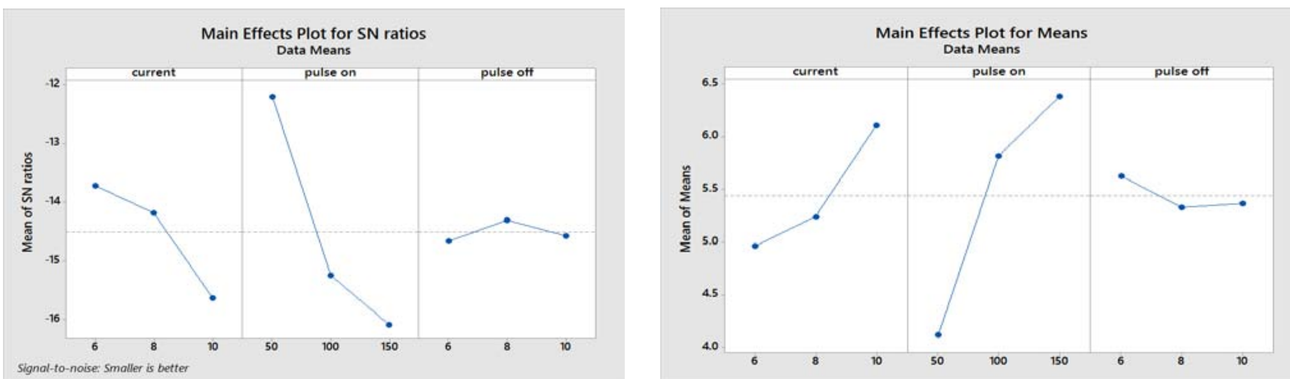

Figure 6: Mean effects plots for SR

V. Conclusion

The main motive of the present study was to experimentally inspect the effect of aluminium as electrode which is tool on MRR, TWR and SR on AISI D2 steel. Optimum conditions for the output parameters are.

1. The Optimum conditions for MRR is Current (10 A), Pulse on (100 μs), Pulse off (10 μs) for AISI D2 steel.
2. For TWR, the most prompting factor is pulse off time, followed by current and then pulse on time. The optimum condition for TWR is Current (6A), Pulse on (150 μs), Pulse off (6 μs) for AISI D2 steel.
3. For SR, pulse on time is the most prompting factor followed by current and pulse off time. The optimum condition for SR is current (6A), Pulse on (50 μs), Pulse off (8 μs) for AISI D2 steel.

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Design Optimization of Golf Clubhead and Ball with Numerical Analysis

By Zhiqiang Wu, Takayuki Tamaogi, Yuji Sogabe & Yutaka Arimitsu

Ehime University

Abstract- The design optimizations of a golf clubhead and a ball were performed with numerical experiments. The golf clubhead was designed for maximizing the flying distance of a golfball. The thickness distribution of the clubface, the shape of the clubhead and the mass distribution were set to be the design variables. Since the sensitivity function of this kind of problem is difficult to be derived, a non-sensitivity-based method called the basis vector method was used. The basis vectors were created by using eigenmodes obtained from modal analysis. Another numerical approach of Design of Experiment was used for the optimal design of a multi-piece golfball for maximizing the flying distance and improving the feeling at impact. In this optimization, the thickness and material properties of each layer were set as design variables. Numerical examples were provided to show the effectiveness of presented approach to the optimal design of golf clubhead and ball.

Keywords: *optimal design, fem analysis, design of experiment, golf club, golf ball .*

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DESIGNOPTIMIZATIONOFGOLFCLUBHEADANDBALLWITHNUMERICALANALYSIS

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Design Optimization of Golf Clubhead and Ball with Numerical Analysis

Zhiqiang Wu [α], Takayuki Tamaogi [σ], Yuji Sogabe [ρ] & Yutaka Arimitsu [Ѡ]

Abstract- The design optimizations of a golf clubhead and a ball were performed with numerical experiments. The golf clubhead was designed for maximizing the flying distance of a golfball. The thickness distribution of the clubface, the shape of the clubhead and the mass distribution were set to be the design variables. Since the sensitivity function of this kind of problem is difficult to be derived, a non-sensitivity-based method called the basis vector method was used. The basis vectors were created by using eigenmodes obtained from modal analysis. Another numerical approach of Design of Experiment was used for the optimal design of a multi-piece golfball for maximizing the flying distance and improving the feeling at impact. In this optimization, the thickness and material properties of each layer were set as design variables. Numerical examples were provided to show the effectiveness of presented approach to the optimal design of golf clubhead and ball.

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I. Introduction

The performance of a golf club is evaluated from various viewpoints, such as the flying distance of a golfball after impact, the size of sweet area, and the sidespin, etc. Especially, the distance is always attached importance by most players. The design of the golf club, which matches to the users with different skill, becomes increasingly important, and many researches have been reported in this area. Iwatsubo et al. [1] investigated optimum rigidity of the head to maximize the release velocity of the ball. In their study, the impact phenomenon is simulated as a model of spring-mass-damper system with a few degrees of freedom. They proposed the concept of impedance matching. In their later work [2], they tried to apply the concept of impedance matching to a three-dimensional model, and discussed the boundary condition for calculating the natural frequencies of clubhead and ball. Winfield and Tan [3] studied the optimization of clubhead loft and swing elevation angles for maximum distance. They also studied the optimum geometric shape of the clubface to minimize dispersion in off-center hits [4]. In their studies, the rigid models were used in the numerical analyses. There are also some studies of the effect of shaft deflection [5] and the mass distribution in the clubhead [6]. However, research on the detailed design of the clubhead, for instance, the thickness distribution of the head is scarce. To this problem, the authors proposed an approach to optimize the thickness distribution of a clubface so that the initial velocity of a golf ball gets to the maximum [7]. The authors also discussed the optimization of a golf club to reduce the side spin of a golf ball [8]. Our work was followed by Petersen and McPhee [9] who optimized the thickness distribution of a clubface to maximize the initial velocity of a golf ball with a procedure of three-stages design. Recently, some studies have been reported on the acoustics design of a golf club [10], [11]. In addition, Naruo and Mizota studied the aerodynamics of a golf ball experimentally [12], [13], and their work makes it be possible to numerically simulate the flying trajectory of the ball while designing a golf club by numerical approach.

In this study, firstly, the shape optimization of a clubhead for maximizing the distance of a flying ball with a constraint on volume of the clubhead is treated. The thickness distribution of the clubface, the shape of clubhead and the mass distribution are set to be the design variables. To overcome the difficulty that the sensitivity cannot be derived analytically in this problem, we choose the basis vector method for shape optimization. As same as our previous work, we also create the basis vectors by using the eigenmodes that can be obtained from modal analysis. Secondly, the optimization of a golfball for maximizing the flying distance and improving the feeling at impact is treated. The Design of Experiment is used to optimize thickness and material properties of each layer of a multi-piece ball. Finally, numerical examples are provided to show the effectiveness of presented approach to the optimal design of golf clubhead and ball.

II. Formulation of Optimization of Clubhead

In general, for a shape optimization problem, it is necessary to derive the design sensitivity that expresses the relation between the variation of an objective function and the variation of the design variables. However, it is difficult to be derived analytically in impact problem due to the use of explicit method for impact simulation. In this case, numerical techniques, such as the finite difference approach, the response

Author α ρ Ѡ: Department of Mechanical Engineering, Ehime University, Matsuyama, Japan. e-mails: wu.zhiqiang.mh@ehime-u.ac.jp sogabe.yuji.mc@ehime-u.ac.jp, arimitsu.yutaka.mb@ehime-u.ac.jp
Author σ: Niihama National College of Technology, Niihama, Japan. e-mail: tamaogi@mec.niihama-nct.ac.jp

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surface method and the basis vector method can be used. In this study, since the number of design variables, which are the thickness distribution of the golf club, is large, the use of finite difference approach and the response surface method are very costly. Another reason why we do not use the finite difference approach is that it has worse accuracy than the use of basis vector method because of the rounding error. Therefore, we chose the basis vector method to use for shape optimization.

a) Basis Vector Method

In the basis vector method for shape optimization, the change of the grid's locations $\Delta \boldsymbol{C}$, that is, the shape variation is calculated as a linear combination of perturbation vectors, each weighted with its respective design variable $\alpha_i\,(i=1,2,\cdots,N)$. The perturbation vector is the difference between a basis vector $\boldsymbol{C}_i\,(i=1,2,\cdots,N)$ and the original locations of grids $\boldsymbol{C}_0$. That is

$$\Delta \boldsymbol{C} = \alpha_1(\boldsymbol{C}_1-\boldsymbol{C}_0)+\alpha_2(\boldsymbol{C}_2-\boldsymbol{C}_0)+\cdots+\alpha_N(\boldsymbol{C}_N-\boldsymbol{C}_0) \tag{1}$$

Where *N* is the number of basis vectors, which is usually smaller than degrees of freedom of design in order to reduce the computation time. Using basis vector method, the original shape optimization problem is exchanged to the problem of finding the optimal solution of weight coefficient $\alpha_i\ (i=1,2,\cdots,N)$. In general, this approximate method cannot guarantee the objective to reach the optimum solution. The accuracy of the solution depends on the selection of the basis vectors.

