Global Journals Inc.

(A Delaware USA Incorporation with “Good Standing”; Reg. Number: 0423089)
Sponsors: Open Association of Research Society
Open Scientific Standards

Publisher’s Headquarters office

Global Journals Inc., Headquarters Corporate Office, Cambridge Office Center, II Canal Park, Floor No. 5th, Cambridge (Massachusetts), Pin: MA 02141 United States
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Open Association of Research Society, Marsh Road, Rainham, Essex, London RM13 8EU United Kingdom.

Packaging & Continental Dispatching

Global Journals, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please email us at local@globaljournals.org

eContacts

Press Inquiries: press@globaljournals.org
Investor Inquiries: investors@globaljournals.org
Technical Support: technology@globaljournals.org
Media & Releases: media@globaljournals.org

Pricing (Including by Air Parcel Charges):

For Authors:
22 USD (B/W) & 50 USD (Color)

Yearly Subscription (Personal & Institutional):
200 USD (B/W) & 250 USD (Color)
EDITORIAL BOARD MEMBERS (HON.)

John A. Hamilton, "Drew" Jr.,
Ph.D., Professor, Management
Computer Science and Software
Engineering
Director, Information Assurance
Laboratory
Auburn University

Dr. Wenying Feng
Professor, Department of Computing &
Information Systems
Department of Mathematics
Trent University, Peterborough,
ON Canada K9J 7B8

Dr. Henry Hexmoor
IEEE senior member since 2004
Ph.D. Computer Science, University at
Buffalo
Department of Computer Science
Southern Illinois University at Carbondale

Dr. Osman Balci, Professor
Department of Computer Science
Virginia Tech, Virginia University
Ph.D. and M.S. Syracuse University, Syracuse, New York
M.S. and B.S. Bogazici University, Istanbul, Turkey

Yogita Bajpai
M.Sc. (Computer Science), FICCT
U.S.A. Email: yogita@computerresearch.org

Dr. T. David A. Forbes
Associate Professor and Range
Nutritionist
Ph.D. Edinburgh University - Animal
Nutrition
M.S. Aberdeen University - Animal
Nutrition
B.A. University of Dublin- Zoology

Dr. Thomas Wischgoll
Computer Science and Engineering,
Wright State University, Dayton, Ohio
B.S., M.S., Ph.D.
(University of Kaiserslautern)

Dr. Abdurrahman Arslanyilmaz
Computer Science & Information Systems
Department
Youngstown State University
Ph.D., Texas A&M University
University of Missouri, Columbia
Gazi University, Turkey

Dr. Xiao-hong He
Professor of International Business
University of Quinnipiac
BS, Jilin Institute of Technology; MA, MS,
PhD, (University of Texas-Dallas)

Burcin Bekerich-Gerber
University of Southern California
Ph.D. in Civil Engineering
DDes from Harvard University
M.S. from University of California, Berkeley
& Istanbul University
Dr. Bart Lambrecht
Director of Research in Accounting and Finance
Lancaster University Management School
BA (Antwerp); MPhil, MA, PhD (Cambridge)

Dr. Söhnke M. Bartram
Department of Accounting and Finance
Lancaster University Management School
Ph.D. (WHU Koblenz)
MBA/BBA (University of Saarbrücken)

Dr. Carlos García Pont
Associate Professor of Marketing
IESE Business School, University of Navarra
Doctor of Philosophy (Management), Massachusetts Institute of Technology (MIT)
Master in Business Administration, IESE, University of Navarra
Degree in Industrial Engineering, Universitat Politècnica de Catalunya

Dr. Miguel Angel Ariño
Professor of Decision Sciences
IESE Business School
Barcelona, Spain (Universidad de Navarra)
CEIBS (China Europe International Business School).
Beijing, Shanghai and Shenzhen
Ph.D. in Mathematics
University of Barcelona
BA in Mathematics (Licenciatura)
University of Barcelona

Dr. Fotini Labropulu
Mathematics - Luther College
University of Regina
Ph.D., M.Sc. in Mathematics
B.A. (Honors) in Mathematics
University of Windso

Dr. Philip G. Moscoso
Technology and Operations Management
IESE Business School, University of Navarra
Ph.D in Industrial Engineering and Management, ETH Zurich
M.Sc. in Chemical Engineering, ETH Zurich

Dr. Lynn Lim
Reader in Business and Marketing
Roehampton University, London
BCom, PGDip, MBA (Distinction), PhD, FHEA

Dr. Sanjay Dixit, M.D.
Director, EP Laboratories, Philadelphia VA Medical Center
Cardiovascular Medicine - Cardiac Arrhythmia
Univ of Penn School of Medicine

Dr. Mihaly Mezei
ASSOCIATE PROFESSOR
Department of Structural and Chemical Biology, Mount Sinai School of Medical Center
Ph.D., Evtis Lornd University
Postdoctoral Training,
New York University

Dr. Han-Xiang Deng
MD., Ph.D
Associate Professor and Research Department Division of Neuromuscular Medicine
Davee Department of Neurology and Clinical Neuroscience
Northwestern University
Feinberg School of Medicine
Dr. Pina C. Sanelli  
Associate Professor of Public Health  
Weill Cornell Medical College  
Associate Attending Radiologist  
NewYork-Presbyterian Hospital  
MRI, MRA, CT, and CTA  
Neuroradiology and Diagnostic Radiology  
M.D., State University of New York at Buffalo, School of Medicine and Biomedical Sciences

Dr. Roberto Sanchez  
Associate Professor  
Department of Structural and Chemical Biology  
Mount Sinai School of Medicine  
Ph.D., The Rockefeller University

Dr. Wen-Yih Sun  
Professor of Earth and Atmospheric Sciences  
Purdue University Director National Center for Typhoon and Flooding Research, Taiwan  
University Chair Professor  
Department of Atmospheric Sciences, National Central University, Chung-Li, Taiwan  
University Chair Professor  
Institute of Environmental Engineering, National Chiao Tung University, Hsinchu, Taiwan  
Ph.D., MS The University of Chicago, Geophysical Sciences  
BS National Taiwan University, Atmospheric Sciences  
Associate Professor of Radiology

Dr. Michael R. Rudnick  
M.D., FACP  
Associate Professor of Medicine  
Chief, Renal Electrolyte and Hypertension Division (PMC)  
Penn Medicine, University of Pennsylvania  
Presbyterian Medical Center, Philadelphia  
Nephrology and Internal Medicine  
Certified by the American Board of Internal Medicine

Dr. Bassey Benjamin Esu  
B.Sc. Marketing; MBA Marketing; Ph.D Marketing  
Lecturer, Department of Marketing, University of Calabar  
Tourism Consultant, Cross River State Tourism Development Department  
Co-ordinator, Sustainable Tourism Initiative, Calabar, Nigeria

Dr. Aziz M. Barbar, Ph.D.  
IEEE Senior Member  
Chairperson, Department of Computer Science  
AUST - American University of Science & Technology  
Alfred Naccash Avenue – Ashrafieh
**President Editor (HON.)**

**Dr. George Perry, (Neuroscientist)**  
Dean and Professor, College of Sciences  
Denham Harman Research Award (American Aging Association)  
ISI Highly Cited Researcher, Iberoamerican Molecular Biology Organization  
AAAS Fellow, Correspondent Member of Spanish Royal Academy of Sciences  
University of Texas at San Antonio  
Postdoctoral Fellow (Department of Cell Biology)  
Baylor College of Medicine  
Houston, Texas, United States

**Chief Author (HON.)**

**Dr. R.K. Dixit**  
M.Sc., Ph.D., FICCT  
Chief Author, India  
Email: authorind@computerresearch.org

**Dean & Editor-in-Chief (HON.)**

**Vivek Dubey (HON.)**  
MS (Industrial Engineering),  
MS (Mechanical Engineering)  
University of Wisconsin, FICCT  
Editor-in-Chief, USA  
eliderusa@computerresearch.org  

**Sangita Dixit**  
M.Sc., FICCT  
Dean & Chancellor (Asia Pacific)  
deanind@computerresearch.org  

**Suyash Dixit**  
(B.E., Computer Science Engineering), FICCTT  
President, Web Administration and Development, CEO at IOSRD  
COO at GAOR & OSS  

**Er. Suyog Dixit**  
(M. Tech), BE (HONS. in CSE), FICCT  
SAP Certified Consultant  
CEO at IOSRD, GAOR & OSS  
Technical Dean, Global Journals Inc. (US)  
Website: www.suyogdixit.com  
Email:suyog@suyogdixit.com  

**Pritesh Rajvaidya**  
(MS) Computer Science Department  
California State University  
BE (Computer Science), FICCT  
Technical Dean, USA  
Email: pritesh@computerresearch.org

**Luis Galárraga**  
J!Research Project Leader  
Saarbrücken, Germany
CONTENTS OF THE VOLUME

i. Copyright Notice
ii. Editorial Board Members
iii. Chief Author and Dean
iv. Table of Contents
v. From the Chief Editor’s Desk
vi. Research and Review Papers

1. Analysis of Al₂O₃/Al FGM as Biomaterial of Artificial Human Femoral Bone and Compare with Ti6Al4V Alloy Through Computational Study. 1-8
2. Glance of Hydro forming of Tubular Structure and Sheet Metal with Varing Blank Holding Loads by FEA & FTI. 9-14
3. Analysis of MRR and SR with Different Electrode for SS 316 on Die-Sinking EDM using Taguchi Technique. 15-21
4. The Characteristics of Torsionally Flexible Metal Coupling. 23-27
5. Failure Mode, Effects and Criticality Analysis of Load Haul Dump Vehicles (100t) in Open Cast Mines. 29-33

vii. Auxiliary Memberships
viii. Process of Submission of Research Paper
ix. Preferred Author Guidelines
x. Index
Analysis of $\text{Al}_2\text{O}_3/\text{Al}$ FGM as Biomaterial of Artificial Human Femoral Bone and Compare with Ti6Al4V Alloy through Computational Study

By Tousif Ahmed, Muhammad Ziaur Rahman & Debasish Adhikary

Abstract - A finite element model of bones with accurate geometry and material properties generated in CAD softwares are being widely used to make realistic investigations on the mechanical behavior of bone structures. The aim of this study is to create a model of real proximal human femur bone for evaluating the finite element analysis (FEA) and investigate the use of Ti6Al4V and $\text{Al}_2\text{O}_3/\text{Al}$ FGM for artificial femur. Here, behavior of femur bone is analyzed in ANSYS 13 workbench under physiological load conditions and compared with artificial femur composed of Ti6Al4V and $\text{Al}_2\text{O}_3/\text{Al}$ FGM. The CAD model was imported in Ansys 13.0 workbench, meshed and analysed in Ansys mechanical APDL workbench under the loading conditions. It was found that both material are suitable for artificial bone material. Human femur with $\text{Al}_2\text{O}_3/\text{Al}$ FGM showed better mechanical properties and less weight compared to Ti6Al4V. In the biological environment, the demands of biomaterials are challenging. This study will be useful to surgeon in femur surgeries and bone prosthesis. These better synthetic bone substitutes will most probably be commercially available for orthopaedic applications in the near future.

Keywords : $\text{Al}_2\text{O}_3/\text{Al}$ FGM; Ti6Al4V; ansys 13.0; FEA; femur; solid works; CAD.

GJRE-A Classification : FOR Code: 091399
Analysis of \( \text{Al}_2\text{O}_3/\text{Al} \) FGM as Biomaterial of Artificial Human Femoral Bone and Compare with Ti6Al4V Alloy through Computational Study

Tousif Ahmed " & Muhammad Ziaur Rahman " & Debasis Adhikary "

Abstract - A finite element model of bones with accurate geometry and material properties generated in CAD softwares are being widely used to make realistic investigations on the mechanical behavior of bone structures. The aim of this study is to create a model of real proximal human femur bone for evaluating the finite element analysis (FEA) and investigate the use of Ti6Al4V and Al\(_2\)O\(_3/\)Al FGM for artificial femur. Here, behavior of femur bone is analyzed in ANSYS 13 workbench under physiological load conditions and compared with artificial femur composed of Ti6Al4V and Al\(_2\)O\(_3/\)Al FGM. The CAD model was imported in Ansys 13.0 workbench, meshed and analysed in Ansys mechanical APDL workbench under the loading conditions. It was found that both material are suitable for artificial bone material. Human femur with Al\(_2\)O\(_3/\)Al FGM showed better mechanical properties and less weight compared to Ti6Al4V. In the biological environment, the demands of biomaterials are challenging. This study will be useful to surgeon in femur surgeries and bone prosthesis. These better synthetic bone substitutes will most probably be commercially available for orthopaedic applications in the near future.

Keywords : Al\(_2\)O\(_3/\)Al FGM; Ti6Al4V; ansys 13.0; FEA; femur; solid works; CAD.

1. INTRODUCTION

Titanium alloys are considered to be the most attractive metallic materials for biomedical applications. In biomedical applications Titanium alloys specifically Ti6Al4V is mostly favoured. But it is a matter of great concern that this alloy has possible toxic effect resulting from released vanadium and aluminum in case of permanent implant applications [13].

This unique study is conducted to analyze the prospect of Al\(_2\)O\(_3/\)Al FGM which is a relatively new concept as biomaterials. As, FGM has relatively less decompose rate over time, this is one of the most prospective materials in permanent implant applications.

