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Biomaterial of Artificial

Flexible Metal Coupling

Highlights

Glance of Hydroforming

Femoral Bone and Compare

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 3 VERSION 1.0

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Mechanical and Mechanics Engineering

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Analysis of Al_2O_3/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
Bangladesh University of Engineering and Technology

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_2O_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_2O_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_2O_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_2O_3/Al FGM; Ti6Al4V; ansys 13.0; FEA; femur; solid works; CAD.*

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Analysis of Al_2O_3/Al FGM as Biomaterial of Artificial Human Femoral Bone and Compare with Ti6Al4V Alloy through Computational Study

Tousif Ahmed [α] & Muhammad Ziaur Rahman [σ] & Debasish Adhikary [ρ]

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_2O_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_2O_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_2O_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_2O_3 /Al FGM; Ti6Al4V; ansys 13.0; FEA; femur; solid works; CAD.*

I. 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 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_2O_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) finiteelement analysis (FEA) for orthopedic application iswell accepted for more than three decades [1]. Boneexhibits 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, theuse 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 excceds 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 fulfil 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.

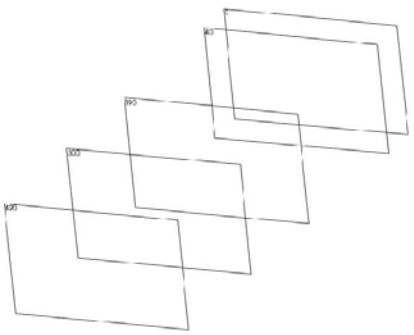

Figure 1 : Planes defined for sketching

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

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 onthe plane 40.

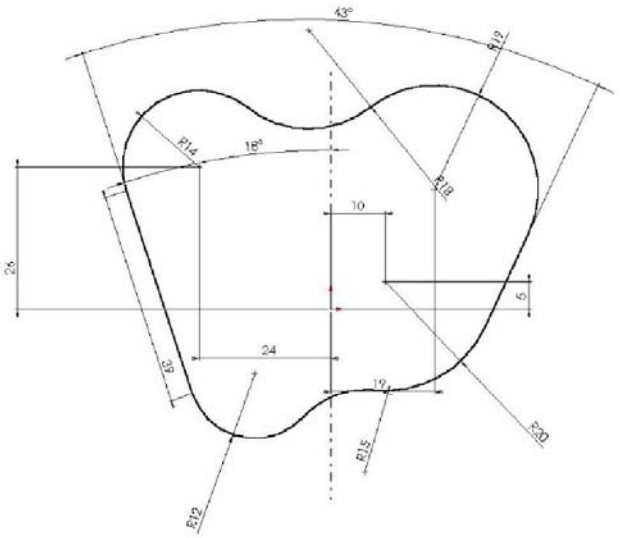

Figure 2 : The shape defining sketch

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

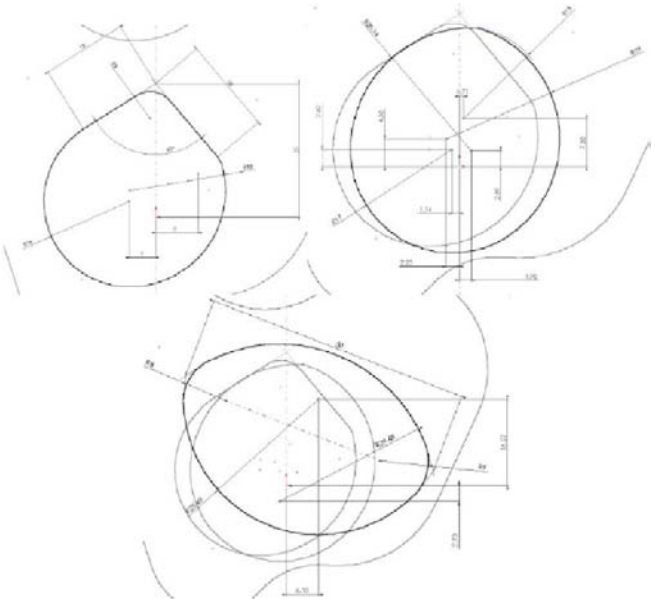

Figure 3 : Sections for defining the full profile

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.