b) Optimization Formulation

Consider a shape optimization for maximizing an objective function *f*, the flying distance of a ball, with a constraint on the volume *m* of the head, by using basis vector method. Since the impact problem is a nonlinear problem, we cannot obtain the optimal solution by one cycle of optimization analysis. Assuming that the shape variation is small enough in one cycle of optimization, we can get the approximate linear relations between α_i and the variation of *f*, *m* as following:

$$\Delta f = \sum_{i=1}^{N} \alpha_i \Delta f_i \tag{2}$$

$$\Delta m = \sum_{i=1}^{N} \alpha_i \Delta m_i \tag{3}$$

Where Δf_i denotes the change of objective function, and Δm_i denotes the change of head volume, while the original shape changes to the *i*th basis vector. The optimization problem can be stated as

$$\begin{aligned} &\text{find} && \alpha_i\ ,\ i=1,2,\cdots,N \\ &\text{maximize} && \Delta f \\ &\text{subjected to} && \Delta m = 0 \end{aligned} \tag{4}$$

This is a linear programming problem, which can be solved by LP algorithm. In this study, we exchange this problem to a stationary problem of a Lagrange functional expressed as

$$L = \sum_{i=1}^{N} \alpha_i \Delta f_i + \Lambda_1 \sum_{i=1}^{N} \alpha_i \Delta m_i + \Lambda_2 \left(\sum_{i=1}^{N} \alpha_i^2 - A_0 \right) \tag{5}$$

Where $A_0 > 0$ is used to control the length of one step, and to guarantee a unique solution. Λ_1 , Λ_2 are Lagrange multipliers. Taking the variation of *L*, we can obtain the necessary conditions as

$$\left.\begin{aligned} \frac{\partial L}{\partial \alpha_i} &= \Delta f_i + \Lambda_1 \Delta m_i + 2\Lambda_2 \alpha_i = 0 \\ \frac{\partial L}{\partial \Lambda_1} &= \sum_{i=1}^{N} \alpha_i \Delta m_i = 0 \\ \frac{\partial L}{\partial \Lambda_2} &= \sum_{i=1}^{N} \alpha_i^2 - A_0 = 0 \end{aligned}\right\} \tag{6}$$

Then $\alpha_i\,(i=1,2,\cdots,N)$, Λ_1 and Λ_2 can be obtained from these conditions. Using the weight coefficient α_i, the shape is modified as Eq.1 for one cycle. The cycle is iterated until the objective function is convergent.

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III. Numerical Model and Generation of Basis Vectors

a) *Numerical Model for Impact Simulation*

The analysis model of a hollow clubhead and a ball is shown in Fig. 1. The clubhead is discretized with shell elements, and the ball is discretized with solid elements.

b) *Generation of Basis Vectors for Thickness of Clubface*

The generation of basis vectors is a complex and time consuming process. It requires experience and design sense. In this study, for convenience, the basis vectors for thickness variations of clubface are created from eigenmodes. The eigenmodes can be obtained from modal analysis. The procedure to create basis vectors is

1) Undertake a modal analysis of design domain and select some of the eigenmodes.

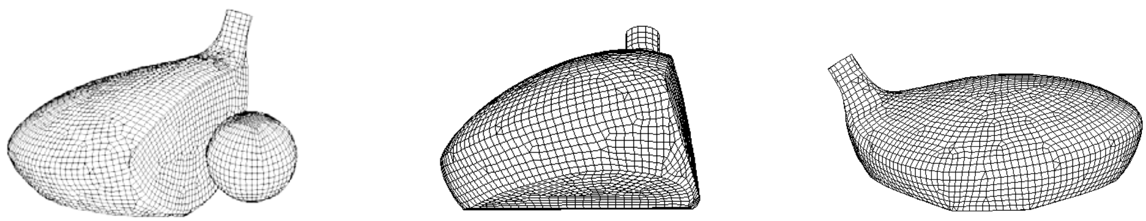


Fig.1: Analysis model and original shape of golf clubhead

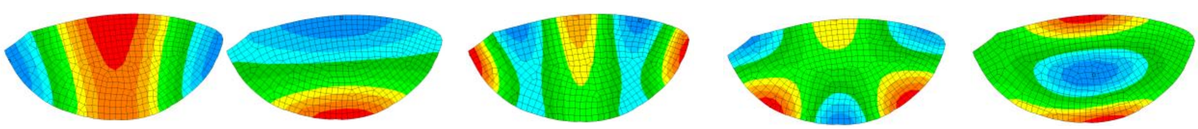


Fig.2: Examples of eigenmodes of clubface used as basis vectors of thickness

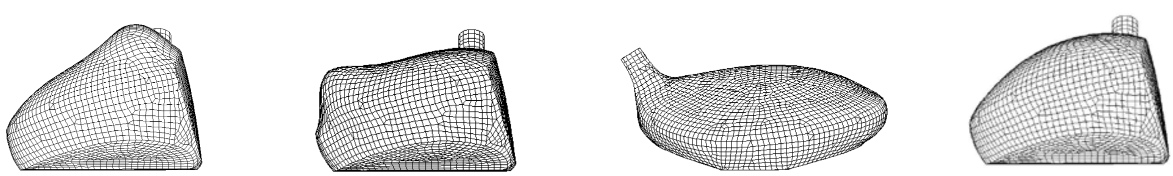


Fig.3: Basis vectors of shape variation

2) Calculate the difference in the eigenmodes and the original locations of grids as the perturbation vector of displacement.
3) Exchange the perturbation vectors of displacement for those of thickness, and then obtain the basis vectors of thickness variation.

10 eigenmodes are selected to generate the basis vectors, and some of them are shown in Fig. 2.

c) *Generation of Basis Vectors for Shape of Clubhead*

4 shape basis vectors are generated. As shown in Fig. 3, 3 of them are obtained from the deformation of clubhead under different static loads and boundary conditions. Another one represents the variation of the loft angle, and it is obtained by changing the loft angle from 10 degree to 10.5 degree.

d) *Setting of Balance Weights*

In order to optimize the mass distribution, 2 balance weights are set to the clubhead. The positions are shown in Fig. 4 with red dots. The perturbation of each vector is set to 2g. The balance weights are treated as the same as other basis vectors.

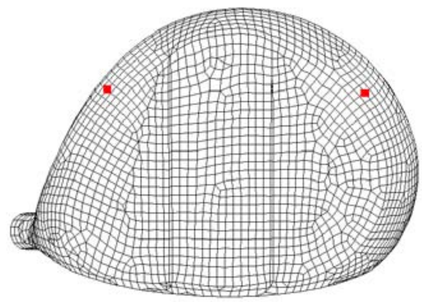


Fig.4: Positions of balance weights

IV. Optimization Analysis of Golf Clubhead

As shown in Fig. 1, the optimization analysis of a hollow clubhead is treated to maximize the flying distance of a golfball.

a) *Analysis Conditions and Material Properties*

The clubhead impacts the ball at the center point with an initial velocity of 42m/s. The swing elevation angle is set to 3 degree. Total time of the analysis is 500μsec with each analysis time step of 0.1μsec. The clubface is made of TiSP700 of which material properties are

Young's modulus=110GPa,
Poisson's ratio=0.33,
density=4540kg/m3.

The crown and sole are made of Ti64 of which material properties are

Young's modulus=110GPa,
Poisson's ratio=0.3,
density=4420kg/m3.

A 3-piece golfball consisted of a cover layer, a silicon rubber layer and a core is used in impact simulation. The materials of the ball are assumed as viscoelastic, and their parameters were identified by impact tests. Figure 5 shows the viscoelastic model for materials of the cover layer, the silicon rubber layer, and the core. The mechanical properties of each material are shown in Table 1. Since we have confirmed through prior analyses that the flying distance of the ball is chiefly influenced by the thickness of the clubface, the design domain of thickness distribution is restricted to the clubface. In addition, the trajectory and the flying distance of the golfball is calculated according to references [12], [13].

Table 1: Material Properties of golf ball

	Core	Silicon Rubber	Cover
Density kg/m^3	1140	1180	960
Poisson's ratio	0.376	0.34	0.319
E_1 MPa	121	33.5	987
E_2 MPa	143	57.9	452
η KPa s	2.86	6.23	6.02

b) *Analysis Result of Clubhead Optimization*

After optimization analysis, the flying distance of the ball increased by about 3.6%, from 205.1m to 212.5m. Figure 6 shows the optimized thickness distribution of the clubface (a) and the shape (b) after 10 iterations. The thickness of the clubface was denoted by color. It is confirmed that the thickness gradually decreased from the bottom to the top of the clubface. In contrast to this, only a small change in the shape is confirmed, except the loft angle which was changed from 10.0 degree to 12.3 degree. It is also found that the balance weights were changed from 2g both to 6.5g and 6.8g, respectively. From the optimized result, it is considered that, in the case of a center shot, there is no strong relation between the flying distance and the shape of the clubhead comparing with the thickness distribution, the loft angle and the mass distribution.