Mechanical properties of human bones and implant devices are of prime interests to Clinicians and engineers for decades. Researches are going on to findout a material that copes with human body well, hasgood mechanical properties and of course low price. To do this the use of three dimensional (3-D) finite element analysis (FEA) for orthopedic application

is well accepted for more than three decades [1]. Bone exhibits elastic linear behavior at macro level for the normal range of regular daily activities [9]. As a result, although the bone is a complex biological tissue, the use of FEA is attractive. The need for reconstructive surgery of bones is continuously increasing along with the ageing of the population as well as the increase of traumatologic injuries. In 2001 350,000 bone grafting was conducted only in USA. Nowadays, over 500,000 bone graft procedures are performed annually, and approximately 2.2 million world wide (Giannoudis et al., 2005) [10]. Per year total cost of this process exceeds billions of dollers. Hence, solely donor material cannot meet this surplus amount of bone replacement. Autografts are still regarded as optimal reconstruction material, because of the lack of good enough synthetic materials. However, highly engineered structures can fulfill the demand of synthetic biomaterials to a great extent. In fact, it is possible to mimic better the structures of living materials, like bone, cartilage or teeth using substitute materials. Therefore, the search for better synthetic bone substitute is consistant.

II. FEMUR'S CAD MODEL GENERATION METHODOLOGY

The 3D model was generated using Solid works 12, a highly efficient and easy to use CAD modeling software. Using a reals bones sketch and dimensions the 3D model was generated using different advanced features of Solid works.

Figure 1 : Planes defined for sketching

Author α : Department of Mechanical Engineering, University of Engineering and Technology, Dkaha-1000, Bangladesh. E-mail : tousif.ahmed54@gmail.com

© 2013 Global Journals Inc. (US)
A total of five planes was created to generate different major features on the specified plane. All planes were offset of the base plane at different distances as shown in Figure 1. Figure 2 shows the drawing sketched on the plane 40.

**Figure 2**: The shape defining sketch

Similarly, in planes 190, 300 and 420 sketches in Figure 3 were drawn.

**Figure 3**: Sections for defining the full profile

Figure 4 presents the base shape generated using Loft feature.

**Figure 4**: The base shape

Revolve feature was used to generate the specific feature shown in Figure 5.

**Figure 5**: Generation of femur head support

At that feature it was attached a secondary shape using Dome command (Figure 6).
Figure 6: Generation of head by dome feature

The features shown in Figure 7 were obtained by using Extrude feature in Insert menu twice.

Figure 7: After bose extrude

Figure 8 shows the modelling done by Loft feature in Solidworks.

Figure 8: Loft feature defining in the mid plane

Two Dome shapes were attached at the two extruded shape and fillets were introduced after that (Figure 9).

Figure 9: Dome feature for accurate shape generation

In an inclined plane with 120 degrees it was drawn the sketch presented in Figure 10.

Figure 10: The sketch drawn in inclined plane

Revolve feature was applied to the previous sketch in Figure 10. The output is shown in Figure 11.
Fillet of 3mm radius was introduced to the selected areas (Figure 12).

After some minor operations and editings the femur bone was fully generated as shown in Figure 13.

III. Modeling of Materials’ Properties

a) $\text{Al}_2\text{O}_3$/Al FGM

For modeling $\text{Al}_2\text{O}_3$/Al FGM methodology of Debabrata Chakraborty, Manish Ranjan and Anil Kumar was adapted [3]. In this study, the functionally graded material of thickness $h$, consisting of two constituent materials has been considered. The effective material properties of FGM shell is obtained by power law distribution where $P(z)$, the material property at any location $z$ was related with $P_t$ and $P_b$ are the material properties of the top surface ($\text{Al}_2\text{O}_3$) and bottom surface (Al) respectively.

$$P(z) = P_t - P_b \left(\frac{2z + h}{2h}\right)^n + P_b$$  \hspace{1cm} (1)

In the equation (1) if $\lambda$ is set to 0, a component fully made of ceramic will be formed. On the other hand content of metal increases as $\lambda$ increases. Poisson's ratio, $\nu$ is assumed to be constant throughout the material. The stress-strain relationship can be expressed as

$$\begin{bmatrix}
\frac{E}{1-\nu}\frac{1}{2}
\nu \frac{1-\nu}{2}
\frac{1-\nu}{2}
\end{bmatrix}
\begin{bmatrix}
\varepsilon_{xx} \\
\varepsilon_{yy}
\end{bmatrix} =
\begin{bmatrix}
\sigma_{xx} \\
\sigma_{yy}
\end{bmatrix}$$

This methodology was validated by the study of dynamic response of a simply supported square isotropic plate subjected to suddenly applied uniform load $q = 100 \text{ kN/m}$. The outcomes were compared with the results published by Kant et al. [6] as shown in Figure. 14. The dimensions and material properties of the plate are $a = b = 250 \text{ mm}$, $h = 50 \text{ mm}$, $E = 21 \text{ GPa}$, $\nu = 0.25$, $\rho = 800 \text{ kg/m}$. It is observed from Figure.2 that the result from the present code converges well with 88 mesh size and in excellent agreement with the already published results of Kant et al. [6].
b) Ti6Al4V Alloy

“Ti6Al4V, Ti-6Al-4V or Ti 6-4, is the most commonly used Titanium alloy. It has a chemical composition of 6% aluminium, 4% vanadium, 0.25% (maximum) iron, 0.2% (maximum) oxygen, and the remainder titanium. It is significantly stronger than commercially pure titanium while having the same stiffness and thermal properties (excluding thermal conductivity, which is about 60% lower in Grade 5 Ti than in CP Ti). Among its many advantages, it is heat treatable. This grade is an excellent combination of strength, corrosion resistance, weld and fabricability. This alpha-beta alloy is the workhorse alloy of the titanium industry. The alloy is fully heat treatable in section sizes up to 15mm and is used up to approximately 400°C (750°F). Since it is the most commonly used alloy – over 70% of all alloy grades melted are a sub-grade of Ti6Al4V, its uses span many aerospace airframe and engine component uses and also major non-aerospace applications in the marine, offshore and power generation industries in particular. Generally, Ti-6Al-4V is used in applications up to 400 degrees Celsius. It has a density of roughly 4420 kg/m³, Young’s modulus of 110 GPa, and tensile strength of 1000 MPa. By comparison, annealed type 316 stainless steel has a density of 8000 kg/m³, modulus of 193 GPa, and tensile strength of only 570 MPa. And tempered 6061 aluminium alloy has 2700 kg/m³, 69 GPa, and 310 MPa, respectively.” [11]

IV. A CASE STUDY: TYPICAL FEMUR UNDER LOAD

To demonstrate the behavior of the femur modeled for Al₂O₃/Al FGM and Ti6Al4V, a simple example is presented here. This example is not a best case or worst case scenario but rather just a pseudo random example to see if and how much proper the materials are for artificial bone.

Relevance Center set to medium. A fine relevance center would yield better results but it causes very high amount of RAM consumption which was unavailable. The Inflation Option settings determine the heights of the inflation layers. Smooth Transition was set for obtaining desired mesh refinement. The Smooth Transition option uses the local tetrahedral element size to compute each local initial height and total height so that the rate of volume change is smooth. Each triangle that is being inflated will have an initial height that is computed with respect to its area, averaged at the nodes. This means that for a uniform mesh, the initial heights will be roughly the same, while for a varying mesh, the initial heights will vary. Increasing the value of the Growth Rate control reduces the total height of the inflation layer. The total height approaches an asymptotic value with respect to the number of inflation layers. Span Angle Center sets the goal for curvature based refinement. The mesh will subdivide in curved regions until the individual elements span this angle. The following choices are available:

- Coarse - 91° to 60°
- Medium - 75° to 24°
- Fine - 36° to 12°

For this study Curvature Normal Angle was set to 180°. Figure. 15 shows surface mesh of femur bone.

![Figure 15: Surface mesh of the femur bone](image)

The three dimensional model of femur bone was imported in ANSYS and was meshed with Ansys default mesh tool. An eccentric and concentrate load of 300N applied at the head of femur bone and fixed support is provided at lateral condyle, medial condyle and patellar surface in Ansys Mechanical workbench. The boundary conditions are shown in Figure. 16 and load applied is shown in Figure. 17.

![Figure 16: Boundary Conditions](image)

The load applied here was ramped load which was applied for 1 second varying linearly 0N to 300N. Figure 5 shows ramp load applied on the femur.

![Figure 17: Applied load on the femur](image)
V. RESULTS AND DISCUSSION

It may be noted that only static load applied on Femur. Though \( \text{Al}_2\text{O}_3/\text{Al} \) FGM is relatively new concept compared to Ti6Al4V, it has higher reliability and less weight. From the properties of Ti6Al4V and Al based FGM (i.e. \( \text{Al}_2\text{O}_3/\text{Al} \) FGM) we can see that FGM has slightly less strength than Ti6Al4V. But from aluminum based FGM sudden release of Al is less frequent and safe. As a result Al based FGM has become a strong competitor in the field of artificial bone material.

Figure 18 and 19 shows the deformation pattern of the femur for Ti6Al4V and \( \text{Al}_2\text{O}_3/\text{Al} \) FGM respectively.

These Figures shows similar patterns of deformation both for Ti6Al4V and \( \text{Al}_2\text{O}_3/\text{Al} \) FGM. From the max-min deformation probe label it is observed that at the head of the femur deformation is maximum and at the lateral condyle deformation is zero. Maximum and minimum deformation of the femur in both cases are shown in Table 1.

Table 1: Maximum and Minimum Deformation

<table>
<thead>
<tr>
<th>Material</th>
<th>Deformation (m)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
<td></td>
</tr>
<tr>
<td>Ti6Al4V</td>
<td>1.2349e-003</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>( \text{Al}_2\text{O}_3/\text{Al} ) FGM</td>
<td>5.6276e-003</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

Observe maximum and minimum values of deformation from table 1 are in acceptable range compared to the values of deformations for actual femur bone studied by Raji Nareliya with a factor of safety 15 [7].

Figure. 20 shows variation of deflection of the bone under load along the path shown in Figure. 21.

From the deflection curve it is observed that \( \text{Al}_2\text{O}_3/\text{Al} \) FGM gives 9 times less deflection than Ti6Al4V for same loading criteria. As, load applied to the femur bone varied linearly with time (Figure 5), we got the deformation almost linear along the path shown. Moreover, this curve is almost identical to Figure. 22 which was obtained by Somkid, Benchawan and Kamonchat’s research work [8].
It is observed from max-min stress probe label that minimum stress occurs at the both ends of the femur and gradually increases to the middle portion of the bone. Maximum and minimum stress of the femur in both cases are shown in table 2.

<table>
<thead>
<tr>
<th>Material</th>
<th>Equivalent (Von Misses) stress (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti6Al4V</td>
<td>Maximum: 2.9744e+007 Minimum: 3072.4</td>
</tr>
<tr>
<td>Al2O3/Al FGM</td>
<td>Maximum: 2.9721e+007 Minimum: 17324</td>
</tr>
</tbody>
</table>

V. Conclusion

In the field of biomedical, research on biomaterial is of utmost important. Typically, in the reconstruction of bone defects, clinicians use autograft bone, based on the fact that the commercially available synthetic materials are not optimal for the reconstruction of bone. Moreover, as stated earlier for total bone replacement the need for specialized biomaterial is of utmost importance. This study deals with Ti6Al4V and Al2O3/Al FGM as prospective candidate of femur bone material. Both of these materials has friendly behavior with MRI. This computational study reveals mechanical characteristics of Ti6Al4V and Al2O3/Al FGM under a random loading. Overall study shows that Al2O3/Al is more suitable than Ti6Al4V in case of both strength and weight of the bone. This study will be useful to surgeon in femur surgeries and bone prosthesis. These better synthetic bone substitutes will most probably be commercially available for orthopaedic applications in the near future.

Acknowledgments

Author would like to acknowledge Lab Aid Hospital, Bangladesh. Accurate dimensions and sketch of the femoral bone was provided by Lab Aid Hospital. Author also like to thank department of mechanical engineering, BUET, as all CAD models and simulations were conducted at ME Simulation Lab.

References

8. Somkid Amornsamankul, Benchawan Wiwatanapataphee, Kamonchat Kaorapapong, "Three-Dimensional Simulation of the Femur Bone Using Finite Element Method" Selected Topics in APPLIED COMPUTER SCIENCE.
Glance of Hydroforming of Tubular Structure and Sheet Metal with Varing Blank Holding Loads by FEA & FTI

By Rakesh Jadhav & Tippa Bhimasankara Rao

Abstract - Hydroforming is a cost-effective way of shaping ductile metals such as aluminium, brass, low alloy steel, stainless steel into lightweight, structurally stiff and strong pieces. One of the largest applications of hydro forming is the automotive industry, which makes use of the complex shapes possible by hydro forming to produce stronger, lighter, and more rigid anybody structures for vehicles. This technique is particularly popular with the high-end sports car industry and is also frequently employed in the shaping of aluminium tubes for bicycle frames. Hydro forming is a specialized type of die forming that uses a high pressure hydraulic fluid to press room temperature working material into a die. Hydroforming is done for tubular structure and sheet metal also. Finite element modeling and simulations of hydroforming sheet metal process and closed sections has been carried out with the emphasis on draw-in effect. For that used FEA and FTI methods. A Finite element model is built to simulate the different stages of the hydroforming process under various blank holding forces.

Keywords : hydro-forming, tubular members, sheet metal, FTI, FEA.

GJRE-A Classification : FOR Code: 840305
Abstract - Hydroforming is a cost-effective way of shaping ductile metals such as aluminium, brass, low alloys steel, stainless steel into lightweight, structurally stiff and strong pieces. One of the largest applications of hydro forming is the automotive industry, which makes use of the complex shapes possible by hydro forming to produce stronger, lighter, and more rigid ready structures for vehicles. This technique is particularly popular with the high-end sports car industry and is also frequently employed in the shaping of aluminium tubes for bicycle frames. Hydro forming is a specialized type of die forming that uses a high pressure hydraulic fluid to press room temperature working material into a die. Hydroforming is done for tubular structure and sheet metal also. Finite element modeling and simulations of hydroforming sheet metal process and closed sections has been carried out with the emphasis on draw-in effect. For that used FEA and FTI methods. A Finite element model is built to simulate the different stages of the hydroforming process under various blank holding forces.