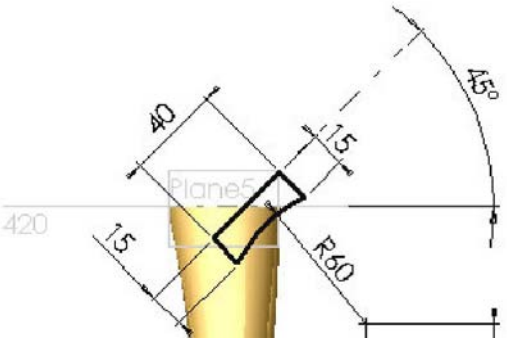

Figure 5 : Generation of femur head support

At that feature it was attached a secondary shape using Dome command (Figure 6).

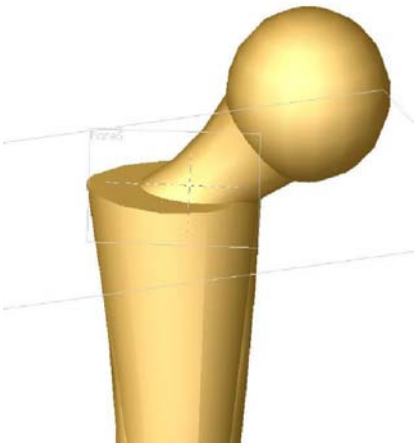

Figure 6 : Generation of head by dome feature

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

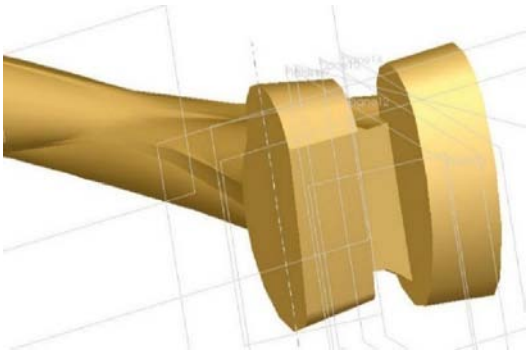

Figure 7 : After bose extrude

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

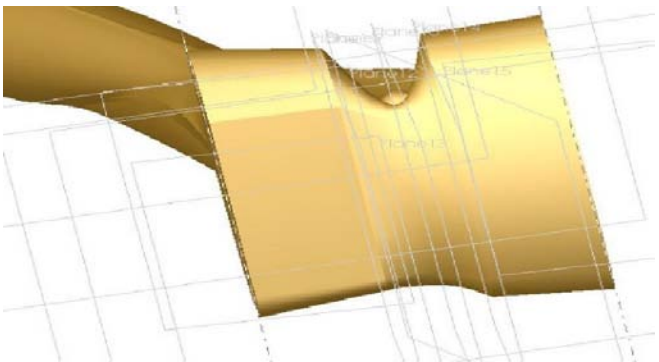

Figure 8 : Loft feature definoing in the mid plane

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

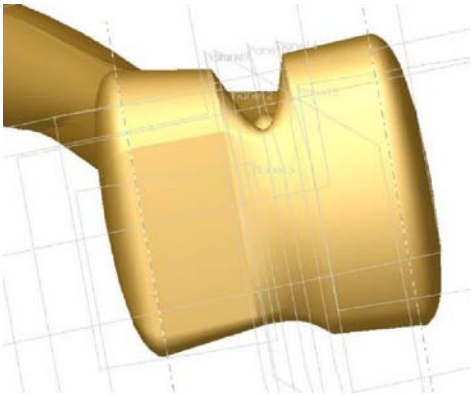

Figure 9 : Dome feature for accurate shape generation

In an inclined plane with 120 degrees it was drawn the sketch presented in Figure 10. 4