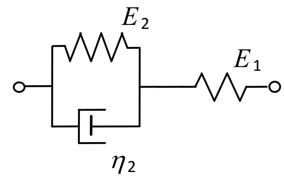
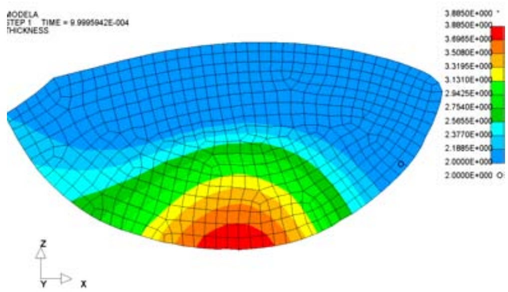
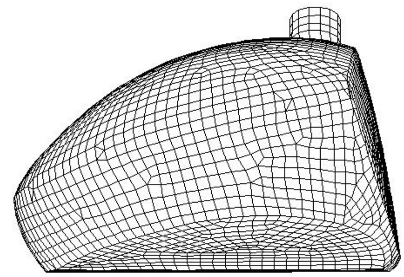


Fig.5: Viscoelastic model for materials of golf ball



(a) Thickness distribution of clubface



(b) Shape of the result

Fig.6: Analysis result of golf club

V. Optimization of Golfball

A long distance golfball is demanded by most players, and a soft feel is also preferable because it is easy to control. The optimal design of a 3-piece golfball for maximizing the flying distance with a soft feel at impact is discussed here. Since the sensitivity function is also difficult to be derived, a numerical method, Design of Experiments is used for the optimization.

a) Formulation of Optimization of Golfball

Figure 7 shows a typical 3-piece golfball consisted of a cover layer, a silicon rubber layer and a core. It is known that the polymeric material properties of which the golfball is composed can be changed easily during the manufacturing process. Here we treat the densities and young's moduli of the 3 pieces as the design variables. These values are assumed to be able to change from 95% to 110% of original values shown in Table 1. The thickness of the cover and the silicon rubber are assumed to be able to change from 1.5mm to 3mm and from 0mm to 3mm, respectively.

Consider an optimal design of the ball to maximize the flying distance impacted by a wood club and have a soft touch impacted by a 5-iron club. The soft touch is expressed as a contact time between ball and club. Then the optimization problem can be stated as

Maximize $$F = W_1 \cdot \frac{L}{L_0} + W_2 \cdot \frac{T}{T_0} \qquad (7)$$

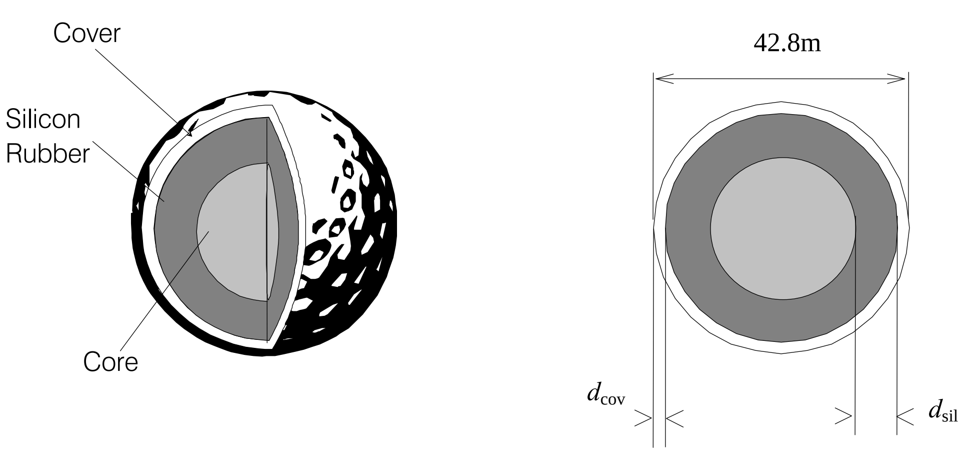


Fig.7: 3-piece golfball

$$\text{subject to} \quad \begin{aligned} & M \le 45.93\text{g} \\ & D = 42.8\text{mm} \\ & 1.5\text{mm} \le d_{\text{cov}} \le 3\text{mm} \\ & 0\text{mm} \le d_{\text{sil}} \le 3\text{mm} \end{aligned} \tag{8}$$

$$\text{and} \quad \begin{aligned} & 95\% \le \rho_{\text{cov}} / \rho'_{\text{cov}} \le 110\% \\ & 95\% \le \rho_{\text{sil}} / \rho'_{\text{sil}} \le 110\% \\ & 95\% \le \rho_{\text{cor}} / \rho'_{\text{cor}} \le 110\% \\ & 95\% \le E_{1\text{cor}} / E'_{1\text{cor}} \le 110\% \end{aligned} \tag{9}$$

Where L is the flying distance of golfball impacted by a wood club, T is the contact time between a 5-iron club and ball, M is the weight and D is the diameter of ball, W_1, W_2 are the weight coefficients, respectively, d_{cov} is the thickness of cover layer, d_{sil} is the thickness of silicon rubber layer, ρ_{cov} is the density of cover, ρ_{sil} is the density of silicon rubber, ρ_{cor} is the density of core and E_{1cor} is the viscoelastic constant of core.

b) Analysis Result of Golfball Optimization

An approach of Design of Experiment is used for the optimization process. As shown in Table 2, the problem is set to a 6 factors 4 levels experiment. Orthogonal array L64 is used and the experiment is conducted numerically by computer simulation as a substitute for actual experiment. Both the weight coefficients W_1, W_2 are set to 0.5. Table 3 shows the optimum solutions and the value of objective function after 64 times simulation. It is found that the objective function increased about 4.9% from an initial value.

Table 2: Setting of factors and levels

Factors	Level 1	Level 2	Level 3	Level 4
d_{cov} (mm)	1.5	2.0	2.5	3.0
d_{sil} (mm)	0.0	1.0	2.0	3.0
ρ_{cov} (%)	95	100	105	110
ρ_{sil} (%)	95	100	105	110
ρ_{cor} (%)	95	100	105	110
E_{1cor} (%)	95	100	105	110

Table 3: Optimum, estimated values and measurements of objective function F

d_{cov} (mm)	1.5		ρ_{cor} (%)	102.53
d_{sil} (mm)	3.0		E_{1cor} (%)	95
ρ_{cov} (%)	102.52		Estimated value	1.049
ρ_{sil} (%)	102.48		F	1.049

VI. Conclusion

Numerical optimizations of a clubhead and a golfball were studied. In the optimization of a clubhead, the thickness distribution, the shape, and the balance weights were optimized to maximize the flying distance of a golfball. The basis vector method was applied to the optimization process, and the basis vectors were created by using eigenmodes. In the optimization of a golfball, approach of Design of Experiment was used to optimize the thickness and material properties of each layer of a multi-piece golfball for maximizing the flying distance and improving the feeling at impact. The effectiveness of our approaches was demonstrated by numerical examples.

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Fast Pyrolysis of *Tectona Grandis* Wood for Bio-Oil: Characterization and Bactericidal Potentials

By Oyebanji, J.A. & Ololade, Z.S.

Bells University of Technology

Abstract- In this study, *Tectona grandis* was pyrolysed in a fixed-bed cylindrical-typed pyrolysis reactor for bio-oil production at a reaction temperature between 410 °C and 530 °C. The product yields were collected at an interval of 30 °C. The highest product yield occurred at 500 °C. Proximate and ultimate analyses were carried out using iso-conversional methods and GC-MS respectively. The proximate analysis of the raw sample showed that the moisture content, volatile matter, fixed carbon and ash content were 6.4%, 77.94%, 14.4%, 1.26% respectively while ultimate analysis of the raw materials showed that the content of carbon, hydrogen, nitrogen, sulphur and oxygen were 49.85%, 4.47%, 0.65%, 0.52%, and 44.51% respectively. The ultimate analysis of bio-oil showed that the content of carbon, hydrogen, nitrogen, oxygen and sulphur were 43.56%, 6.25%, 0.62%, 48.89%, 0.68% respectively. The HHV and LHV of the bio-oil obtained were 35.65 $MJkg^{-1}$ and 17.35 $MJkg^{-1}$ respectively. The GC-MS analysis of the bio-oil of *T. grandis* showed the presence of 21 compounds amounted to 98.9%. The most abundant component was palmitic acid (15.0%). The other major compounds present in the bio-oil were oleic acid (12.3%), *cis*-1, 9-hexadecadiene (12.0%), *cis*-10-pentadecen-1-ol (12.0%), 9-octadecenal (12.0%), *trans*-2-octadecadecen-1-ol (12.0%), myristic acid (5.0%) and stearic acid (5.0%). The bio-oil was active against all the tested bacteria with high zones of inhibition (14.0-30.0 mm). This study established that bio-oil should not only be used as a fuel but can also be purified and served as inhibitor of biofilm and bio-corrosion.