Keywords : hydro-forming, tubular members, sheet metal, FTI, FEA.

1. Introduction

Hydroform is a popular word in sheet metal industry and tube forming industry. Hydro forming process is used for strengthening of the metal, hydramolding also produced less “grainy” parts, allowing for easier metal finishing. In Hydroforming process high pressurised oil and water are used to form a metal.

Sheet-forming process include a very large variety of shapes and sizes, ranging from simple bends to double curvatures with shallow or deep recesses and even very complex shapes. Typical examples are automobile bodies, aircraft panels, appliance bodies, kitchen utensils and beverage cans. Sheet metal process and tube forming process may gives the fair idea about the strategy of metal forming process.

In that, Hydroforming help us to give simplify of operations with light weight structure and complex geometry. In 1970’s that rapid development of computer technology and finite element techniques made computed aided design and manufacturing technology (CAD/CAM) available to industry. At present a great deal of effort is being made to implement CAD/CAM technology in sheet metal forming industry, such as the auto industry, aerospace and aircraft manufacturing industries.

The implementation of computer aided design and manufacturing technology assist the manufacturing industry significantly in reducing the cost, shortening the cycle time for developing new products and improving both quality and productivity.

II. Main Process Variants

a) Sheet Hydroforming

This process is based on the 1950s patent for hydramolding by Fred Leuthesser, Jr. and John Fox of the Schaible Company of Cincinnati, OH it was originally used in producing kitchen spouts. This was done because in addition to the more strength. In sheet hydroforming there are bladder forming (where there is a bladder that contains the liquid; no liquid contacts the sheet) and hydroforming where the fluid contacts the sheet (no bladder). Bladder forming is sometimes called flex forming Flex forming is mostly used for low volume productions, as in the aerospace field. Forming with the fluid in direct contact with the part can be done either with a male solid punch (this version is sometimes called hydro-mechanical deep drawing) or with a female solid die.

In hydro-mechanical deep drawing, a work piece is placed on a draw ring (blank holder) over a male punch then a hydraulic chamber surrounds the work piece and a relatively low initial pressure seats the work piece against the punch. The punch then is raised into the hydraulic chamber and pressure is increased to as high as 15000 psi which forms the part around the punch. Then the pressure is released and punch retracted, hydraulic chamber lifted, and the process is complete.

For large parts, explosive hydroforming can generate the forming pressure by simply exploding a charge above the part (complete with evacuated mold) which is immersed in a pool of water. The tooling can be much cheaper than what would be required for any press-type process. The hydroforming into a mold-process also works using only a shock wave in air as the...
pressuring medium. Particularly when the explosives are close to the work piece, inertia effects make the result more complicated than forming by hydrostatic pressure alone.

b) Tube Hydroforming

In tube hydroforming there are two major practices: high pressure and low pressure. With the high pressure process the tube is fully enclosed in a die prior to pressurization of the tube. In low pressure the tube is slightly pressurized to a fixed volume during the closing of the die (this used to be called the Variform process). Historically, the process was patented in the but it was industrially spread in the '70s for the production of large T-shaped joints for the oil & gas industry. Today it is mostly used in the automotive sector, where many industrial applications can be found. It is also a method of choice for several tubular members of bicycles. In tube hydroforming pressure is applied to the inside of a tube that is held by dies with the desired cross sections and forms. When the dies are closed, the tube ends are sealed by axial punches and the tube is filled with hydraulic fluid.

The internal pressure can go up to a few thousands of bars and it causes the tube to calibrate against the dies. The fluid is injected into the tube through one of the two axial punches. Axial punches are movable and their action is required to provide axial compression and to feed material towards the center of the bulging tube. Transverse counterpunches may also be incorporated in the forming die in order to form protrusions with small diameter/length ratio. Transverse counterpunches may also be used to punch holes in the work piece at the end of the forming process. Designing the process might be a very challenging task, since analytical modelling is possible only for very simples cases. Often FEM simulations must be performed in order to find a feasible process solution and to define the correct loading curves: pressure vs. time and axial feed Vs time.

III. Sheet Metal Aspects

a) Formability Describes The Capacity Of The Sheet Metal To Be Formed Into Designed Shape Without Necking And Fracture. Unlike In The Bulk Deformation Process, Work Pieces In Sheet Forming Are Manipulated To Prevent Reduction In The Cross-Sectional Area So As To Avoid Necking And Fracture.

b) Buckling Or Wrinkling Does Not Only Cause Another Type Of Failure Of The Products, But Also Brings Difficulties In The Theoretical Aspect.

c) Surface Finish Is Another Significant Factor Since Parts Formed By Sheet Forming Processes Are Generally Not Subjected To Further Processing, Except For Surface Coating, Parting And Joining.

d) Spring Back May Affect The Final Shape Of The Product, Especially When More Bending Is Involved In The Operation.

In hydro forming process, liquid is used as medium of energy transfer to form the workpiece. There are essentially two different types of applications of the liquid pressure: Hydraulic die and Hydraulic punch. In this paper, only the hydraulic punch forming process will be discussed. A typical equipment used for this process.

In Figure (3), the blank is clamped by the upper blank holder and lower die which can be either plane or serrated (rough surface). The blank holding load can be controlled by the clamping bolts 1. Pressured liquid enters the room A and force the blank to deform against the solid die 2, so that the desirable shape can be achieved.
The coordinates and displacement used in the axisymmetrical sheet forming process are defined as following: a point P in the blank with a initial distance are moves to the coordinate \((r + Lr, y)\). \(s\) is the curvature coordinate.

\(r\) is the surface normal.
\(E\) is the circumferential coordinate.

Three principle strains are:
- Circumferential strain \(E_a = \log_e \left( \frac{r+r}{r} \right)\)
- Meridional tangential strain \(E_s = \log_e \left( \frac{ds}{dr} \right)\)
- Through thickness strain \(E_t = \log_e \left( \frac{t}{t_0} \right)\)

Figure 3: Schematic illustration of Erichsen Test

Figure 4: Coordinates and displacement in axisymmetric sheet forming process
In order to exhibit the draw-in effect on the sheet metal forming process, it is necessary to define the measure of draw-in. Kaftanoglu and Alexander [4] used the circumferential strain that occurs at the inside diameter or bore of the blank-holder to define the quantity of draw-in. When the draw-in of the flange is totally prevented, the $\varepsilon_a$ is zero. But, once the draw-in occurs, the $E_*$ becomes compressive and numerically larger. Hence, reflect the actual local draw-in quality.

Let see al introduced a draw-in parameter $q >$ by measuring the movement of the flange. In Fig (5), BB is the die opening line, CC is defined as when polar height L is attained, the material on CC of the undeformed blank reaches the die opening line DD. $<p$ is defined in the form of strain $<p = \loge \left( \frac{A_c}{A_D} \right)$ $A_c$ and $A_D$ denote respectively the area inside the circle of CC and DD. $<p$ reflects the overall draw-in quantity.

![Figure 5: Flange movement during the Blanking Process](image)

IV. Calculations & Simulation

Finite Element Modelling:-

Result (a): Simulation in FTI software-
Result (b): Simulation in FEA-

\[ \varepsilon = \ln \left[ 1 - \exp \left( -ne \right) \right] + k \]
Where \( \varepsilon \) is the true strain defined as
\[ \varepsilon = \frac{2}{9} \left[ (\varepsilon_1 - \varepsilon_2)^2 + (\varepsilon_2 - \varepsilon_3)^2 + (\varepsilon_3 - \varepsilon_1)^2 \right]^{0.5} \]

\( \sigma \) is the true strain
\[ \sigma = 1, \left[ (j_1 - j_2)^2 + (j_2 - j_3)^2 + (j_3 - j_1)^2 \right]^{0.5} \]

V. Conclusion

In this investigation, the hydro forming of Axis symmetric sheet metal with different blank holding conditions has been Simulated in FTI and Finite Element Method. The elastoplastic finite element package has been used to calculate the large plastic deformation. Comparison has been made between the simulation results and the experimental results and has a good agreement has been observed.

Based on the verified modelling, the effects of draw-in on the hydro forming process have been analysed. It is observed that during hydro forming process the deformation in the work piece is nearly a balancebiaxial stretching. Draw-in results in little effect on the strain state in the work piece in the hydro forming process.

The severity of deformation in the blank may be reduced by the draw-in action. Because of its higher threshold strain, the balanced biaxial stretching is a state which is expected in sheet metal forming process. With greater draw-in, a higher polar height can be achieved.

The formality which is represented by the limiting of thickness strain at critical section \( E_t \) * remains substantially constant under different draw-in conditions.

In future research, it is suggested that experiments should be carried out for hydro forming process with varying blank load. Effort should be continued to explore how to further reduce the tendency of wrinkling at the die shoulder area. Concerning finite element simulation, a better shell element is needed the two side contact clamping condition.

VI. Acknowledgment

I would also like to express my gratitude to all those who have helped me with my work. Finally, and most importantly, I would like to express my warmest appreciation to my family and friends. Throughout this process, it has been a comforting feeling to have the support of loved ones that not only show genuine interest in my work, but who also help me to complete my work.

References Références Referencias


Analysis of MRR and SR with Different Electrode for SS 316 on Die-Sinking EDM using Taguchi Technique

By Suraj Choudhary & Parveen Saini

Abstract - The development of new materials show the immense growth but the major problem, it is very difficult to machine the newly developed materials. So it is necessary to adopt some new machining methods. Electrical Discharge Machining (EDM) is a non-traditional and most popular machining method to manufacture dies, punches and press tools because of its capability to produce complicated, intricate shapes and to machine hard materials. From the industrial point of view stainless steel 316 is a very commonly used material due to its property of resistant to corrosion. During experimentation, electrode material, current and pulseon time were taken as variables for the study of material removal rate and surface roughness. Three different electrode materials copper, brass and graphite were used with EDM oil as a dielectric fluid in the experiment. Using Taguchi method, L9 orthogonal array has been chosen and three levels corresponding to each of the variables are taken. Experiments have been performed as per the set of experiments designed in the orthogonal array. Results of experimentation were analyzed analytically as well as graphically. Signal to Noise ratio was calculated to analyze the effect of input parameter more accurately. It is found that ANOVA has unable to find the key significant parameters for the output response due to less number of variables and factors. The optimal value of MRR and SR were also calculated using their signal to noise ratio value.

Keywords : EDM, taguchi design orthogonal array.

GJRE A Classification : FOR Code: 290501

Strictly as per the compliance and regulations of :
Analysis of MRR and SR with Different Electrode for SS 316 on Die-Sinking EDM using Taguchi Technique

Suraj Choudhary & Parveen Saini

Abstract - The development of new materials show the immense growth but the major problem, it is very difficult to machine the newly developed materials. So it is necessary to adopt some new machining methods. Electrical Discharge Machining (EDM) is a non-traditional and most popular machining method to manufacture dies, punches and press tools because of its capability to produce complicated, intricate shapes and to machine hard materials. From the industrial point of view stainless steel 316 is a very commonly used material due to its property of resistant to corrosion. During experimentation, electrode material, current and pulse-on time were taken as variables for the study of material removal rate and surface roughness. Three different electrode materials copper, brass and graphite were used with EDM oil as a dielectric fluid in the experiment. Using Taguchi method, L9 orthogonal array has been chosen and three levels corresponding to each of the variables are taken. Experiments have been performed as per the set of experiments designed in the orthogonal array. Results of experimentation were analyzed analytically as well as graphically. Signal to Noise ratio was calculated to analyze the effect of input parameter more accurately. It is found that ANOVA has unable to find the key significant parameters for the output response due to less number of variables and factors. The optimal value of MRR and SR were also calculated using their signal to noise ratio value. From the experimental results it is clear that copper electrode, higher current value (30A) and pulse-on value (50µs) possess highest MRR while brass electrode, lower current value (18A) and higher pulse-on time (60µs) value has better surface finish.

Keywords : EDM, taguchi design orthogonal array.

1. Introduction

a) Electrical Discharge Machining (EDM)

Electrical Discharge Machining is a non-traditional concept of machining. It has been widely used for making dies, punches and molds. It is also used in manufacturing of finished parts for automotive and aerospace industries and surgical components. It is also called spark erosion machining method because in this method material of work piece is removed by erosion effect by the electric spark. This process can be successfully employed to machine electrically conductive parts irrespective of their hardness, shape and toughness [1]. The EDM machine has a tool and a work piece which is to be machined. In die-sinking EDM, the shape of tool used for spark generation is a replica of the shape of which is to be produced. The tool electrode and the work are held at an accurately controlled distance from one another, which are dependent on the operating conditions and referred to as spark gap. Both the tool and the work piece are dipped in a dielectric medium like kerosene, EDM oil etc [2].

b) Historical Background

The origin of electrical discharge machining goes far back to 1770, when English scientist Joseph Priestly discovered the erosive effect of electrical discharges on metals but after that the full advantage of this concept had not been taken till 1943. The Lazarenko, used resistance capacitance type of power supply, which is widely used in 1950s. This idea gave a new born to the EDM process but during the 1948-1950 this idea started to spread in the industrial world area. In 1980s the advancement of computer numerical control (CNC) in EDM has brought a great turn in improving the efficiency of machining operations, pulse recognition, real time analysis, A.C tool wear analysis, controls and expert systems [3,1]. Wire EDM machine (WEDM) touched the new heights of performance. The phase 1990-95 brought the new parametric approach, Neutral networks and Fuzzy controllers. Modern era from 1995 till date brought in various new aspects in EDM machining such as micromachining by EDM and machining without liquid dielectric. Now EDM is more accepted technique for material removal next to CNC Milling [4].

c) Process of EDM

The working principle of EDM is based on the thermoelectric energy. This energy is created between the electrode and the work piece, dipped in dielectric fluid with the passage of electric current. The work piece and electrode are separated by a small gap called spark gap. Pulsed arc discharges occur in this gap filled with a dielectric liquid like hydrocarbon oil or de-ionized (de-mineralized) water. The technique of material removal with EDM is still arguable. This is because ignition of
electrical discharges in a liquid filled gap, when applying EDM, is mostly interpreted as ion action identical as found by physical research of discharges in air or in vacuum.