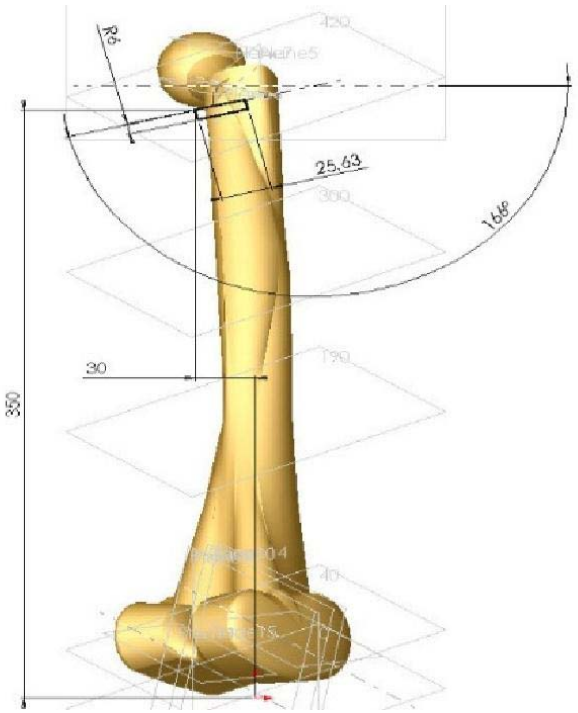

Figure 10 : The sketch drawn in inclined plane

Revolve feature was applied to the previous sketch in Figure 10. The output is shown in Figure 11.

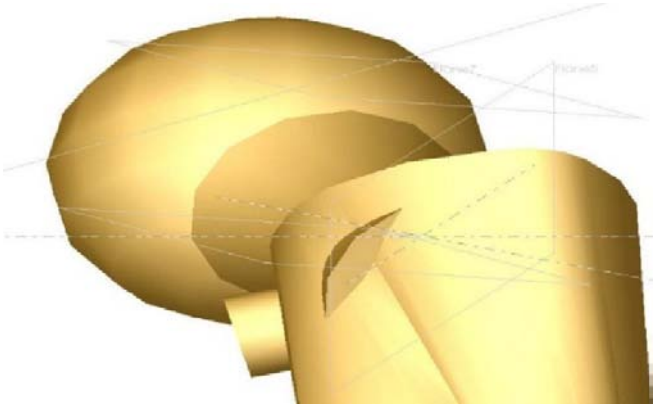

Figure 11 : The Revolve Feature

Fillet of 3mm radius was introduced to the selected areas (Figure 12).

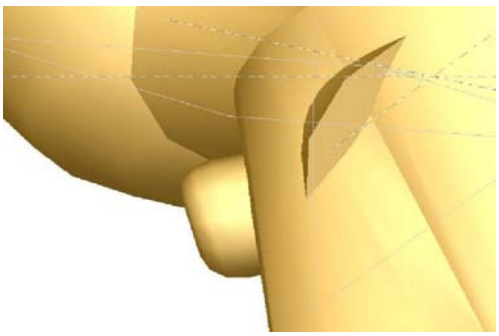

Figure 12 : Fillet of 3 mm radious for obtaining the precedent feature

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

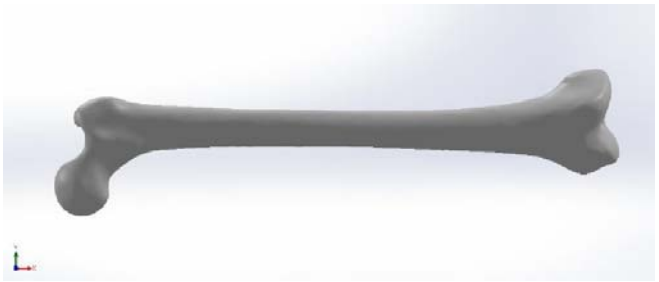

Figure 13 : Complete 3D femur model

III. Modeling of Materials' Properties

a) Al_2O_3/Al FGM

For modeling Al_2O_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 Pt and Pb are the material properties of the top surface (Al_2O_3) and bottom surface (Al) respectively.