Keywords: *tectona grandis, bio-oil, fast pyrolysis, thermogravimetric analysis, bactericidal, bio-corrosion inhibitor.*

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FASTPYROLYSISOFTECTONAGRANDISWOODFORBIOOILCHARACTERIZATIONANDBACTERICIDALPOTENTIALS

Fast Pyrolysis of *Tectona grandis* Wood for Bio-Oil: Characterization and Bactericidal Potentials

Oyebanji, J.A. [α] & Ololade, Z.S. [σ]

Abstract- In this study, *Tectona grandis* was pyrolysed in a fixed-bed cylindrical-typed pyrolysis reactor for bio-oil production at a reaction temperature between 410 ℃ and 530 ℃. The product yields were collected at an interval of 30 ℃. The highest product yield occurred at 500 ℃. Proximate and ultimate analyses were carried out using iso-conversional methods and GC-MS respectively. The proximate analysis of the raw sample showed that the moisture content, volatile matter, fixed carbon and ash content were 6.4%, 77.94%, 14.4%, 1.26% respectively while ultimate analysis of the raw materials showed that the content of carbon, hydrogen, nitrogen, sulphur and oxygen were 49.85%, 4.47%, 0.65%, 0.52%, and 44.51% respectively. The ultimate analysis of bio-oil showed that the content of carbon, hydrogen, nitrogen, oxygen and sulphur were 43.56%, 6.25%, 0.62%, 48.89%, 0.68% respectively. The HHV and LHV of the bio-oil obtained were 35.65 $MJkg^{-1}$ and 17.35 $MJkg^{-1}$ respectively. The GC-MS analysis of the bio-oil of *T. grandis* showed the presence of 21 compounds amounted to 98.9%. The most abundant component was palmitic acid (15.0%). The other major compounds present in the bio-oil were oleic acid (12.3%), *cis*-1, 9-hexadecadiene (12.0%), *cis*-10-pentadecen-1-ol (12.0%), 9-octadecenal (12.0%), *trans*-2-octadecadecen-1-ol (12.0%), myristic acid (5.0%) and stearic acid (5.0%). The bio-oil was active against all the tested bacteria with high zones of inhibition (14.0-30.0 mm). This study established that bio-oil should not only be used as a fuel but can also be purified and served as inhibitor of biofilm and bio-corrosion.

Keywords: tectona grandis, bio-oil, fast pyrolysis, thermogravimetric analysis, bactericidal, bio-corrosion inhibitor.

I. Introduction

Biomass is a promising eco-friendly alternative source of renewable energy in the context of current energy scenarios. It can be converted to bio-fuel through different thermal, biological and physical processes. Biomass has being gaining intense attention as a renewable energy source to mitigate global warming, due to environmental concerns over excessive fossil fuel usage (Balat and Kirtay, 2010; Panwar *et al*., 2011; Rahim *et al*., 2013; Hossain *et al*., 2014; Fadzil *et al*., 2016; Swenson, 2016). The problem of solid waste disposal has become an alarming environmental problem in many countries with lack of effective waste management systems. However, sustainable energy can be generated from these wastes thereby putting an end to environmental pollution generated from them (Khajuria *et al*., 2008; Popoola *et al*., 2013; Anyanwu and Adefila, 2014; Montevecchi, 2016). Pyrolysis of biomass is listed among the most promising technologies able to overcome the global challenges arising from a shortage of fossil fuels, increasing demands for energy, and environmental concerns as well (Ilnicka *et al*., 2014). Means of transforming wastes into useful form of energy by pyrolysis into liquid fuel should be considered very important as sources of energy. Therefore, waste would be more readily useful and environmentally acceptable (Rahim *et al*., 2013; Hossain *et al*., 2014). Pyrolysis is a thermochemical process that transform biomass into liquid, charcoal and non-condensable gases by heating the biomass in the absence of air (Jahirul *et al*., 2012; Verma *et al*., 2012; Lohri *et al*., 2016). Pyrolysis is the chemical decomposition of organic matter by heating in the absence of oxygen (Jahirul *et al*., 2012; Akinola, 2016). Pyrolysis has attracted more interest in producing liquid fuel because of its advantages in storage, transport and versatility in applications (Jahirul *et al*., 2012; Wijayanti *et al*., 2016). The potential of bio-oil production from wood residues using pyrolysis is of great important, it is superiority to other systems of waste-to-energy conversion as it operates at atmospheric pressure and modest temperatures with yields of bio-oil exceeding 70 wt % (Popoola *et al*., 2013; Balogun and Salami, 2016). Biomass is rapidly heated to a high temperature in the absence of oxygen in the fast pyrolysis process (Jahirul *et al*., 2012). Bio-oil can be produced from wood, bark, agricultural wastes, nuts, seeds, algae, grasses, forest residues, and cellulose and lignin. The nature of the feed stocks influences the properties of the obtained bio-oils (Kato *et al*., 2016). Bio-oil has a lower sulphur and nitrogen content compared with that in fossil fuels. Therefore, bio-oil from fast pyrolysis can be used in static applications, such as in boilers, diesel engines for power generation and industrial boilers and kilns to replace fossil fuels. It can be used as a source of high quality chemicals (Hou *et al*., 2016; Wang *et al*., 2016). Moreover, bio-oil can be used as an alternative fuel directly or after application of some purifying and improving processes (Vamvuka, 2011; Hou *et al*., 2016).

Author α: Department of Mechanical Engineering, Bells University of Technology, Ota, Nigeria.
Author σ: Department of Chemical and Food Sciences, Bells University of Technology, Ota, Nigeria. e-mails: zsololade@bellsuniversity.edu.ng, zacchsnatpdt@gmail.com

The bio-corrosion is the deterioration of a materials caused by microorganisms that influence production biofilm and corrosion by changing the electrochemical conditions on the metal or solution interface. Biofilm and bio-corrosion are prevented or delayed by inhibiting the growth or metabolic activities of the microorganisms through biocides, radical scavenging, antioxidation processes and changing the environment in which the corrosion process occurs (Moura *et al*., 2013). Some natural products have been described as potential substances in controlling the growth of several microorganisms aiding biofilm formation, bio-corrosion and wearing of materials. Plant origin biofilm and corrosion inhibitors are biodegradable and do not contain heavy metals or other toxic compounds (Rani and Basu, 2011; Moura *et al*., 2013).

Tectona grandis Linn. commonly known as teak belongs to *verbanaceae* family, it is one of the most famous timber in the world and is renowned for its dimensional stability (Neha and Sangeeta, 2013; Ramesh and Mahalakshmi, 2014). *T. grandis* is a medium-size timber. The wood is often dull yellowish when freshly cut but it turns golden brown or sometimes dark greyish-brown with time, often streaked greyish or blackish (Louppe, 2005; Sholadoye *et al*., 2016). It is a tropical hardwood species highly prized by the wood industries due to its superior mechanical and physical properties, as well as its pleasing aesthetic appearance (Sanwo, 1990; Kjaer *et al*, 1999; Sholadoye *et al*., 2016). The plant is commonly used for furniture making and as building materials in Africa. It forms large percentage of wastes and constituting nuisance to the environment (Adamu *et al*., 2014). Medicinally, it has various pharmacological activities (Neha and Sangeeta, 2013). The dyes obtained from *T. grandis* may be alternative sources to synthetic dyes for the dyeing of natural silk and cotton (Bhuyan *et al*., 2004; Bhuyan and Saikia, 2005). Leaves of *T. grandis* contained mainly anthraquinone moieties in their molecules (Nidavani and Mahalakshmi, 2014). Better management of the wastes from wood industries utilizing *T. grandis* could be achieved by producing clean energy from the materials. This study aimed at investigating the physical and chemical characterization of wood bio-oil from fast pyrolysis of *T. grandis* and to evaluate its bactericidal properties against bio-corrosion aiding bacteria.

II. Materials and Methods

a) Biomass Sample and Pyrolysis Procedure

The wood sample used in this study was obtained from Ota, Nigeria. It was air dried and pulverized to a particle size of 500 μm using Philip milling machine. Pyrolysis was carried out in a fixed-bed cylindrical-typed carbon steel 300 ml reactor heated by a 4 kW furnace with automatic temperature control equipped with a condenser, ice bath and gas collector (figure 1). After been dried to 7% moisture content, 100g the sawdust was used as raw material for the production of bio-oil in a lab-scale fluid-bed fast pyrolysis procedure. Fast pyrolysis of the sawdust was then performed at 410-530 °C at interval of 30 °C in a nitrogen atmosphere with a pyrolysis product residence time of 1.3 s. The obtained bio-oil was kept at 4 °C in a refrigerator until further analysis (Patra *et al*., 2015).