As well as with investigations on the break through strength of insulating hydrocarbon liquids. EDM with a system comprising two major components: a machine tool and power supply [5]. The electrode (tool) is held in machine tool, which advances towards the work piece and produces a high frequency series of electrical spark discharge.

The spark is generated by a pulse generator between electrode and work material. The reduced spark gap results that the applied voltage is high enough to ionize the dielectric fluid. The electrode and work piece are separated by the short duration pulses which are generated in liquid dielectric gap. The spark is generated at the smallest inter electrode gap. The erosive effect of discharges removes the material from the tool and the work piece. The discharge energy is concentrated on very small cross-section with the dielectric fluid. It flushes out the removed material during machining and cools the electrode from heating. The erosion of work piece material uses electrical energy and converts them into the thermal energy through a series of electrical discharges.

The material is removed by partial vaporization or melting. The removed debris which is in molten state re-solidified and flushes out with help of dielectric fluid. The thermal energy generates plasma between tool and work material having temperature range 8000°C to 12000°C and high as 20000°C. When the DC supply is switch off then plasma channel breaks down results in reduction in temperatures [6].

In EDM operation, the material removal rate is less than the conventional machining. The amount of material removal is dependent upon the amount of pulsed current in each discharge, frequency of the discharge, dielectric flushing condition, electrode material and work piece material. Surface finish is an important factor for the work-piece. It becomes more vital so as to produce a better surface when hard materials are machined, requiring no subsequent polishing.

Surface finish is also important in the case of tools and dies for moulding as well as drawing operations. Surface finish mainly depends upon the type of electrode used, value of discharged current and polarity [4].

II. Past Work

Many researchers used the steel for their experimentation like AISI 304, En 31, XW 42 and many more on EDM but still no work is done on Stainless Steel 316 which is one of the most commonly used steel in manufacturing industries due to its better corrosion resistance, weldability properties and called as “marine grade stainless steel". Mostly work has been done by using kerosene as a dielectric only few researchers used the EDM oil. In all steel that used as studied in literature brass and graphite is the least used as a tool electrode. Only few researchers used the ANOVA technique for the analysis of result due to lack of experimental design. Without the use of ANOVA, no significant parameters and individual contribution of input parameter to the response cannot be calculated [7].

The behaviour of different material is different during the machining both for electrode and work piece in EDM because every material have different composition so it is necessary to know that which material gives the highest material removal rate and better surface finish with suitable electrode especially for those material which is commonly in use. So in this work it was proposed to study the effects of different input parameter electrode material, current and pulse-on time on Material removal rate (MRR) and Surface roughness (SR) with EDM oil as a dielectric. The experimental design has been done by using Taguchi technique. The response has been analysed using S/N ratio and analysis of Variance.

III. Experimental Setup & Procedure

The experiments have been conducted on Electrical Discharge Machine model T-3822 of Electronic available at Ambala college of Engg. Mithapur in the machine Lab as shown in Fig 3.1. Many input parameters like discharge voltage, pulse on time, pulse off time, polarity, peak current, electrode gap and dielectric pressure can be varied in EDM process. Each factor has its own effect on the output parameters such as tool wear rate (TWR), material removal rate (MRR), surface roughness (SR), hardness of the machined surface, overcut size and profile/geometry accuracy. The range of the input parameters is constrained by this model of EDM machine.

Figure 3.1 : Set-up of Electrical Discharge Machine
The input parameters, which were kept constant during the experimentation, are below in the Table No.3.1.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameter</th>
<th>Set Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Polarity</td>
<td>Positive</td>
</tr>
<tr>
<td>2</td>
<td>Machining Time</td>
<td>15 minute</td>
</tr>
<tr>
<td>3</td>
<td>Pulse off</td>
<td>5µs</td>
</tr>
<tr>
<td>4</td>
<td>Open circuit voltage</td>
<td>80±5%</td>
</tr>
<tr>
<td>5</td>
<td>Dielectric Pressure</td>
<td>EDM oil</td>
</tr>
<tr>
<td>6</td>
<td>Diameter of electrodes</td>
<td>10mm</td>
</tr>
</tbody>
</table>

Surface roughness was measured using the apparatus of company Mitutoyo; model Surfest SJ-301 at MMU, Mullana. The equipment uses the stylus method of measurement and measure roughness up to 100µm. Surface roughness of each sample was measured at three different positions of each machined sample.

Stainless Steel 316 is secondly most common used austenitic steel. Stainless steel 316 is the standard molybdenum-bearing grade. The molybdenum gives 316 better overall corrosion resistant properties than grade 304, particularly higher resistance to pitting and corrosion in chloride environments. It has excellent forming and welding techniques. It also has good welding characteristics.

<table>
<thead>
<tr>
<th>C(%)</th>
<th>Mn</th>
<th>Si</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.08</td>
<td>2</td>
<td>0.75</td>
<td>0.045</td>
<td>0.03</td>
<td>18</td>
<td>3</td>
<td>14</td>
<td>0.10</td>
</tr>
</tbody>
</table>

The composition for the stainless steel 316 shown in Table No.3.2. The work piece dimensions for the experiment were Ø60 mm and thickness 10 mm. The mechanical, physical and electrical properties of stainless steel 316 are shown in the table no. 3.3 and 3.4 respectively.

### Table 3.3: Mechanical properties for Stainless steel 316

<table>
<thead>
<tr>
<th>Tensile stress (MPa)</th>
<th>Yield stress (MPa)</th>
<th>Rockwell hardness (HRB)</th>
<th>Brinell hardness (HB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>515</td>
<td>205</td>
<td>95</td>
<td>217</td>
</tr>
</tbody>
</table>

### Table 4.1: Factors & their levels for experiments

<table>
<thead>
<tr>
<th>Factors</th>
<th>Levels</th>
<th>Observed Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrode Material</td>
<td>Level 1</td>
<td>Level 2</td>
</tr>
<tr>
<td>Current, Amp</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Pulse-on, µs</td>
<td>35</td>
<td>50</td>
</tr>
</tbody>
</table>

This grade cannot heat treated by thermal treatment. Stainless steel 316 typical applications include: Laboratory equipments, Food preparation equipment (especially in chloride environment), Chemical containers, Springs, Heat Exchangers.

### IV. Design of Experiments and Data Analysis

L₉ orthogonal array was used in this experiment for the machining parameters. This orthogonal array consists of three control factors and three levels as shown in the table no 4.1. In this study, the material removal rate and surface roughness were analyzed on the basis of maximum and minimum values respectively. So by taguchi method “higher is better” chooses for MRR, and “smaller is better” for SR. Both of the output response was performed with three replication at each set value. The results were analysed on S/N ratio and analysis of variance (ANOVA) which is based on Taguchi method.[7]

**Higher is better**

\[(S/N)_{HB} = -10 \log (MSD_{HB})\]

Where \( MSD_{HB} = \frac{1}{r} \sum_{i=1}^{r} (y_i^2) \)

\( MSD_{HB} = \) Mean Square deviation for higher the better response.

\( r = \) no. of trials

\( y_i = \) the \( i^{th} \) measured value in a row

**Smaller is better**

\[(S/N)_{LB} = -10 \log (MSD_{LB})\]

Where \( MSD_{LB} = \frac{1}{r} \sum_{i=1}^{r} (y_i^2) \)

\( MSD_{LB} = \) Mean Square deviation for lower the better response

### V. Analysis Of Variance (ANOVA)

The knowledge of the contribution of individual factors is critically important for the control the final response. The analysis of variance (ANOVA) is a common statistical technique to determine the percent contribution of each factor for results of the experiment. It calculates parameters known as sum of squares SS(tr), degree of freedom (DOF), variance and percentage of each factor. Since the procedure of ANOVA is a very complicated and employs a considerable of statistical formula, only a brief description of is given as following.

The Sum of Squares SS(tr) is a measure of the deviation of the experimental data from the mean value of the
data[8].

$$SS(tr) = n \sum_{i=1}^{c}(\bar{y}_i - \bar{y})^2$$

Where $n =$ number of response observations

$\bar{y}$ = mean of all observations

$\bar{y}_i =$ mean of $i^{th}$ response

The sum of square of error (SSE) within the groups is calculated by the formula

$$SSE = \sum_{i=1}^{c} \sum_{j=1}^{n}(y_{ij} - \bar{y}_i)^2$$

Where $c =$ no of trials

$y_{ij} =$ Corresponding element of $i, j$

The mean sum of square ($S_B^2$) between the treatments is

$$S_B^2 = \frac{n \sum_{i=1}^{c}(\bar{y}_i - \bar{y})^2}{c-1}$$

The degree of freedom for the factor between treatments is c-1 and for the error is $n_{T-c}$.

The Fisher’s ratio is also called F value. The principle of the F test is that the larger value for a particular parameter, the greater the effect on the performance characteristics due to the change in that parameter. F value is defined as:

$$F = \frac{\text{Mean square for the term}}{\text{Mean square for the error term}}$$

**Table 5.1**: $L_9$ orthogonal array with S/N ratio for the MRR & SR

<table>
<thead>
<tr>
<th>Experiment No.</th>
<th>Electrode Material</th>
<th>Current (Amp)</th>
<th>Pulse-on (µs)</th>
<th>Material Removal Rate (gms)</th>
<th>S/N ratio for MRR</th>
<th>Surface Roughness (µm)</th>
<th>S/N ratio of SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Copper</td>
<td>10</td>
<td>35</td>
<td>1.44</td>
<td>1.42</td>
<td>1.55</td>
<td>3.327</td>
</tr>
<tr>
<td>2</td>
<td>Copper</td>
<td>18</td>
<td>50</td>
<td>2.82</td>
<td>2.78</td>
<td>2.77</td>
<td>8.9109</td>
</tr>
<tr>
<td>3</td>
<td>Copper</td>
<td>30</td>
<td>65</td>
<td>4.14</td>
<td>4.22</td>
<td>4.15</td>
<td>12.4008</td>
</tr>
<tr>
<td>4</td>
<td>Brass</td>
<td>10</td>
<td>50</td>
<td>0.28</td>
<td>0.29</td>
<td>0.3</td>
<td>-10.7624</td>
</tr>
<tr>
<td>5</td>
<td>Brass</td>
<td>18</td>
<td>65</td>
<td>0.48</td>
<td>0.46</td>
<td>0.5</td>
<td>-6.3909</td>
</tr>
<tr>
<td>6</td>
<td>Brass</td>
<td>30</td>
<td>35</td>
<td>0.71</td>
<td>0.75</td>
<td>0.79</td>
<td>-2.5235</td>
</tr>
<tr>
<td>7</td>
<td>Graphite</td>
<td>10</td>
<td>65</td>
<td>0.58</td>
<td>0.54</td>
<td>0.59</td>
<td>-4.9018</td>
</tr>
<tr>
<td>8</td>
<td>Graphite</td>
<td>18</td>
<td>35</td>
<td>1.86</td>
<td>1.88</td>
<td>2.02</td>
<td>5.6487</td>
</tr>
<tr>
<td>9</td>
<td>Graphite</td>
<td>30</td>
<td>50</td>
<td>2.66</td>
<td>2.61</td>
<td>2.56</td>
<td>8.3296</td>
</tr>
</tbody>
</table>

**Table No 5.2**: Average effect response table of S/N ratio for MRR

<table>
<thead>
<tr>
<th>Level</th>
<th>Electrode material</th>
<th>Current</th>
<th>Pulse-on</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.213</td>
<td>-4.1123</td>
<td>2.1508</td>
</tr>
<tr>
<td>2</td>
<td>-6.5589</td>
<td>2.7229</td>
<td>2.1594</td>
</tr>
<tr>
<td>3</td>
<td>3.0255</td>
<td>6.0689</td>
<td>0.3694</td>
</tr>
<tr>
<td>Delta</td>
<td>14.7719</td>
<td>10.1812</td>
<td>1.79</td>
</tr>
<tr>
<td>Rank</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table No 5.3**: Average effect response table of raw data for MRR

<table>
<thead>
<tr>
<th>Level</th>
<th>Electrode material</th>
<th>Current</th>
<th>Pulse-on</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.81</td>
<td>0.7767</td>
<td>1.38</td>
</tr>
<tr>
<td>2</td>
<td>0.5067</td>
<td>1.73</td>
<td>1.8967</td>
</tr>
<tr>
<td>3</td>
<td>1.7</td>
<td>2.51</td>
<td>1.74</td>
</tr>
<tr>
<td>Delta</td>
<td>2.3033</td>
<td>1.733</td>
<td>0.5167</td>
</tr>
<tr>
<td>Rank</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Figure No. 5.1**: Main effects plot for S/N ratio for MRR
After the collection of raw data the calculated S/N ratio value for MRR and SR is shown in the table no.5.1. With help of data shown in table no 5.1., the average effect response of raw data is calculated for MRR and SR is shown in table no.5.3 and 5.6 respectively and average effect response of S/N ratio is calculated for MRR and SR is shown in table no. 5.2 and
5.5 respectively. Electrode material, current and pulse on time is assigned as rank 1, 2, and 3 respectively according to their larger value of delta. Rank 1 means highest contribution factor for the MRR and Rank 3 means lowest contribution factor for MRR. Pulse on is the least contribution parameter. From the figure no. 5.2, it is observes that MRR goes on increasing with higher values of current. MRR has highest value at current 30A. MRR has lowest value at pulse-on 30µs and highest value at 50µs. Copper electrode has highest MRR and Brass have lowest MRR value. Graphite electrode gives average value of MRR comparison with copper and graphite. From the figure no.5.3 it is analysed that the copper electrode has highest surface roughness and brass has lowest surface roughness. It means brass is preferable electrode for better surface roughness. For current, 10A the surface finish is better than other values 18A and 30A. High pulse-on value 65µs has better surface finish than other values 35µs and 50µs.