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

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

$$\begin{Bmatrix}\sigma_{xx}\\ \sigma_{yy}\\ \tau_{xy}\\ \tau_{yz}\\ \tau_{zx}\end{Bmatrix} = \begin{bmatrix}1 & \nu & 0 & 0 & 0\\ \nu & 1 & 0 & 0 & 0\\ 0 & 0 & \frac{1-\nu}{2} & 0 & 0\\ 0 & 0 & 0 & \frac{1-\nu}{2} & 0\\ 0 & 0 & 0 & 0 & \frac{1-\nu}{2}\end{bmatrix}\begin{Bmatrix}\varepsilon_{xx}\\ \varepsilon_{yy}\\ \gamma_{xy}\\ \gamma_{yz}\\ \gamma_{zx}\end{Bmatrix}$$

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 kN/m^2 .The outcomes were compared with the results published by Kant et al. [6] as shown in Figure. 14. T2he dimensions and material properties of the plate are a = b = 250 mm, h = 50 mm, E = 21 GPa, ν = 0.25, ρ = 800 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].

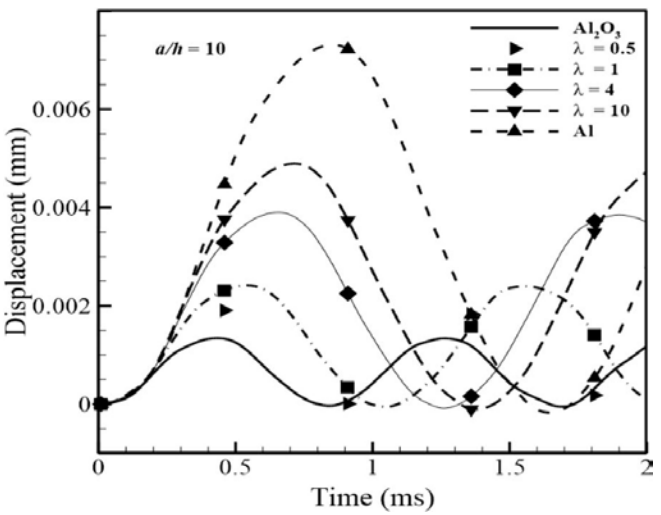

Figure 14 : Effect of power law gradient on central deflection of Al_2O_3/Al FGM cylindrical shell [3]

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 Al_2O_3/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 - 91o to 60o
- Medium - 75o to 24o
- Fine - 36o to 12o6

For this study Curvature Normal Angle was set to 18O. Figure. 15 shows surface mesh of femur bone.

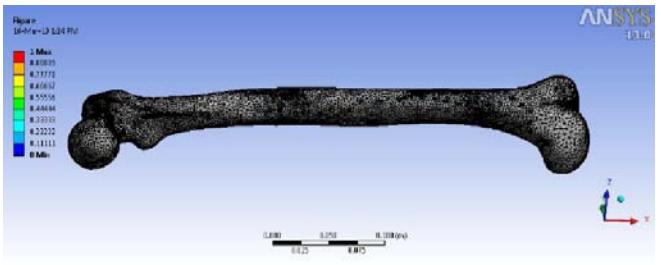

Figure 15 : Surface mesh of the femur bone

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

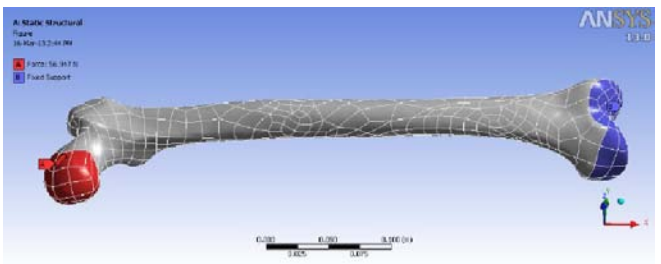

Figure 16 : Bourdary Conditions

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.