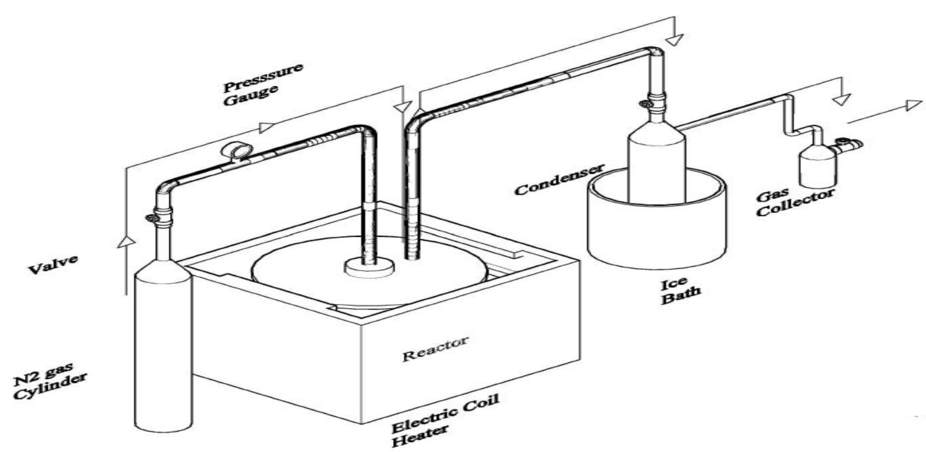

Figure 1: Experimental set-up of the pyrolysis unit

b) Compositional Analysis

Compositional analysis was conducted using both observation and instrumental analytical methods to obtain the extractive and lignin contents according to ASTM D1108-96 and ASTM D1106-96, respectively (Balogun *et al*., 2014).

c) Heating Values

The heating values were determined according to ASTM D5865, standard test method for gross calorific value of coal and coke on dry basis using the oven dried samples. The PAAR 1341 oxygen bomb calorimeter with benzoic acid pellets was used to determine the gross calorific value (HHV) while the net calorific value (LHV) was calculated using wt% of hydrogen resulting from elemental analysis of the sample (Okoroigwe and Saffron, 2012).

d) GC-MS Analysis

The bio-oil was analysed using Shimadzu GC-MS-QP2010 Plus (Japan). The separations were carried out using a Restek Rtx-5MS fused silica capillary column (5%-diphenyl-95%-dimethylpolysiloxane) of 30 m× 0.25 mm internal diameter (di) and 0.25 mm in film thickness. The conditions for analysis were set as follows; column oven temperature was programmed from 60-280 °C (temperature at 60 °C was held for 1.0 min, raised to 180 °C for 3 min and then finally to 280 °C held for 2 min); injection mode, Split ratio 41.6; injection temperature, 250 °C; flow control mode, linear velocity (36.2 cm/sec); purge flow 3.0 ml/min; pressure, 56.2 kPa; helium was the carrier gas with total flow rate 45.0 ml/min; column flow rate, 0.99 ml/min; ion source temperature, 200 °C; interface temperature, 250 °C; solvent cut time, 3.0 min; start time 3.5 min; end time, 24.0 min; start m/z, 50 and end m/z, 700. Detector was operated in EI ionization mode of 70 eV. Components were identified by matching their mass spectra with those of the spectrometer data base using the NIST computer data bank, as well as by comparison of the fragmentation pattern with those reported in the literature (Ololade *et al*., 2014).

e) Bactericidal Activities

The antibacterial potentials of the bio-oil were evaluated by agar-well diffusion method against biofilm and bio-corrosion aiding gram-positive bacteria (*Micrococcus varians*, *Streptococcus agalactiae* and *Staphylococcus aureus*) and gram-negative bacteria (*Escherichia coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Serratia marcescens* and *Salmonella typhimurium*). The bacteria isolates were sub-cultured in Nutrient agar and incubated at 37 °C for 24 hours. All the cultured bacteria were adjusted to 0.5 McFarland standards, 20 ml of sterilized Nutrient agar medium was poured into each Petri dish aseptically and plates were swabbed with inocula of the test organisms, and kept for 15 minutes for adsorption. Using sterile cork borer of 6 mm diameter wells were bored into the seeded agar plates, and these were loaded with different concentrations (1000, 500 and 250 μgml^{-1}) of the bio-oil solution. The plates were allowed to stay in a refrigerator for 1 hour to allow proper diffusion of the bio-oil solution into the medium and incubated at 37 °C for 24 hours before visual assessment of the inhibition zones. Antimicrobial activities were expressed as inhibition diameter zones in millimetre (mm). Synthetic antibiotics was used as control (Ololade *et al*., 2014).

III. Results and Discussion

a) Physical and Chemical Properties

The colour of the obtained wood bio-oil from *T. grandis* was golden yellow with slight pungent odour. The elemental composition, moisture content, density, ash content, viscosity, pH, lower heating value (LHV) and higher heating values (HHV) of the feed materials and bio-oil were given in Table 1 and 2. Table 1 showed that high energy values could be obtained from feed material. Compared to results gotten from analyses of bio-oils from the other sources, the results indicated that the bio-oil used in this study contained more carbon (43.56%) and oxygen (48.89%). The low nitrogen (0.62%) and sulphur (0.68%) showed that the bio-oil has low pollutant effect which showed that they are eco-friendly bio-oil. Moreover, HHV and LHV were 35.65 and 17.35 $MJkg^{-1}$ respectively, were also greater than other bio-oil reported (Okoroigwe *et al*., 2012; Rahim *et al*., 2013; Hossain *et al*., 2014). The moisture content and viscosity of the bio-oil were similar to those of the other bio-oils (Okoroigwe *et al*., 2012), indicating that the bio-oil could be easily handled. The moisture content could be traced to moisture in feed sample and water of dehydration reactions, the pH and ash content was at the threshold range for bio-oils from biomass (Okoroigwe *et al*., 2012; Kato *et al*., 2016). The pH of this bio-oil could be neutralized in other to prevent corrosion and other reactions of the bio-oil when used for engines and boilers (Sukhbaatar *et al*., 2009; Okoroigwe *et al*., 2012).

Table 1: Properties of T. grandis Wood Sample

Proximate analysis (wt. %)		Ultimate analysis (wt. %)	
Moisture content	6.40	Carbon	49.85
Volatile matter	77.94	Hydrogen	4.47
Fixed carbon	14.40	Nitrogen	0.65
Ash	1.26	Sulphur	0.52
		Oxygen	44.51
		HHV($MJkg^{-1}$)	17.05
		LHV($MJkg^{-1}$)	14.55

Table 2: Properties of the Wood Bio-oil of T. grandis

Physical property		Ultimate analysis	(wt.%)
Moisture content (%)	28.92	Carbon	43.56
Density(g cm^{-3})	51.24	Hydrogen	6.25
Ash (%)	0.7	Nitrogen	0.62
Dynamic Viscosity (cp)	53.25	Oxygen	48.89
pH	2.62	Sulphur	0.68
		HHV($MJkg^{-1}$)	35.65
		LHV($MJkg^{-1}$)	17.35

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b) *Effect of Temperature on the Product Yields*

The products (bio-oil, pyro-gas and char) yields at different pyrolysis temperature were shown in figure 2. The bio-oil yield increases with increase in temperature up to 500 °C. Above 500 °C, there is decrease in the yield. This is because bio-oil secondary reactions yield more gas and char at temperature Above 500 °C, there was decrease in the yield, because bio-oil secondary reactions yield more gas and char at temperature above 500 °C. This is similar to what was obtained from the pyrolysis of other biomasses (Fagbemi *et al*., 2001). Char yield decreased from 35.0 wt% to 17.0 wt% with increase pyrolysis temperature. This was due to increase rate of primary decomposition at high temperature or through secondary decomposition of the solid residue. The obtained result was similar to what was gotten from other bio-oils (Gheorghe *et al*., 2010; Okoroigwe *et al*., 2012). It was observed that as temperature increased from 410-530 °C the bio-gas yield increased from 12.0 wt% to 31.5 wt%.