The purpose of analysis of variance is to determine which input parameter significantly affects the MRR and SR. shown in table no. 5.4 and 5.7 for MRR and SR respectively. In this case the ANOVA table is not supporting because all the parameters were found insignificant. The calculated F-value is less than the Fcritical which is 99. The no. of variables were less for analysing it with ANOVA. For selecting the proper significant parameter with help of ANOVA, larger orthogonal array should be selected.[9]

a) Optimal Design for MRR and SR

In the experimental analysis, main effect plot of S/N ratio for MRR and SR is used for estimating the S/N ratio of MRR with optimal design condition. As shown in the figure no.5.1, electrode material (A) has highest value at level 1 so named it A1. For the current (B) and pulse-on (C) it is B3 and C2 respectively. After evaluating the optimal parameter settings, the next step of the Taguchi approach is to predict and verify the enhancement of quality characteristics using the optimal parametric combination[7]. The estimated S/N ratio using the optimal level of the design parameters can be calculated:

\[ y_{n_{opt}} = 1.5598 + (8.213 - 1.5598) + (6.0689 - 1.5598) + (2.1594 - 1.5598) = 13.3217 \]

Where \( n_{opt} = n_{m} + \sum_{i=1}^{a} (\bar{n}_{i} - n_{m}) \)

where \( n_{m} \) = the total mean of S/N ratio

\( \bar{n}_{i} = \) mean S/N ratio at optimum level

\( a = \) number of design parameters that effect quality characteristics

Based on the above equation the estimated multi response signal to noise ratio can be obtained.

\[ y_{n_{opt}} = 1.5598 + (8.213 - 1.5598) + (6.0689 - 1.5598) + (2.1594 - 1.5598) = 13.3217 \]

\[ y_{opt} = 4.65 \]

As per the optimal level again the experiment is performed as A1 B3 C2. The experimental value that is obtained is 4.10. So the value of percentage change is 11.82%.

For the surface roughness as shown in figure no.5.4 electrode material (A) has highest value at level 2 means at brass so we named it A2. For the current (B) and pulse-on (C) it is B1 and C3 respectively. The estimated S/N ratio using the optimal level of the design parameters can be calculated:

\[ y_{n_{opt}} = -18.458 + (-15.78 + 18.458) + (-16.83 + 18.458) + (-17.37 + 18.458) = -13.064 \]

\[ y_{opt} = 4.49 \]

As per the optimal level again the experiment is performed as A2 B1 C3. The experimental value that is obtained is 4.41. So the value of percentage change is 1.78%.

VII. Conclusion

In the present study, for EDM process the effect of electrode material (copper, brass and graphite), current and pulse-on has been investigated. The effect of input parameter on output response Material removal rate and Surface roughness were analysed for work material stainless steel 316. L9 orthogonal array based on Taguchi design and ANOVA was performed for analysing the result.

1. For the MRR, electrode material is most influencing factor and then discharge current and the last is pulse-on time. MRR increases with the higher value of discharge current.

2. Copper electrode shows the highest MRR while the brass electrode shows the least MRR. For lower value of pulse-on time (35µs) the MRR is low and highest at 50µs. At current 30A, the MRR is highest.

3. For surface roughness, the electrode material is most influencing factor and then discharge current and the last is pulse-on time. SR is better with lower value of current.

4. Brass electrode shows the better surface finish while the copper electrode shows the worst surface finish as comparative to graphite and brass. For higher value of pulse-on (65µs) time the SR is best. At higher current 30A, the SR is highest which is not preferable.

5. Graphite electrode has intermediate value of MRR and SR as comparative to copper and brass electrode. For further study more input parameter can be considered.
References Références Referencias


The Characteristics of Torsionally Flexible Metal Coupling

By Dr. Hab. Inż. Krzysztof Filipowicz

Silesian University of Technology Akademicka 2

Abstract - The paper presents construction of metal coupling of high torsional flexibility. In addition, the paper presents preliminary tests results which enable to determine the above characteristics.

Keywords: machines, construction of machines, driving device, couplings II.

GJRE-A Classification: FOR Code: 030204
Abstract - The paper presents construction torsionally flexible metal coupling, description of test stands and the methodology for determining the static characteristics of a metal coupling of high torsional flexibility. In addition, the paper presents preliminary tests results which enable to determine the above characteristics.

Keywords: machines, construction of machines, driving device, couplings.

1. Introduction

The tendency to increase the effectiveness of technological processes and at the same time the efficiency of machines through growth of power with simultaneous optimisation of their size and mass often leads to the increase of dynamic interactions of particular units of the machines. The dynamic interactions taking place in the power transmission system components are definitely disadvantageous. Broad research has shown that even relatively small dynamically affecting force can cause considerably bigger internal forces and displacements to appear than significantly bigger statically affecting force.

From the experiments regarding exploitation and the information of machine shops stems the fact that the level of knowledge about constructing and the insufficiently examined problems with the process of utilization need further research. The efficacy and reliability of machines are shaped during the processes of construction, manufacturing and exploitation. Sufficient knowledge about working load affects the decisions made at all three of those phases and that has a close link to the durability of particular elements and units of the machines. In the process of construction nominal external load is taken into account with a certain reserve, e.g. with the aid of the factor of implementation \( K_a \) (formerly overload \( K_p \)). However, assessing other factors that have influence on the load of the elements of the machine, like e.g. those stemming from faulty performance and assembly as well as the interaction between cooperating elements, is hampered because of their random character and unspecified synergism in generating dynamic loads.

Decreasing the dynamic loads between particular elements of the power transmission system components of a mill, which usually include engine, mechanical gear and actuator can be accomplished through the accurate selection of couplings linking those respective elements. Thanks to couplings it is possible to considerably reduce the dynamic loads in the power transmission system components caused by both external and internal factors. This function is best fulfilled by torsionally flexible couplings characterised by adequate resilient and deadening features.

In the majority of the machines used in mining, building and road industry most of the power transmission system components is liable to random loads both in the phase of start and steady flow as well as stop. Those power systems are prone to be affected by overloads, shock loads and frequent starting under great load. An excellent instance of the above is the power system of a drag chain conveyor. Difficult operating conditions require the usage of couplings with great flexibility susceptibility. Currently the most loaded power transmission systems of mining machines employ one or two liner flexible couplings, liquid couplings of various kinds (e.g. SH, TV produced by Voith Turbo GmbH, etc.) or different types of integrated power transmission systems, like WB/CST DBT, that comprise of epicyclic gearbox and multiple-plate coupling. The aforementioned examples of couplings are characterised by specific advantages and disadvantages described in technical literature.

The Institute of Mining Mechanisation developed a completely new construction, namely torsionally flexible metal coupling, which fulfils most of the requirements of application as regards the considerably loaded power transmission systems of mills [1, 2, 3, 4].

Through the mitigation of torque alterations this coupling causes the absorption of energy, which affects the stabilisation of torsional vibration and the beneficial change of its flow. This contributes to a significant reduction of dynamic loads and thereby ensures the accurate performance of the power transmission system of a mill. And this means the increase of durability and reliability of its constituents.

Author: Prof. nzw. Institute of Mining Mechanisation, Faculty of Mining and Geology at the Silesian University of Technology Akademicka 2, 44-100 Gliwice, Poland. E-mail: krzysztof.filipowicz@polsl.pl
One of the constructional forms of bidirectional torsionally flexible metal coupling is shown in figure 1.

The tenet of torsionally flexible metal coupling rests in the operating torque affecting the active part of the coupling directly through the shaft (1) and then being conveyed to the sliding sleeve (2) with the aid of a multi-start thread. The increasing value of the torque causes the rotation of the shaft (1) against the sliding sleeve (2) and at the same time the torque converter housing (3). The axial force that is thus produced in the multi-start thread initiates plane motion of the sliding sleeve alongside the crankshaft centreline (release lever axle).

The limitation of the motion of the sliding sleeve to plane motion is achieved through motor splined coupling positioned between the sleeve (2) and the torque converter housing (3). Plane motion of the sliding sleeve causes simultaneously the compression of a set of dished plate springs (4) that is especially selected to match the assumed qualities of the coupling. The compression of the springs causes the internal elastic strain force to affect the set. This force in every temporal, fixed location of the sliding sleeve counterbalances the axial force produced in the multi-start thread, which is the result of the external insert momentum operating. Every temporal overload of the power system with the insert momentum triggers additional compression of the resilient elements of the coupling and decreasing the load causes their annealing.

### III. Determining the Static Characteristics of the Coupling

The static characteristic of a flexible coupling is a dependency of the torque $M_{obr}$ which turns the coupling by the specific angle of rotation $\phi$ between the active and the passive element of the coupling. The changes of the torque in this case should be very slow.

$$M_{obr} = f(\phi)$$  \hspace{1cm} (1)

Where: $M_{obr}$ - The torque moment on the flexible coupling, Nm, $\phi$ - Relative angle of rotation of the coupling elements, radian or degrees.

The shape of the static characteristics depends on the construction of the coupling, the material used for the flexible connecting link i.e. the elastic-damping system and the very shape of the connecting link. In case of couplings with flexible rubber elements or elastomers which are most commonly used in power transmission systems of working machines, the characteristic is nonlinear with damping which makes it hard to choose the proper coupling for the power transmission system.

a) The testing stand and methodology of determining the static characteristics of a flexible coupling

The testing stand used to determine the static characteristics of a coupling is used to test the
mechanical couplings built in the Institute of Mining Mechanisation at the Silesian University of Technology, as shown in Fig.2.

The electric motor (1) powered by the inverter, which enables the smooth regulation of the rotational speed from 0 to 1700 min⁻¹, is connected with the tensometric torque meter (5) used to test the torque moment \( M_{obr} = M_{stat} \). The value of the measured torque is read and recorded by means of a computerised measuring apparatus (7) of type SCXI produced by National Instruments. One of the elements of the tested flexible metal coupling - the housing (2) is directly attached to the output shaft of the torque meter. The other element of the coupling - the output shaft - is attached to the hydraulic disc brake (3) which is controlled from the pressure supply system (4).

The output shaft of the coupling i.e. the passive element of the coupling is attached to the rotary disc with an angular scale 0°÷360° (6). An indicating needle attached to the coupling housing was used to read the relative angular displacement of the elements \( \varphi = \varphi_{stat} \).

When the coupling is secured at the testing stand by means of a fully blocked hydraulic brake, one of the elements of the flexible clutch may no longer turn. The electric motor is activated by means of an inverter and the static torque \( M_{stat} \) is gradually increased. The torque moment changes every 10 Nm in order to reach the maximum \( M_{max} = 100 \) Nm. At the same time the relative angular displacement of the coupling elements \( \varphi_{stat} \) on the angular scale of the disc is read by means of an indicating needle attached to the movable housing. The precision of the reading is ± 1°. The readings of the dependency of the torque \( M_{stat} \) on the relative angular displacement \( \varphi_{stat} \) is carried out with and without the load. The aim of this procedure is to determine the hysteresis loop which presents the value of the mechanical energy damping in the coupling.

**Figure 2**: The testing stand used to test the mechanical couplings, where: 1 – Electric motor, 2 – Tested flexible coupling, 3 – Hydraulic disc brake, 4 – Control system of hydraulic brake, 5 – Torque meter, 6 – Disc with an angular scale, 7 – Measuring-recording set

b) The static characteristics of a torsionally flexible metal coupling

The tests enabled to determine the basic static characteristics of the four options of a torsionally flexible metal coupling for spring sets as shown in table 1. Figures 3 are the graphic illustration of the determined static characteristics of different options of the coupling.

The tests were carried out with the use of couplings with four different sets of disc springs. The choice of these sets was based on the analysis of disc springs characteristics arranged in packs and forming sets. The sets were chosen so that with the maximum torque moment \( M_{max} = 100 \) Nm, the springs would work below the accepted working range, that is 75% of the maximum deflection.

Table 1 contains the data regarding the disc springs used in the coupling and the sets that were placed in it.
Table 1: The sets of the disc springs used in the coupling

<table>
<thead>
<tr>
<th>Coupling Number</th>
<th>Type of disc springs DIN 2093</th>
<th>The number of springs in the pack</th>
<th>The arrangement of the pack</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40 x 20,4 x 2.5</td>
<td>5</td>
<td>&lt;&lt;&lt;&lt;&lt; &gt;&gt;&gt;&gt;&gt;</td>
</tr>
<tr>
<td>2</td>
<td>40 x 20,4 x 2.5</td>
<td>4</td>
<td>&lt;&lt;&lt; &gt;&gt;&gt;</td>
</tr>
<tr>
<td>3</td>
<td>40 x 20,4 x 2.25</td>
<td>4</td>
<td>&lt;&lt;&lt; &gt;&gt;&gt;</td>
</tr>
<tr>
<td>4</td>
<td>40 x 20,4 x 2</td>
<td>4</td>
<td>&lt;&lt;&lt; &gt;&gt;&gt;</td>
</tr>
</tbody>
</table>

When the coupling characteristics are linear as those obtained in the tests, we can determine the coefficient called the torsional rigidity of the coupling $k$ for each of them. For the determined linear static characteristics, the dependency is expressed as follows:

$$ k = \frac{M_{stat}}{\varphi_{stat}} $$

(2)

Where: $M_{stat}$ – the static torque moment on the coupling, Nm; $\varphi_{stat}$ – the corresponding relative angular displacement of the coupling elements, radian or degrees.