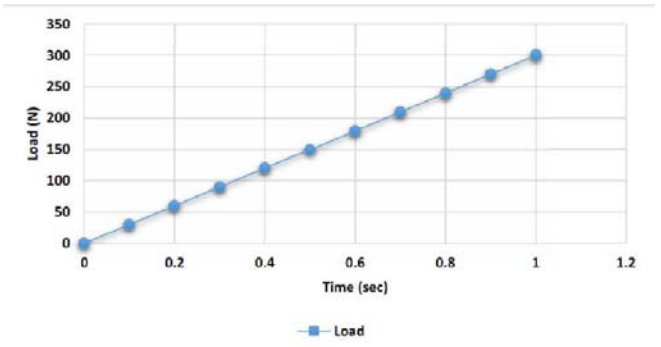

Figure 17 : Applied load on the femur

V. Results and Discussion

It may be noted that only static load applied on Femur. Though Al_2O_3/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. Al_2O_3/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 Al_2O_3/Al FGM respectively.

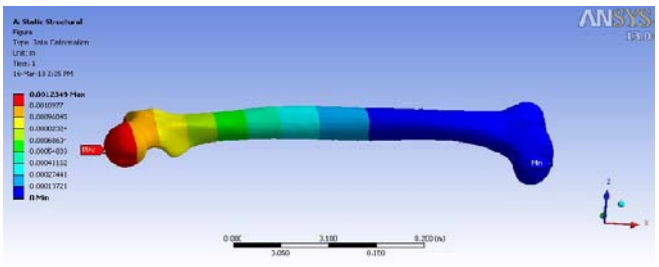

Figure 18 : Deformation Contour for Ti6Al4V

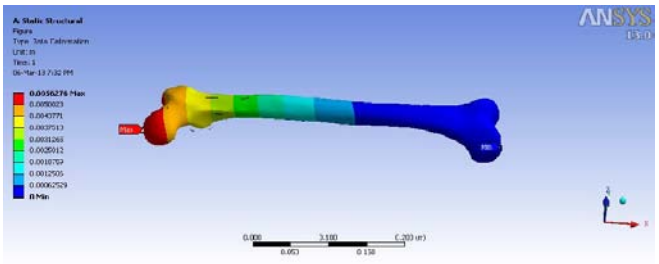

Figure 19 : Deformation Contour for Al_2O_3/Al FGM

These Figures shows similar patterns of deformation both for Ti6Al4V and Al_2O_3/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

Material	Deformation (m)	
	Maximum	Minimum
Ti6Al4V	1.2349e-003	0.0
Al_2O_3/Al FGM	5.6276e-003	0.0

Observed 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 fector of safety 15 [7].