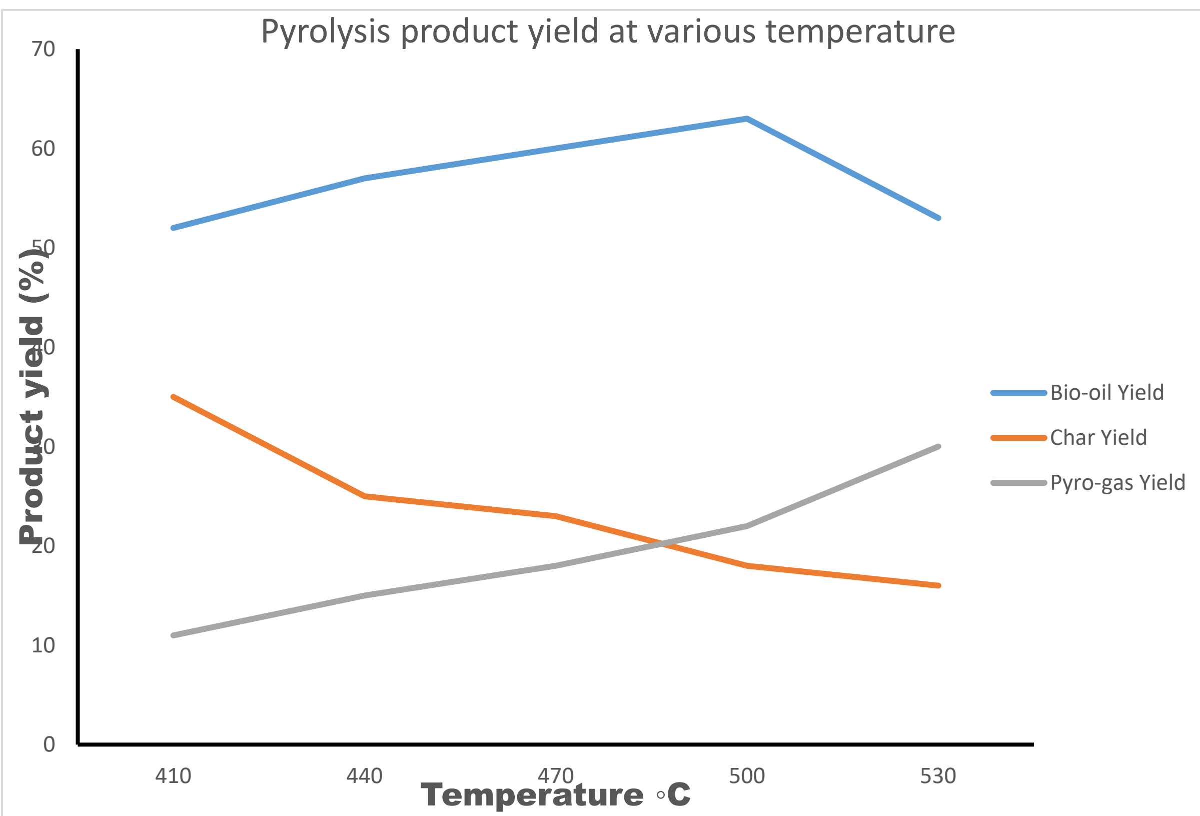

Figure 2: Product yield at different reactor

c) *Chemical Composition of the Wood Bio-oil*

The GC-MS analysis of the bio-oil of *T. grandis* showed the presence of twenty-one compounds amounted to 98.9%. The most abundant component was palmitic acid (15.0%). The other major compounds present in the bio-oil were oleic acid (12.3%), *cis*-1, 9-hexadecadiene (12.0%), *cis*-10-pentadecen-1-ol (12.0%), 9-octadecenal (12.0%), *trans*-2-octadecadecen-1-ol (12.0%), myristic acid (5.0%) and stearic acid (5.0%). The GC-MS indicated the presence of hydrocarbons, fatty acids, alcohols, esters, ethers, ketones, furan and phenolic compounds.

Table 3: Chemical composition of the Wood Bio-oil of *T. grandis*

Compound	Retention Index	Percentage Composition
luprosil	676	3.0
2,5-dimethylfuran	732	2.4
1,4-dimethyl-1H-pyrazole	804	0.8
2-methylbutyric acid	811	1.0
3-octene	824	0.8
5-methyl-3-methylene-5-hexen-2-one	887	0.5
4,5-dimethyl-1H-imidazol	927	0.8
cyclooctane	959	0.4
corylone	972	0.4
3-methylcyclopentane-1,2-dione	1003	0.4
methyl-1-cyclohexenyl ketone	1027	1.6
o-guaiacol	1090	0.5
2-nitroethylpropionate	1067	1.0
cis-1,9-hexadecadiene	1610	12.0
cis-10-pentadecen-1-ol	1763	12.0
myristic acid	1769	5.0
palmitic acid	1968	15.0
9-octadecenal	2007	12.0
trans-2-octadecadecen-1-ol	2061	12.0
stearic acid	2167	5.0
oleic acid	2175	12.3
Percentage Total		**98.9**

d) Bactericidal activities

The antimicrobial screening of the *T. grandis* wood bio-oil gave wide inhibition zones against the tested biofilm and bio-corrosion aiding bacteria strains compared with the synthetic antibiotics. The inhibition zones of the bio-oil (20-30 mm) were greater than that of gentamicin (Gen) a synthetic antibiotics (15-20 mm) except for *S. marcescens* (30 mm). The investigated bio-oil of *T. grandis* could be an agent of prevention, inhibition and elimination of microorganisms aiding formation of biofilm and bio-corrosion of industrial materials (Rani and Basu, 2011; Moura *et al*., 2013). Bio-oils from this plant can also potentially be used in drug formulation against multi-drug resistant bacteria, food processing and preservation due to its large spectrum of biological properties, low environmental risk and low cost (Patra *et al*., 2015).

Table 4: Zones of Inhibition (mm) showing the Antimicrobial Potentials of the Wood Bio-oil of *T. grandis*

	Bio-oil			Synthetic Antibiotic Gen
Conc. (μgml^{-1}) / Organisms	1000	500	250	10μg
E. coli	24	25	27	17
K. pneumoniae	30	30	30	15
P. aeruginosa	20	20	20	16
P. mirabilis	21	21	22	16
S. typhimurium	20	23	23	18
S. marcescens	22	22	14	30
M. varians	27	27	24	18
S. agalactiae	24	24	27	-
S. aureus	23	25	28	20

Keynote: Resistant (--), not sensitive (<8 mm), sensitive (9–14 mm), very sensitive, (15–19 mm) and ultrasensitive (>20 mm)

IV. Conclusion

In this study, the potentials of waste-to-energy system in Nigeria had been assessed. The obtained results of this study showed that the bio-oil produced met the qualities of other liquid products from other energy classified biomass. This showed that the obtained bio-oil could be a good source of energy for the heating of reactor chambers and could be a good substitute for coal in power generation. This study

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established the fact that understanding the compositions of bio-oils will add to their use in thermochemical conversion platforms, as this information will be extremely important in evaluating the bio-oils' stabilities, properties, and toxicities. The studied bio-oil has the potential of being used as alternative eco-friendly and cheap natural product as inhibitor of biofilm, bio-corrosion and wear materials, also as therapeutic agent for human and animals.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Modeling and Experimental Analysis of Effect of Tool Geometry on Single Point Incremental Sheet Metal Forming

By Rahul Pachori & Naveen Agrawal
Mewar University

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Modeling and Experimental Analysis of Effect of Tool Geometry on Single Point Incremental Sheet Metal Forming

Rahul Pachori [α] & Naveen Agrawal [σ]

Abstract- Dieless manufacturing process involves progressive deformation of the sheet metal using a punch (or tool). During the incremental deformation process, the sheet may or may not be supported on its back side. There are various factors that affect the process of die less sheet forming. The objective of this work is to identify the effect of tool geometry on formability of sheet metal components in the case of single point incremental sheet metal forming. For this purpose numbers of experiments have been performed with three different tool geometries, which are spherical tool, elliptical tool tip with straight diameter and elliptical tool tip with tapered diameter. The entire exercise has also been simulated in virtual environment and a good correlation between the simulation and the experimental work is observed. It has been observed that the results of the analysis would help to improve the selection of appropriate tool and obtain better forming limit for a given sheet metal.

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I. Introduction

Incremental sheet metal forming is a new method, which consists of improved possibilities of sheet metal forming. Now days, incremental sheet metal forming has become very attractive method for making 3-D complex shapes. The main advantage of this process is the cost and time reduction by eliminating the making of special purpose dies. With the controlled movement of a tool; wide range of 3D shapes can be formed directly from the CAD model by moving the tool along an optimized path. This process is suitable for small batch production as well as to fabricate complex geometries [1-4].

There are several ways in which various ISF methods can be categorized. The traditional method is to define through the surface shape achieved with the process, i.e. convex surface or the concave surface. [5-6]. Incremental CNC forming technology can be used to achieve non-symmetrical shapes formed on the concave surface [7]. The convex surface forming was the first variation of ISF, known as Die less NC Forming. It was introduced in Japan by Matsubara [8].

Author α: Mechanical Engineering Discipline Mewar University, Department of Mechanical Engineering, Chittorgarh.
e-mail: Rpachori2006@gmail.com

The current ISF processes can be divided in various groups, depending on the number of contact points between sheet and tool and also on the clamping mechanism. The first is the 'Single Point Incremental Sheet Forming' (SPISF), where only a single tool is used to form the component. The sheet is supported only at the edges with the clamps. Other variant is the 'Two point Incremental Sheet forming' (TPISF), where a full or partial stationary die is present to support the sheet.

The advanced variants are under research where the support die is also moving [9]. Another interesting variant under research is the ISF by hammering [10-11]. Most of the ISF configurations use the 3 axis CNC machines as the base, but new configurations based on the robotized tools are also experimented [12-13]. Kitazawa has implemented ISF using a lathe [14-15]. In order to achieve the desired accuracy in the form and dimension using ISF, it is important to know the factors influencing the process and their relationship. Several attempts have been made to investigate the behavior of the sheet metal in ISF [16-19].

In literature, many experiments on die less forming have been reported, but the effect of tool geometry on sheet metal deformation process is not well defined. Most of the experiments performed to obtain a range of wall angles in the case of sheet metal deformation use either a hemispherical or ball nose tool. In the present work, specific experiments have been carried out to achieve a range of wall angles varying from wall angle 50° to 75° with a step size of 5°, so that comparative study between three different tool geometries can be performed.

II. Experimental Details

a) Process description and tooling setup

The usual forming strategy in ISF consists of a single forming stage where the tool traces along a sequence of contour lines with a small vertical down motion in between (Fig.1). In general for forming of sheet, a hemispherical or ball nose tool is used but to observe the effect of contact area on formability, this tool is compared with two other tools, for the same process parameters.

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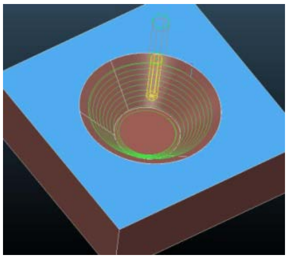


Fig. 1: Single point incremental sheet forming

In the present work, a single point incremental sheet metal forming process was performed on a CNC machining center, for three different tool geometries.