Figure 3: The illustration of some static characteristics of torsionally flexible metal coupling, where: a – Coupling no. 1, b – Coupling no. 2, c – Coupling no. 3, d – Coupling no. 4
The flexible metal coupling is not only rigid but it also absorbs energy. The histeresis loop was obtained during loading and unloading and it presented the histeresis losses of the mechanical energy in the coupling called damping. In the flexible metal coupling damping is achieved by means of constructive friction in screw joints mainly.

The value of the mechanical energy damping in the coupling is specified by the damping coefficient that is determined as follows:

\[
\psi = \frac{A_r}{A_s}
\]

(3)

<table>
<thead>
<tr>
<th>Coupling Number</th>
<th>Type of disc springs</th>
<th>The torsional rigidity coefficient ( k ), Nm/°</th>
<th>The damping coefficient ( \psi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40 x 20.4 x 2.5</td>
<td>1.77</td>
<td>0.20</td>
</tr>
<tr>
<td>2</td>
<td>40 x 20.4 x 2.5</td>
<td>0.80</td>
<td>0.33</td>
</tr>
<tr>
<td>3</td>
<td>40 x 20.4 x 2.25</td>
<td>0.67</td>
<td>0.45</td>
</tr>
<tr>
<td>4</td>
<td>40 x 20.4 x 2</td>
<td>0.45</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Table 2: The obtained torsional rigidity coefficient \( k \) and the damping coefficient \( \psi \)

IV. Summary

The preliminary tests carried out to determine the static characteristics of a torsionally flexible metal coupling lead to the following general conclusions:

- The proposed testing stands as well as the methodology of the static characteristics test enable to quickly and correctly determine the static characteristics with acceptable precision and repeatability of the achieved measurements results.
- The determined static characteristics of the torsionally flexible coupling are linear with damping of linear correlation coefficient \( r = 0.98 \).
- The position and slope of the static characteristics and values of the torsional rigidity and damping coefficients are strictly linked with the application of the disc springs sets in the coupling, the more rigid the springs the greater torsional rigidity of the coupling and the lower the damping coefficient.
- The coupling characteristics can be shaped by the proper choice of disc springs sets, though one has to take into consideration the condition of the proper performance of the spring i.e. up to 75% of its maximum strain.
- The torsionally flexible metal coupling enables to obtain significant angles of the relative angular displacement of the elements even up to a few hundred degrees; the obtained angles are determined by the applied sets of disc springs.

The presented conclusions clearly indicate the advantageous features of the presented constructive solution of the flexible coupling. None of the mechanical couplings which have been used so far in road, building and mining machinery has the above characteristics and the static characteristics as those mentioned above. Classic flexible couplings enable to obtain angles of mutual torsion only up to a few degrees, in most cases with difficult to describe nonlinear characteristics.

References Références Referencias

This page is intentionally left blank
Failure Mode, Effects and Criticality Analysis of Load Haul Dump Vehicles (100t) in Open Cast Mines

By NL Narayana, Dr. NVS Raju, Chaithanya. K & Dr. P. Ram Reddy

Abstract - Failure mode, effects and criticality analysis (FMECA) is an extension of failure mode and effects analysis (FMEA). FMEA is a bottom-up, inductive analytical method which may be performed at either the functional or piece-part level. FMECA extends FMEA by including a criticality analysis, which is used to chart the probability of failure modes against the severity of their consequences. The result highlights failure modes with relatively high probability and severity of consequences, allowing remedial effort to be directed where it will produce the greatest value.

The objective of FMECA is to identify all failure modes in a system design. Its purpose is to find all critical and catastrophic failures that can be minimised at the earliest.

Keywords: criticality analysis, failure mode, failure effects, risk priority number, etc.

GJRE-A Classification: FOR Code: 091106
Failure Mode, Effects and Criticality Analysis of Load Haul Dump Vehicles (100t) in Open Cast Mines

NL Narayana *, Dr. NVS Raju *, Chaithanya K p & Dr. P. Ram Reddy Ø

Abstract - Failure mode, effects and criticality analysis (FMECA) is an extension of failure mode and effects analysis (FMEA). FMEA is a bottom-up, inductive analytical method which may be performed at either the functional or piece-part level. FMECA extends FMEA by including a criticality analysis, which is used to chart the probability of failure modes against the severity of their consequences. The result highlights failure modes with relatively high probability and severity of consequences, allowing remedial effort to be directed where it will produce the greatest value.

The objective of FMECA is to identify all failure modes in a system design. Its purpose is to find all critical and catastrophic failures that can be minimised at the earliest.

Keywords : criticality analysis, failure mode, failure effects, risk priority number, etc.

1. INTRODUCTION

Every machinery, equipment, buildings undergo deterioration due to their use and exposure to environmental conditions. This deterioration must be detected well in advance so as to forestall loss and damage. Industries, therefore, address such issues time to time through repairs, renovations, rejuvenations, restructuring, etc., so as to enlarge their useful life to a maximum possible extent. In this context, the maintenance assumes importance as an engineering function and is made responsible for provision of the condition of these machines, equipments, buildings and services that will permit uninterrupted implementation of plans requiring their use. This means that estimation of the failure mode, failure effect, and the failure criticality to maintain the machine in good condition is necessary.

The objective of FMECA is to identify all failure modes in a system design. Its purpose is to find all critical and catastrophic failures that can be minimised at the earliest. Hence, FMECA must be started as soon as the preliminary information is available and investigation is extended as more information is available in suspected problem areas.

In this paper the results of FMECA analysis is published for 100 Ton dumpers working at Open Cast Mines – III, SCCL, Ramagundam.

II. PROCEDURE

Failure Mode, Effects and Criticality Analysis (FMECA) is an analysis technique which facilitates the identification of potential problems in the design or process by examining the effects of lower level failures. Recommended actions or compensating provisions are made to reduce the likelihood of the problem occurring, and mitigate the risk.

III. MIL-STD-1629A

This standard establishes requirements and procedures for performing a failure mode, effects, and criticality analysis (FMECA) to systematically evaluate and document, by item failure mode analysis, the potential impact of each functional or hardware failure on mission success, personnel and system safety, system performance, maintainability, and maintenance requirements. Each potential failure is ranked by the severity of its effect in order that appropriate corrective actions may be taken to eliminate or control the high risk items.

IV. CRITICALITY ANALYSIS

To perform criticality analysis of the failures identified Risk Priority Number (RPN) for each failure must be calculated. To calculate the RPN the failures are listed along with the failure times and their severity and occurrence are calculated.

The key inputs used in failure modeling using FMECA are as follows

V. SEVERITY (S)

Severity (S) is a numerical measure of how serious is the effect of the failure to the customer. It is to assess the failure result on an assumed scale with questioning, if the component or system failure results in a mere nuisance or can it result in serious injury. The degree of severity is generally measured on a scale of 1 to 10 where 10 is the most severe.
VI. Occurrence (O)

Occurrence (O) is a measure of probability that a particular mode will actually happen. The degree of occurrence is measured on a scale of 1 to 10, where 10 signify the highest probability of occurrence.

VII. Detection (D)

Detection (D) is a measure of probability that a particular mode would be detected in the manufacturer’s own operation before reaching the customer. The level of detection is measured on a scale of 0.1 to 1, where 0.1 signifies virtually no ability to detect the fault.

VIII. Risk Priority Number (RPN)

Provides an alternate evaluation approach to Criticality Analysis. The risk priority number provides a qualitative numerical estimate of design risk. RPN is defined as the product of three independently assessed factors: Severity (S), Occurrence (O) and Detection (D).

\[ RPN = (S) \times (O) \times (D) \]

Criticality Ranking According To RPN

Criticalities of the failures are given ranking according to the RPN they are given according to the following table (table 1).

<table>
<thead>
<tr>
<th>Failure Number</th>
<th>Failure Classification</th>
<th>Maintenance Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Catastrophic</td>
<td>Replace the equipment</td>
</tr>
<tr>
<td>2, 3 &amp; 4</td>
<td>Critical Failure</td>
<td>Complete overhaul</td>
</tr>
<tr>
<td>5, 6 &amp; 7</td>
<td>Marginal</td>
<td>Repair the component</td>
</tr>
<tr>
<td>8, 9 &amp; 10</td>
<td>Minor</td>
<td>Inspect daily</td>
</tr>
</tbody>
</table>

Table 1: Classification of failures according to failure number

IX. Conclusions

From the analysis done by risk priority number it can be concluded that

1. For 100 T dumpers as a group, Radiator leaks and Engine failures are frequent failures that are hampering the production, based on the catastrophic nature of the failure and risky nature of failure, the radiator and engine must be replaced whenever the next failure occurs.
2. For 100 T dumpers as a group, Suspension failures and brake failures are critical failures that are the other obstacles, for such failures they must be checked for every trip so that any inconvenience can be avoided.
3. For dumper CD-302, Gears must be replaced as soon as possible, based on the catastrophic nature of the failure.
4. For dumper CD-303, Radiator must be replaced.
5. For dumper CD-305, Engine must be replaced.
6. For dumper CD-306, Radiator must be replaced.
7. For dumper CD-307, Radiator must be replaced.
8. For dumper CD-308, Suspension must be replaced.
9. For dumper CD-309, Engine must be replaced.
10. For dumper CD-310, Suspension must be replaced.
11. For dumper CD-310, Brakes must be replaced.
12. For dumper CD-312, Suspension must be replaced.
13. For dumper CD-313, Engine must be replaced.

REFERENCES Références Referencias

2. Raju N V S, Plant Maintenance & Reliability Engineering, CENGAGE Learning
12. Jasper L. Coetzee, The role of NHPP models in the practical analysis of maintenance failure data,


**APPENDIX**

FMECA of all 100 Ton Dumpers

<table>
<thead>
<tr>
<th>F</th>
<th>Failure Name</th>
<th>Frequency</th>
<th>Time</th>
<th>Occurrence</th>
<th>Severity</th>
<th>Detection</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Radiator Leak</td>
<td>30</td>
<td>1987</td>
<td>0.1663</td>
<td>0.3447</td>
<td>0.4</td>
<td>0.00298</td>
</tr>
<tr>
<td>2</td>
<td>Engine Failure</td>
<td>23</td>
<td>967</td>
<td>0.1429</td>
<td>0.1678</td>
<td>1</td>
<td>0.00340</td>
</tr>
<tr>
<td>3</td>
<td>Suspension Failure</td>
<td>11</td>
<td>945</td>
<td>0.1304</td>
<td>0.1659</td>
<td>0.7</td>
<td>0.00150</td>
</tr>
<tr>
<td>4</td>
<td>Brake Failure</td>
<td>80</td>
<td>482</td>
<td>0.1553</td>
<td>0.0838</td>
<td>0.9</td>
<td>0.01117</td>
</tr>
<tr>
<td>5</td>
<td>Air compressor failure</td>
<td>55</td>
<td>633</td>
<td>0.1242</td>
<td>0.1098</td>
<td>0.6</td>
<td>0.00982</td>
</tr>
<tr>
<td>6</td>
<td>Cylinder Failure</td>
<td>12</td>
<td>1188</td>
<td>0.0745</td>
<td>0.2061</td>
<td>0.3</td>
<td>0.00546</td>
</tr>
<tr>
<td>7</td>
<td>Steering problems</td>
<td>13</td>
<td>256</td>
<td>0.0807</td>
<td>0.0444</td>
<td>0.8</td>
<td>0.00299</td>
</tr>
<tr>
<td>8</td>
<td>Bolts and stud failure</td>
<td>14</td>
<td>666</td>
<td>0.0707</td>
<td>0.1155</td>
<td>0.2</td>
<td>0.00202</td>
</tr>
<tr>
<td>9</td>
<td>Bucket &amp; wear plate damage</td>
<td>14</td>
<td>255</td>
<td>0.0707</td>
<td>0.0442</td>
<td>0.5</td>
<td>0.00199</td>
</tr>
<tr>
<td>10</td>
<td>Hose failure and burst failure</td>
<td>19</td>
<td>372</td>
<td>0.1180</td>
<td>0.0645</td>
<td>0.1</td>
<td>0.00083</td>
</tr>
</tbody>
</table>

Table 2: Calculation of Risk Priority of all 100T Dumpers

![Figure 1](image_url)  

**Figure 1**: Failure number Vs RPN of 100 T Dumpers

From the table 2 and figure 1 it can be concluded that failure 1 i.e. Radiator leaks is of high risk, is catastrophic failure. The failures (2 3 and 4) of engine, suspension, and brake are critical, cylinder failures and steering problems are categorised as marginal failures and the other failures are minor failures. According to Table 1 the engine and radiator must be replaced when
the failure occurs again and again. Similarly the critical failures can be avoided by complete overhaul of the dumper. Marginal failures can be avoided by repairing of steering system and cylinders. To avoid minor failures daily preliminary inspection of the whole dumper must be done before moving into the coal mine.