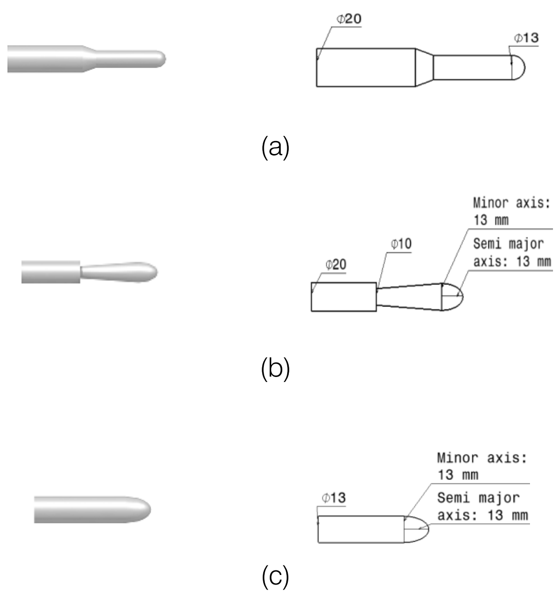


Fig. 2: Tool geometries used (a) spherical (b) elliptical with decreasing diameter (c) elliptical with straight diameter

The tool geometries are shown with the help of Fig. 2 (Fig. 2.(a) spherical, 2.(b) elliptical with decreasing diameter, 2.(c) elliptical with straight wall).

The experiments have been carried out with sheet metal specimen supported about its contour and rigidly fixed with the fixture with the help of normal clamping device [Fig. 3]. There is no lateral movement of the sheet during forming. This whole arrangement was fixed on to the worktable of the milling machine. At any instant only a small portion of the sheet is subjected to the local deformation. In the present work, tools made up of stainless steel are clamped in the spindle of the milling machine. The experiments are performed on aluminum sheets of 1 mm thickness with single point incremental sheet forming.

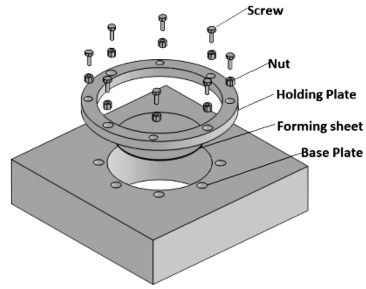


Fig. 3: Clamping mechanism of the sheet

b) Final geometry and material

Initially a disc of 200 mm diameter and 1 mm thickness is taken and we obtain symmetrical cone geometry as shown in Fig. 4. This is used to identify forming limit of sheet metal components. Due to frequent use in automobile and other sheet metal industries, Al 1050-O aluminum alloy sheets were taken for experiment.

Fig. 4: Cone shaped geometry

From the experimental observations and available literatures most influencing parameters for single point incremental sheet metal forming are listed below (Table 1). During the experiment, process parameters have been kept same; apart from wall angle and tool diameter (Fig. 5), for all the three tool geometries to obtain the comparative study.

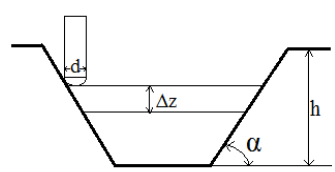


Fig. 5: Schematic view of ISF

Table 1: Process parameters

Constant	Parameters
Forming Depth "h"	80 mm
Tool Rotation	50 rpm
Feed Rate	1700 mm/min
Vertical Step Size "Δz"	0.5 mm
Tool Path	Spiral (clock wise)
Lubricant	Hydraulic oil (grade-68)
Varying	Parameters
Wall Angle "α"	50˚, 55˚, 60˚, 65˚, 70˚, 75
Tool Diameter	7, 10, 13 mm

c) The force measurements

The knowledge about the deformation force is very important for successful forming operation and to achieve final geometry precisely. It also helps in the selection of appropriate equipment.

In order to identify deformation force and to avoid tool failure the experiments have been carried out. The force measurement set-up is shown in Fig. 6. It consists of SPISF fixture, which is mounted on the piezoelectric dynamometer. The dynamometer is also connected with the data acquisition board and a PC for output signals. The output signals have been recorded at 1000 Hz frequency for accurate results.

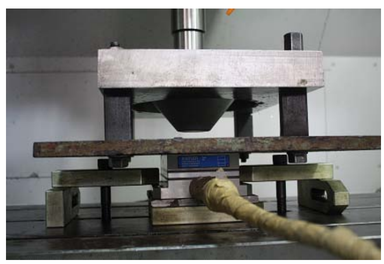


Fig. 6: Force measurement setup in SPISF

d) Effect of wall angle

Experiments have been carried out for wall angles of 50˚ to 75˚, with step size of 5˚ and as represented in Fig. 7, which shows the effect of wall angle on maximum forming force (Fz). With other process parameters same as in Table 1, cone geometry is formed up to 80 mm depth and actual data is plotted. To maintain the accuracy data (Force measurement) has been recorded at high frequency (1000 Hz).

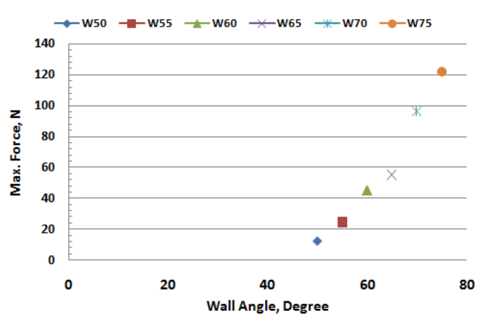


Fig. 7: Comparison of maximum forces for various wall angles

By increasing the wall angle the magnitude of maximum force occur during forming continuously increase. In case of lower wall angles (below 65˚ the force distribution is uniform but when wall angle exceeds 70˚ the force tends to increase continuously. In case of 70˚ wall angle, the desired depth is achieved, but in case of 75˚ wall angle, the fracture occurs at a depth of 14 mm only. Thus, the value of maximum force for 75˚ wall angle can be used to define the limit in case of SPIF for 1 mm thick aluminum sheet.

e) Effect of tool diameter

To see the effect of tool diameter on forming forces, experiments have been carried out for the wall angle of 50˚ and tool diameter of 7 mm, 10 mm and 13 mm respectively, with other process parameters remaining same (Table 1).

With increase in the tool diameter the value of maximum forming forces also increase (Fig. 8); this happens because the contact area between tool and sheet increases with the increase in tool diameter.

Similar results are obtained for remaining wall angles as well.

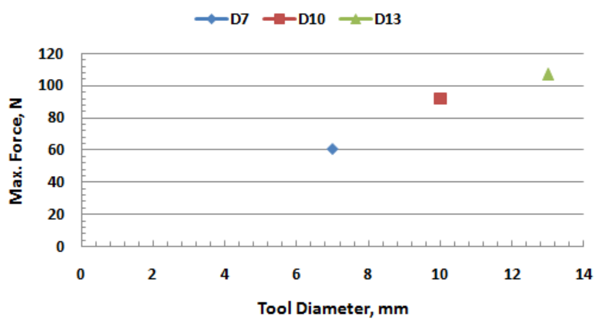


Fig. 8: Comparison of forces for different tool diameter

In case of steeper wall angle (above 70° in our case) the forming limit of specimen decreases as shown in Fig. 9. For the 7 mm tool the sheet can be formed up to 14 mm depth, whereas in case of 10 and 13 mm diameter tool forming limit is 12 and 10 mm respectively.

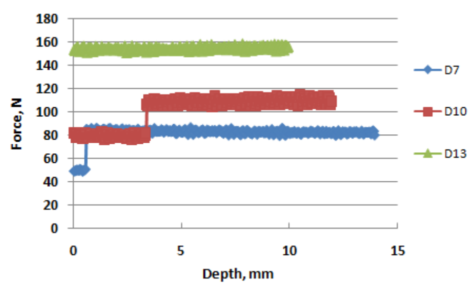


Fig. 9: Forming limit for different tool diameters

f) Comparison of different tool geometries

A set of experiments have been performed and it is observed that the maximum deformation force in case of elliptical tool tip is considerably low as compared to spherical tool tip (Fig. 10-12). The reason behind is that, in case of elliptical tool the contact area between tool and sheet is considerably low as compared to spherical one. Due to the absence of overloading the forming limit of the specimen has increased.