### FMECA of Dumper – CD 302

<table>
<thead>
<tr>
<th>F No</th>
<th>Failure Name</th>
<th>frequency</th>
<th>time</th>
<th>occurrence</th>
<th>severity</th>
<th>detection</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gears failure</td>
<td>3</td>
<td>96</td>
<td>0.0789</td>
<td>0.4222</td>
<td>0.5</td>
<td>0.0178</td>
</tr>
<tr>
<td>2</td>
<td>brake failures</td>
<td>5</td>
<td>202</td>
<td>0.0316</td>
<td>0.0876</td>
<td>0.9</td>
<td>0.0116</td>
</tr>
<tr>
<td>3</td>
<td>radiator leaks</td>
<td>7</td>
<td>258</td>
<td>0.1842</td>
<td>0.1140</td>
<td>0.4</td>
<td>0.0084</td>
</tr>
<tr>
<td>4</td>
<td>Railings damage</td>
<td>4</td>
<td>96</td>
<td>0.1033</td>
<td>0.0484</td>
<td>1</td>
<td>0.0049</td>
</tr>
<tr>
<td>5</td>
<td>steering problems</td>
<td>3</td>
<td>96</td>
<td>0.0789</td>
<td>0.0464</td>
<td>0.8</td>
<td>0.0029</td>
</tr>
<tr>
<td>6</td>
<td>pivot, bolts and studs failure</td>
<td>4</td>
<td>270</td>
<td>0.1033</td>
<td>0.1504</td>
<td>0.1</td>
<td>0.0014</td>
</tr>
<tr>
<td>7</td>
<td>cylinder failure</td>
<td>3</td>
<td>136</td>
<td>0.0789</td>
<td>0.0657</td>
<td>0.2</td>
<td>0.0010</td>
</tr>
<tr>
<td>8</td>
<td>Bucket damage</td>
<td>4</td>
<td>44</td>
<td>0.1653</td>
<td>0.0283</td>
<td>0.3</td>
<td>0.0007</td>
</tr>
<tr>
<td>9</td>
<td>type problems</td>
<td>3</td>
<td>22</td>
<td>0.0789</td>
<td>0.0106</td>
<td>0.7</td>
<td>0.0006</td>
</tr>
<tr>
<td>10</td>
<td>suspension failure</td>
<td>2</td>
<td>32</td>
<td>0.0536</td>
<td>0.1555</td>
<td>0.6</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

### Table 3: Calculation of Risk Priority Number of CD-302 Dumper

From the table 3 and figure 2 it can be concluded that failure 1 i.e. gears failure is of high risk, is catastrophic failure. The failures (2, 3 and 4) of brake failure, radiator leaks and railings damage are classified as critical. Steering, pivots bolts and studs failure and cylinder are categorised as marginal failures and the other failures are minor failures. According to Table 1 the gears failures and radiator must be replaced when the failure occurs again and again. Similarly the critical failures can be avoided by complete overhaul of the dumper. Marginal failures can be avoided by repairing of steering, pivots bolts and studs, cylinders. To avoid minor failures daily preliminary inspection of the whole dumper must be done before moving into the coal mine.

### FMECA of Dumper – CD 303

<table>
<thead>
<tr>
<th>F No</th>
<th>Failure Name</th>
<th>Frequency</th>
<th>time</th>
<th>occurrence</th>
<th>severity</th>
<th>detection</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>radiator leaks</td>
<td>8</td>
<td>156</td>
<td>0.0667</td>
<td>0.0176</td>
<td>0.4</td>
<td>0.0136</td>
</tr>
<tr>
<td>2</td>
<td>Engine failures</td>
<td>2</td>
<td>195</td>
<td>0.0667</td>
<td>0.1039</td>
<td>1</td>
<td>0.0122</td>
</tr>
<tr>
<td>3</td>
<td>water boiling in radiator</td>
<td>4</td>
<td>108</td>
<td>0.1333</td>
<td>0.1013</td>
<td>0.8</td>
<td>0.0108</td>
</tr>
<tr>
<td>4</td>
<td>suspension failure</td>
<td>4</td>
<td>243</td>
<td>0.1333</td>
<td>0.2330</td>
<td>0.3</td>
<td>0.0091</td>
</tr>
<tr>
<td>5</td>
<td>cylinder failure</td>
<td>2</td>
<td>113</td>
<td>0.0667</td>
<td>0.0160</td>
<td>0.6</td>
<td>0.0042</td>
</tr>
<tr>
<td>6</td>
<td>pivot, bolts and studs failure</td>
<td>2</td>
<td>93</td>
<td>0.0667</td>
<td>0.0872</td>
<td>0.5</td>
<td>0.0029</td>
</tr>
<tr>
<td>7</td>
<td>clutch failure</td>
<td>2</td>
<td>19</td>
<td>0.0667</td>
<td>0.0178</td>
<td>0.9</td>
<td>0.0011</td>
</tr>
<tr>
<td>8</td>
<td>Gear failure</td>
<td>1</td>
<td>47</td>
<td>0.0333</td>
<td>0.0441</td>
<td>0.7</td>
<td>0.0010</td>
</tr>
<tr>
<td>9</td>
<td>hose failure and hoist failure</td>
<td>3</td>
<td>90</td>
<td>0.1000</td>
<td>0.0844</td>
<td>0.1</td>
<td>0.0008</td>
</tr>
<tr>
<td>10</td>
<td>Bucket damage</td>
<td>2</td>
<td>22</td>
<td>0.0667</td>
<td>0.0206</td>
<td>0.2</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

### Table 4: Calculation of Risk priority of CD-303 Dumper

From the table 4 and figure 3 it can be concluded that failure 1 i.e. Radiator leaks is of high risk, is catastrophic failure. The failures (2, 3 and 4) of engine, suspension, and water boiling in radiator are critical. Cylinder failures and pivots, bolts and studs failure, clutch failure are categorised as marginal failures and the other failures are minor failures. According to Table 1 the engine and radiator must be replaced when the failure occurs again and again. Similarly the critical failures can be avoided by complete overhaul of the dumper. Marginal failures can be avoided by repairing
of pivots, bolts, studs, clutch, and cylinders. To avoid minor failures daily preliminary inspection of the whole dumper must be done before moving into the coal mine.

**FMECA of Dumper – CD 305**

<table>
<thead>
<tr>
<th>F No</th>
<th>Failure Name</th>
<th>Frequency</th>
<th>Time (hr)</th>
<th>Occurrence</th>
<th>Severity</th>
<th>Detection</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engine failure</td>
<td>3</td>
<td>121</td>
<td>0.1429</td>
<td>0.2523</td>
<td>1</td>
<td>0.0332</td>
</tr>
<tr>
<td>2</td>
<td>Leaks and liquid change</td>
<td>4</td>
<td>213</td>
<td>0.1905</td>
<td>0.3777</td>
<td>0.2</td>
<td>0.0144</td>
</tr>
<tr>
<td>3</td>
<td>Air compressor broken</td>
<td>2</td>
<td>67</td>
<td>0.0952</td>
<td>0.1188</td>
<td>0.7</td>
<td>0.0079</td>
</tr>
<tr>
<td>4</td>
<td>Tyre problems</td>
<td>2</td>
<td>23</td>
<td>0.0952</td>
<td>0.0408</td>
<td>0.8</td>
<td>0.0031</td>
</tr>
<tr>
<td>5</td>
<td>Railings damage</td>
<td>2</td>
<td>33</td>
<td>0.0952</td>
<td>0.0583</td>
<td>0.5</td>
<td>0.0028</td>
</tr>
<tr>
<td>6</td>
<td>Transmission failure</td>
<td>2</td>
<td>26</td>
<td>0.0952</td>
<td>0.0461</td>
<td>0.4</td>
<td>0.0018</td>
</tr>
<tr>
<td>7</td>
<td>Belt and pulley failure</td>
<td>2</td>
<td>16</td>
<td>0.0952</td>
<td>0.0284</td>
<td>0.6</td>
<td>0.0016</td>
</tr>
<tr>
<td>8</td>
<td>Rock ejector damaged</td>
<td>2</td>
<td>33</td>
<td>0.0952</td>
<td>0.0583</td>
<td>0.1</td>
<td>0.0006</td>
</tr>
<tr>
<td>9</td>
<td>Brake failures</td>
<td>1</td>
<td>7</td>
<td>0.0476</td>
<td>0.0124</td>
<td>0.9</td>
<td>0.0005</td>
</tr>
<tr>
<td>10</td>
<td>Bucket damage</td>
<td>1</td>
<td>15</td>
<td>0.0476</td>
<td>0.0266</td>
<td>0.3</td>
<td>0.0004</td>
</tr>
</tbody>
</table>

**Table 5**: Calculation of Risk priority of CD-305 Dumper

From the table 5 and figure 4 it can be concluded that failure 1 i.e. engine failure is of high risk, is catastrophic failure. The failures (2, 3 and 4) of leaks and liquid change, air compressor broken, tyre problems are critical. Railings damage air compression failure, belt and pulley failure are categorised as marginal failures and the other failures are minor failures. According to Table 1 the engine and must be replaced when the failure occurs again and again. Similarly the critical failures can be avoided by complete overhaul of the dumper. Marginal failures can be avoided by repairing of railings, belt and pulley, air compressor. To avoid minor failures daily preliminary inspection of the whole dumper must be done before moving into the coal mine.

**FMECA of Dumper – CD 306**

<table>
<thead>
<tr>
<th>F No</th>
<th>Failure Name</th>
<th>Frequency</th>
<th>Time (hr)</th>
<th>Occurrence</th>
<th>Severity</th>
<th>Detection</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Radiator leaks</td>
<td>4</td>
<td>78</td>
<td>0.2222</td>
<td>0.1705</td>
<td>0.3</td>
<td>0.0119</td>
</tr>
<tr>
<td>2</td>
<td>Bucket damage</td>
<td>2</td>
<td>58</td>
<td>0.1111</td>
<td>0.1327</td>
<td>0.4</td>
<td>0.0059</td>
</tr>
<tr>
<td>3</td>
<td>Not taking load</td>
<td>1</td>
<td>51</td>
<td>0.0556</td>
<td>0.1167</td>
<td>0.7</td>
<td>0.0045</td>
</tr>
<tr>
<td>4</td>
<td>Brake failures</td>
<td>1</td>
<td>31</td>
<td>0.0556</td>
<td>0.0709</td>
<td>0.8</td>
<td>0.0032</td>
</tr>
<tr>
<td>5</td>
<td>Pivot, bolts and studs failure</td>
<td>2</td>
<td>116</td>
<td>0.1111</td>
<td>0.2854</td>
<td>0.1</td>
<td>0.0019</td>
</tr>
<tr>
<td>6</td>
<td>Steering box failures</td>
<td>2</td>
<td>16</td>
<td>0.1111</td>
<td>0.0398</td>
<td>0.5</td>
<td>0.0020</td>
</tr>
<tr>
<td>7</td>
<td>Steering problems</td>
<td>1</td>
<td>15</td>
<td>0.0556</td>
<td>0.0343</td>
<td>0.9</td>
<td>0.0017</td>
</tr>
<tr>
<td>8</td>
<td>Hose failure and hose failure</td>
<td>3</td>
<td>45</td>
<td>0.1667</td>
<td>0.1050</td>
<td>0.1</td>
<td>0.0017</td>
</tr>
<tr>
<td>9</td>
<td>Engine failure</td>
<td>1</td>
<td>12</td>
<td>0.0556</td>
<td>0.0275</td>
<td>1</td>
<td>0.0015</td>
</tr>
<tr>
<td>10</td>
<td>Tyre problems</td>
<td>1</td>
<td>15</td>
<td>0.0556</td>
<td>0.0343</td>
<td>0.6</td>
<td>0.0011</td>
</tr>
</tbody>
</table>

**Table 6**: Calculation of Risk priority of CD-305 Dumper

From the table 6 and figure 5 it can be concluded that failure 1 i.e. Radiator leaks is of high risk, is catastrophic failure. The failures (2, 3 and 4) of bucket damage, not taking load, brakes failures are critical. Pivots bolts and studs failures, steering box failures and steering failures are categorised as marginal failures and the other failures are minor failures. According to Table 1 the engine and radiator must be replaced when the failure occurs again and again. Similarly the critical failures can be avoided by complete overhaul of the dumper. Marginal failures can be avoided by repairing of pivots, bolts, studs and steering box and steering system. To avoid minor failures daily preliminary inspection of the whole dumper must be done before moving into the coal mine.
FELLOWS

FELLOWS OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (FARSE)

- 'FARSE' title will be awarded to the person after approval of Editor-in-Chief and Editorial Board. The title 'FARSE' can be added to name in the following manner. eg. Dr. John E. Hall, Ph.D., FARSE or William Walldroff Ph. D., M.S., FARSE
- Being FARSE is a respectful honor. It authenticates your research activities. After becoming FARSE, you can use 'FARSE' title as you use your degree in suffix of your name. This will definitely will enhance and add up your name. You can use it on your Career Counseling Materials/CV/Resume/Visiting Card/Name Plate etc.
- 60% Discount will be provided to FARSE members for publishing research papers in Global Journals Inc., if our Editorial Board and Peer Reviewers accept the paper. For the life time, if you are author/co-author of any paper bill sent to you will automatically be discounted one by 60%
- FARSE will be given a renowned, secure, free professional email address with 100 GB of space eg.johnhall@globaljournals.org. You will be facilitated with Webmail, Spam Assassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.
- FARSE member is eligible to become paid peer reviewer at Global Journals Inc. to earn up to 15% of realized author charges taken from author of respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account or to your PayPal account.
- Eg. If we had taken 420 USD from author, we can send 63 USD to your account.
- FARSE member can apply for free approval, grading and certification of some of their Educational and Institutional Degrees from Global Journals Inc. (US) and Open Association of Research, Society U.S.A.
- After you are FARSE. You can send us scanned copy of all of your documents. We will verify, grade and certify them within a month. It will be based on your academic records, quality of research papers published by you, and 50 more criteria. This is beneficial for your job interviews as recruiting organization need not just rely on you for authenticity and your unknown qualities, you would have authentic ranks of all of your documents. Our scale is unique worldwide.
- FARSE member can proceed to get benefits of free research podcasting in Global Research Radio with their research documents, slides and online movies.
- After your publication anywhere in the world, you can upload you research paper with your recorded voice or you can use our professional RJs to record your paper their voice. We can also stream your conference videos and display your slides online.
- FARSE will be eligible for free application of Standardization of their Researches by Open Scientific Standards. Standardization is next step and level after publishing in a journal. A team of research and professional will work with you to take your research to its next level, which is worldwide open standardization.
• FARSE is eligible to earn from their researches: While publishing his paper with Global Journals Inc. (US), FARSE can decide whether he/she would like to publish his/her research in closed manner. When readers will buy that individual research paper for reading, 80% of its earning by Global Journals Inc. (US) will be transferred to FARSE member's bank account after certain threshold balance. There is no time limit for collection. FARSE member can decide its price and we can help in decision.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (MARSE)