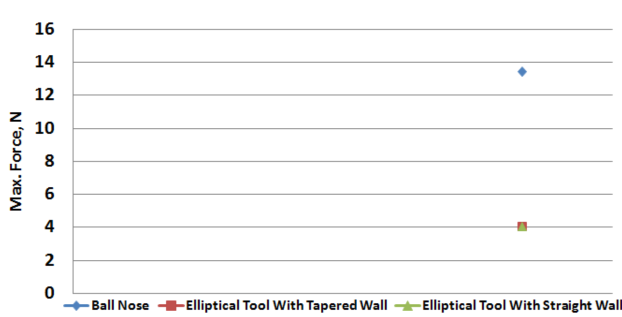


Fig.10: Comparison of maximum force for different tool geometries in case of tool diameter 7 mm and wall angle 50°

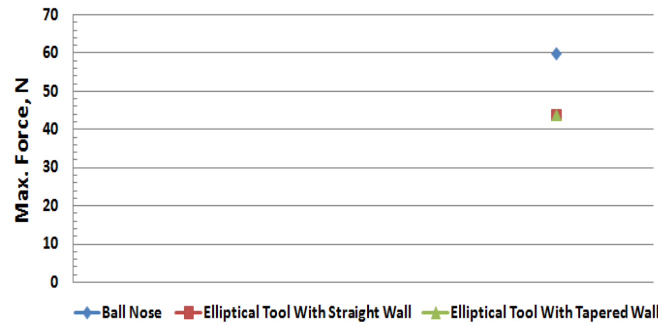


Fig.11: Comparison of maximum force for different tool geometries in case of tool diameter 10 mm and wall angle 50°

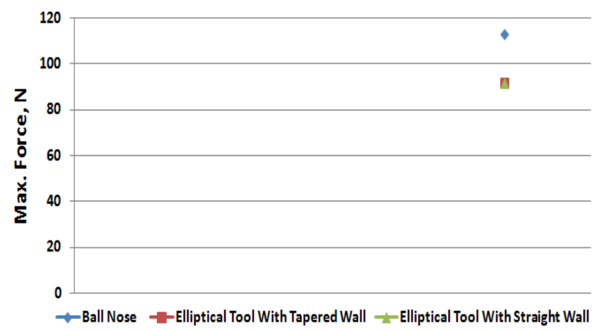


Fig.12: Comparison of maximum forces for different tool geometries in case of tool diameter 13 mm and wall angle 50°

In case of steeper wall angles (above 70°) the forming limit of the component with the elliptical tool increases considerably. For 1 mm aluminum sheet forming limit in case of spherical tool is 14 mm but in case of elliptical tool with straight wall it is 19 mm and for elliptical tool with tapered wall it is 21 mm (Fig. 13).

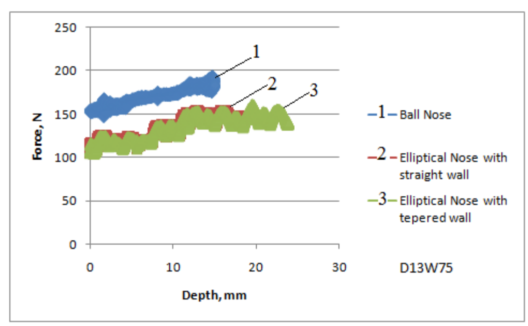


Fig.13: Forming limit for different tool geometries in case of tool diameter 13 mm and wall angle 75°

When the tool is at certain depth in case of steeper wall angles there arises a problem of collision between the tool and the wall of the sheet specimen. To overcome this problem, authors have suggested tool with tapered wall. By the graph (Fig. 13) it can be noticed that forming limit increases considerably in case of tool with tapered wall.

In the present work, contact area is calculated for both the tools in case of 50° wall angle and 0.5 mm step down (Fig. 14) for same forming depth. It is found that in case of spherical tool contact area is larger than the elliptical tool.

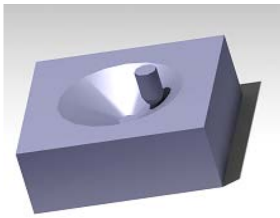
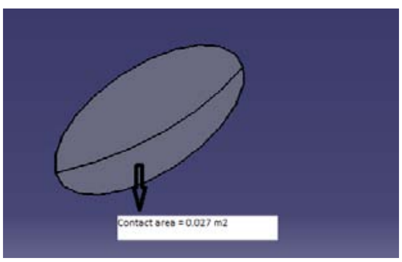
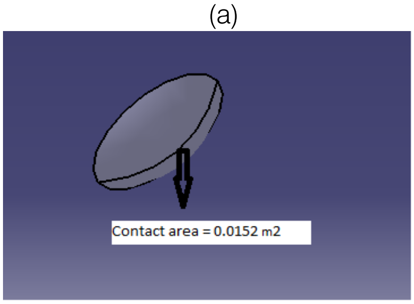


Fig.14: Tool sheet interface at 50° wall angle

As we can see that, contact area in case of spherical tool [Fig. 15 (a)] is 0.03569 m2 but in case of elliptical tool [Fig. 15 (b)] contact area is 0.01813 m2. Therefore, more deformation force would be transferred from tool to the sheet in case of a spherical tool and it directly affects the formability of component.



(a)



(b)

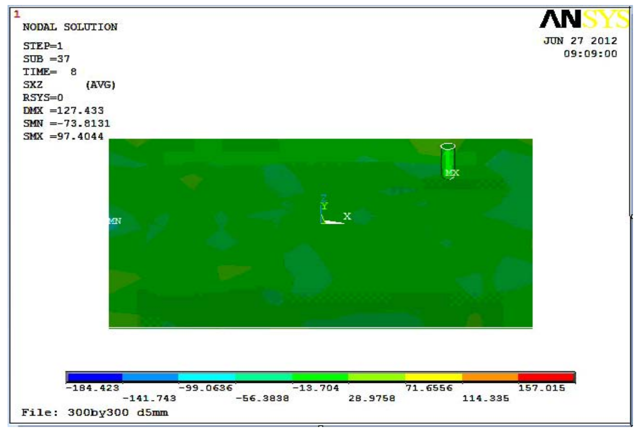
Fig.15: Contact area for (a) spherical and (b) elliptical tool

III. Simulation Results

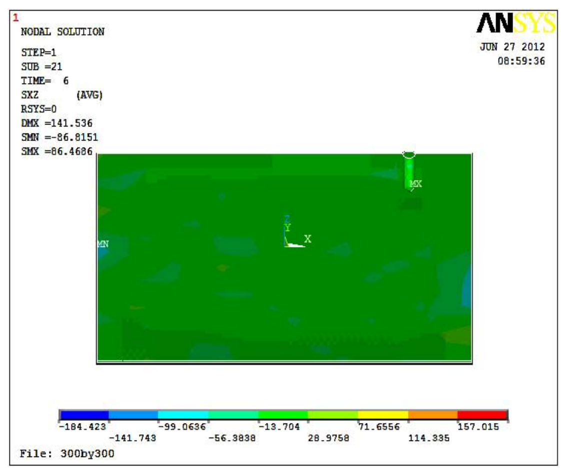
The single point incremental sheet forming process has been simulated in finite element analysis software, LS-DYNA. Anisotropic yield criteria, material model Hill, Bar lat and multi-linear stress-strain approaches have been employed [20]. For the tool, Solid-164 tetrahedral mesh element, and rigid body behavior and for the sheet shell-163 square element, plastic anisotropic body behavior is employed. The values of the yield stress, density, young's modulus and Poisson's ratio have been set for high carbon steel (Tool) and aluminum (sheet).

Simulations have been carried out for spherical and elliptical tools of diameter 7 mm, 10 mm and 13 mm and wall angle of 50° to 75° with a step size 5°. This work presents a case where tool diameter is of 13 mm and wall angle 50° Same tool path as given to the CNC-milling machine is defined through array parameters in the LS-DYNA and value of maximum deformation force is identified.

Simulation results are shown with the help of Fig. 16(a) and 16(b). In case of spherical tool, the maximum force magnitude attained by the sheet is 97 N and for elliptical tool it is 86 N.



(a)



(b)

Fig.16: LS-DYNA Force (Fz) results for (a) spherical and (b) elliptical tool

As it may be seen by comparing Fig. 12 and Fig. 16 [(a), (b)], the force values are generally in agreement, except for existence of high peak value in the experimental data. These peaks may be attributed to the plunging action when the tool takes a step-down.

IV. Conclusions

A study to observe the effect of tool geometry on the formability of the component for conical shape is performed for different tool diameters and wall angles. It is found that by changing the tool geometry from spherical to elliptical shape the forming limit of specimen increases considerably. Through the analysis, it is observed that contact area plays major role in terms of deformation force, which directly affects the forming limit of the component. In addition the elliptical tool with tapered wall gives more forming limit. Further when the tool deals with steeper wall angles the problem of tool collision with the wall of the specimen has been solved.

The ISF process is simulated in FEM LS-DYNA and by comparing experimental and simulation results, a good correlation of forces is observed.

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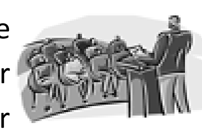

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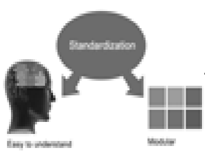

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The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

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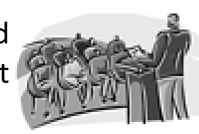
The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.
The author fees of such paper may be waived off up to 40%.



The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

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The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

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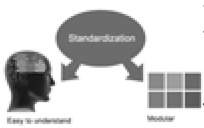

After nomination of your institution as “Institutional Fellow” and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
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The following entitlements are applicable to individual Fellows:

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Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.

- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.

- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone. "

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The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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

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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.

General style:

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
- As a outline of job done, it is always written in past tense
- 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:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- 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.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

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.
- Submit to generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.
- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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