• 'MARSE' title will be awarded to the person after approval of Editor-in-Chief and Editorial Board. The title 'MARSE' can be added to name in the following manner. eg. Dr. John E. Hall, Ph.D., MARSE or William Walldroff Ph. D., M.S., MARSE
• Being MARSE is a respectful honor. It authenticates your research activities. After becoming MARSE, you can use 'MARSE' title as you use your degree in suffix of your name. This will definitely will enhance and add up your name. You can use it on your Career Counseling Materials/CV/Resume/Visiting Card/Name Plate etc.
• 40% Discount will be provided to MARSE members for publishing research papers in Global Journals Inc., if our Editorial Board and Peer Reviewers accept the paper. For the life time, if you are author/co-author of any paper bill sent to you will automatically be discounted one by 60%
• MARSE will be given a renowned, secure, free professional email address with 30 GB of space eg.johnhall@globaljournals.org. You will be facilitated with Webmail, SpamAssassin, Email Forwarders, Auto-Responders, Email Delivery Route tracing, etc.
• MARSE member is eligible to become paid peer reviewer at Global Journals Inc. to earn up to 10% of realized author charges taken from author of respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account or to your PayPal account.
• MARSE member can apply for free approval, grading and certification of some of their Educational and Institutional Degrees from Global Journals Inc. (US) and Open Association of Research,Society U.S.A.
• MARSE is eligible to earn from their researches: While publishing his paper with Global Journals Inc. (US), MARSE can decide whether he/she would like to publish his/her research in closed manner. When readers will buy that individual research paper for reading, 40% of its earning by Global Journals Inc. (US) will be transferred to MARSE member's bank account after certain threshold balance. There is no time limit for collection. MARSE member can decide its price and we can help in decision.
Auxiliary Memberships

**ANNUAL MEMBER**

- Annual Member will be authorized to receive e-Journal GJRE for one year (subscription for one year).
- The member will be allotted free 1 GB Web-space along with subDomain to contribute and participate in our activities.
- A professional email address will be allotted free 500 MB email space.

**PAPER PUBLICATION**

- The members can publish paper once. The paper will be sent to two-peer reviewer. The paper will be published after the acceptance of peer reviewers and Editorial Board.
The Area or field of specialization may or may not be of any category as mentioned in ‘Scope of Journal’ menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as ‘Knowledge Abstract’ at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

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).

The Author can submit the paper either online or offline. The authors should prefer online submission. **Online Submission:** There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

(II) Choose corresponding Journal.

(III) Click ‘Submit Manuscript’. Fill required information and Upload the paper.

(B) If you are using Internet Explorer, then Direct Submission through Homepage is also available.

(C) If these two are not convenient, and then email the paper directly to dean@globaljournals.org.

Offline Submission: Author can send the typed form of paper by Post. However, online submission should be preferred.
PREFERRED AUTHOR GUIDELINES

MANUSCRIPT STYLE INSTRUCTION (Must be strictly followed)

Page Size: 8.27” X 11”

- Left Margin: 0.65
- Right Margin: 0.65
- Top Margin: 0.75
- Bottom Margin: 0.75
- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, “Abstract” word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

You can use your own standard format also.

Author Guidelines:

1. General,
2. Ethical Guidelines,
3. Submission of Manuscripts,
4. Manuscript’s Category,
5. Structure and Format of Manuscript,
6. After Acceptance.

1. GENERAL

Before submitting your research paper, one is advised to go through the details as mentioned in following heads. It will be beneficial, while peer reviewer justify your paper for publication.

Scope

The Global Journals Inc. (US) welcome the submission of original paper, review paper, survey article relevant to the all the streams of Philosophy and knowledge. The Global Journals Inc. (US) is parental platform for Global Journal of Computer Science and Technology, Researches in Engineering, Medical Research, Science Frontier Research, Human Social Science, Management, and Business organization. The choice of specific field can be done otherwise as following in Abstracting and Indexing Page on this Website. As the all Global
Journals Inc. (US) are being abstracted and indexed (in process) by most of the reputed organizations. Topics of only narrow interest will not be accepted unless they have wider potential or consequences.

2. ETHICAL GUIDELINES

Authors should follow the ethical guidelines as mentioned below for publication of research paper and research activities.

Papers are accepted on strict understanding that the material in whole or in part has not been, nor is being, considered for publication elsewhere. If the paper once accepted by Global Journals Inc. (US) and Editorial Board, will become the copyright of the Global Journals Inc. (US).

**Authorship:** The authors and coauthors should have active contribution to conception design, analysis and interpretation of findings. They should critically review the contents and drafting of the paper. All should approve the final version of the paper before submission.

The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

1) Substantial contributions to conception and acquisition of data, analysis and interpretation of the findings.

2) Drafting the paper and revising it critically regarding important academic content.

3) Final approval of the version of the paper to be published.

All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

Acknowledgements: Contributors to the research other than authors credited should be mentioned under acknowledgement. The specifications of the source of funding for the research if appropriate can be included. Suppliers of resources may be mentioned along with address.

**Appeal of Decision:** The Editorial Board’s decision on publication of the paper is final and cannot be appealed elsewhere.

**Permissions:** It is the author’s responsibility to have prior permission if all or parts of earlier published illustrations are used in this paper.

Please mention proper reference and appropriate acknowledgements wherever expected.

If all or parts of previously published illustrations are used, permission must be taken from the copyright holder concerned. It is the author’s responsibility to take these in writing.

Approval for reproduction/modification of any information (including figures and tables) published elsewhere must be obtained by the authors/copyright holders before submission of the manuscript. Contributors (Authors) are responsible for any copyright fee involved.

3. SUBMISSION OF MANUSCRIPTS

Manuscripts should be uploaded via this online submission page. The online submission is most efficient method for submission of papers, as it enables rapid distribution of manuscripts and consequently speeds up the review procedure. It also enables authors to know the status of their own manuscripts by emailing us. Complete instructions for submitting a paper is available below.

Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.
To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

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

4. MANUSCRIPT’S CATEGORY

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

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

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

Research articles: These are handled with small investigation and applications

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

5. STRUCTURE AND FORMAT OF MANUSCRIPT

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

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

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

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

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

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

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

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

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

(h) Brief Acknowledgements.

(i) References in the proper form.

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

© Copyright by Global Journals Inc.(US) | Guidelines Handbook

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

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

**Format**

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

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

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

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

**Structure**

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

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

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

Key Words

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

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

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

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

© Copyright by Global Journals Inc.(US)| Guidelines Handbook
One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.

It may take the discovery of only one relevant paper to steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.

One should avoid outdated words.

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

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

Acknowledgements: Please make these as concise as possible.

References

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

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

The Editorial Board and Global Journals Inc. (US) recommend that citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

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

Tables, Figures and Figure Legends

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

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

Preparation of Electronic Figures for Publication

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

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.
Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

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

6.1 Proof Corrections

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded (Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)

The Global Journals Inc. (US) are enclosed by our publishing’s Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors’ final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

6.3 Author Services

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

6.4 Author Material Archive Policy

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

6.5 Offprint and Extra Copies

A PDF offprint of the online-published article will be provided free of charge to the related author, and may be distributed according to the Publisher’s terms and conditions. Additional paper offprint may be ordered by emailing us at: editor@globaljournals.org.

You must strictly follow above Author Guidelines before submitting your paper or else we will not at all be responsible for any corrections in future in any of the way.

© Copyright by Global Journals Inc.(US) | Guidelines Handbook
Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper?

So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

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

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

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

4. **Make blueprints of paper:** The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. **Ask your Guides:** If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. **Use of computer is recommended:** As you are doing research in the field of Computer Science, then this point is quite obvious.

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

8. **Use the Internet for help:** An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. **Use and get big pictures:** Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. **Bookmarks are useful:** When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

26. **Go for seminars**: Attend seminars if the topic is relevant to your research area. Utilize all your resources.
27. **Refresh your mind after intervals:** Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

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

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

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

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

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

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

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

**Informal Guidelines of Research Paper Writing**

**Key points to remember:**

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

**Final Points:**

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

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

© Copyright by Global Journals Inc. (US) | Guidelines Handbook
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 one 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 replace 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.
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.
Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

<table>
<thead>
<tr>
<th>Topics</th>
<th>Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A-B</td>
</tr>
<tr>
<td></td>
<td>C-D</td>
</tr>
<tr>
<td></td>
<td>E-F</td>
</tr>
<tr>
<td>Abstract</td>
<td>Clear and concise with appropriate content, Correct format. 200 words or below</td>
</tr>
<tr>
<td></td>
<td>Above 200 words</td>
</tr>
<tr>
<td>Introduction</td>
<td>Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited</td>
</tr>
<tr>
<td>Methods and Procedures</td>
<td>Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads</td>
</tr>
<tr>
<td>Result</td>
<td>Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake</td>
</tr>
<tr>
<td>Discussion</td>
<td>Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph, reference cited</td>
</tr>
<tr>
<td>References</td>
<td>Complete and correct format, well organized</td>
</tr>
</tbody>
</table>

© Copyright by Global Journals Inc.(US) | Guidelines Handbook
### Index

<table>
<thead>
<tr>
<th>A</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace · 7, 11, 18</td>
<td></td>
</tr>
<tr>
<td>Alongside · 32</td>
<td></td>
</tr>
<tr>
<td>Alterations · 30</td>
<td></td>
</tr>
<tr>
<td>Analytically · 18</td>
<td></td>
</tr>
<tr>
<td>Apparatus · 22, 34</td>
<td></td>
</tr>
<tr>
<td>Approximately · 2, 7</td>
<td></td>
</tr>
<tr>
<td>Artificial · 2, 7, 8</td>
<td></td>
</tr>
<tr>
<td>Assigned · 26</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomaterials · 2</td>
<td></td>
</tr>
<tr>
<td>Boneexhibits · 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartilage · 2</td>
<td></td>
</tr>
<tr>
<td>Categorised · 43, 44, 45, 46</td>
<td></td>
</tr>
<tr>
<td>Conductive · 19</td>
<td></td>
</tr>
<tr>
<td>Consequences · 40</td>
<td></td>
</tr>
<tr>
<td>Continuously · 2</td>
<td></td>
</tr>
<tr>
<td>Contribution · 21, 22, 26</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasis · 11</td>
<td></td>
</tr>
<tr>
<td>Equipment · 13, 22, 40, 42</td>
<td></td>
</tr>
<tr>
<td>Especially · 21, 22, 32</td>
<td></td>
</tr>
<tr>
<td>Evaluating · 2, 26</td>
<td></td>
</tr>
<tr>
<td>Experimental · 16, 18, 21, 23, 26</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Failures · 40, 42, 43, 44, 45, 46</td>
<td></td>
</tr>
<tr>
<td>Flexible · 30, 32, 33, 34, 36, 37</td>
<td></td>
</tr>
<tr>
<td>Frequency · 20</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>G</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Generated · 2, 3, 4, 6, 20</td>
<td></td>
</tr>
<tr>
<td>Generates · 20</td>
<td></td>
</tr>
<tr>
<td>Geometry · 2, 11, 21</td>
<td></td>
</tr>
<tr>
<td>Graphite · 18, 21, 26, 27</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaftanoglu · 15, 16</td>
<td></td>
</tr>
<tr>
<td>Kamonchat's · 8</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Machining · 18, 19, 20, 21, 22, 28</td>
<td></td>
</tr>
<tr>
<td>Manipulated · 12</td>
<td></td>
</tr>
<tr>
<td>Manufacture · 18</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerical · 19</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>O</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthopaedic · 2, 9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial · 20</td>
<td></td>
</tr>
<tr>
<td>Preliminary · 30, 37, 40, 44, 46</td>
<td></td>
</tr>
<tr>
<td>Proximal · 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconstruction · 2, 9</td>
<td></td>
</tr>
<tr>
<td>Requiring · 20, 40</td>
<td></td>
</tr>
<tr>
<td>Rmoelectric · 19</td>
<td></td>
</tr>
<tr>
<td>Roughness · 18, 21, 22, 26, 28</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated · 16</td>
<td></td>
</tr>
<tr>
<td>Sinking · 19</td>
<td></td>
</tr>
<tr>
<td>Sketching · 3</td>
<td></td>
</tr>
<tr>
<td>Stainless · 7, 11, 18, 21, 22, 26</td>
<td></td>
</tr>
<tr>
<td>Subsequent · 20</td>
<td></td>
</tr>
<tr>
<td>Substitutes · 2, 9</td>
<td></td>
</tr>
<tr>
<td>Surface · 7, 12, 20, 21, 22, 24, 26, 28</td>
<td></td>
</tr>
</tbody>
</table>
Torque · 30, 32, 33, 34, 36
Torsionally · 30, 32, 34, 36, 37
Toughness · 19
Traumatologic · 2

Variables · 18, 26
Vestigations · 20