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

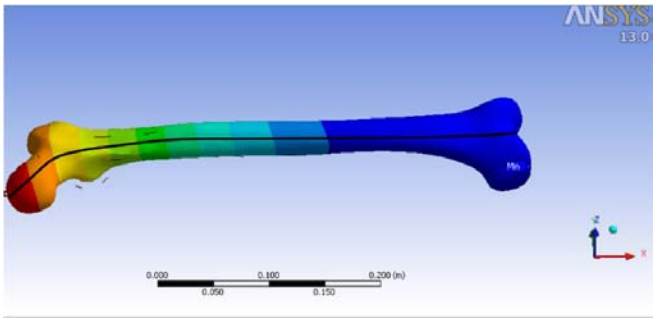

Figure 20 : Path along which deflection is measured

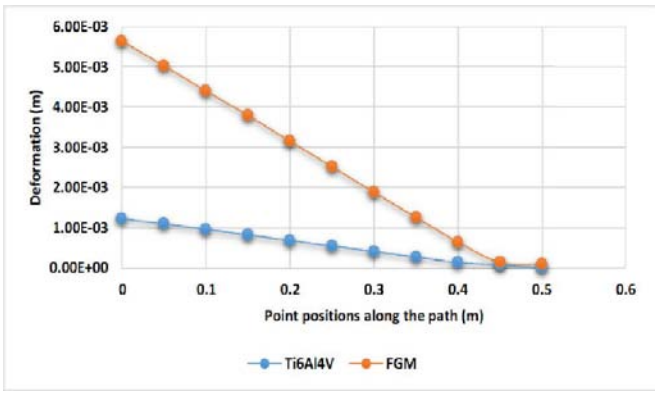

Figure 21 : Deflection Curve

From the deflection curve it is observed that Al_2O_3 /Al FGM gives 9 times less deflection than Ti6Al4V for same loading criteria. As, load applied to the femur bonr was 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].

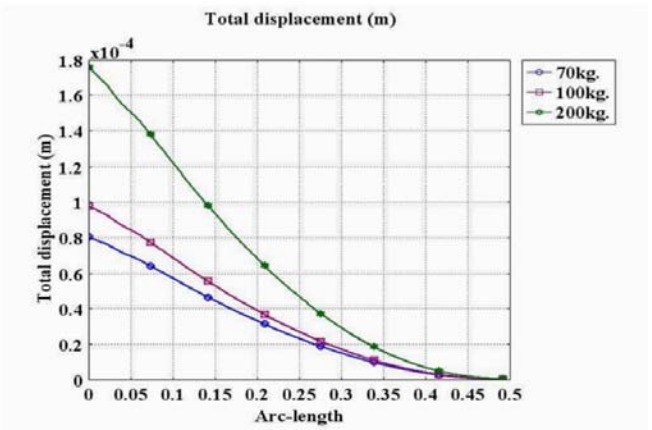

Figure 22 : Profile of total displacement along the axial of femur bone [8]

Stress development contour due to concentrated load apply on the femur head for Ti6Al4V and Al_2O_3/Al FGM can be observed from Figure. 23 and Figure. 24 respectively.

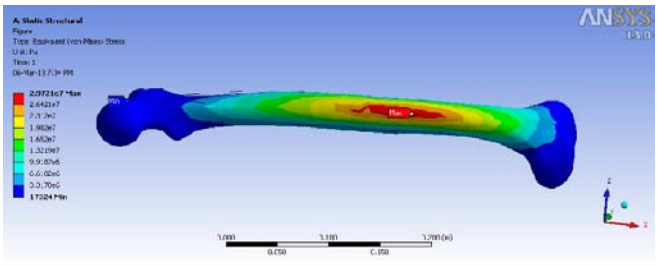

Figure 23 : Stress Contour for Ti6Al4V

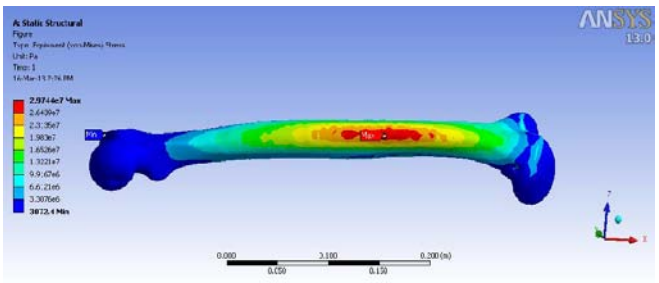

Figure 24 : Stress Contour for Al_2O_3/Al FGM

It is observed from max-min stress probe lebel that minimum stress occurs at the both ends of the femur and gradually increases to the middle portion of the bone. Mximum and minimum stress of the femur in both cases are shown in table 2.

Table 2 : Maximum and minimum stress

Material	Equivalent (Von Misses) stress (Pa)	
	Maximum	Minimum
Ti6Al4V	2.9744e+007	3072.4
Al_2O_3/Al FGM	2.9721e+007	17324

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 Al_2O_3/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 Al_2O_3/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.

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References Références Referencias

1. M. Viceconti, L. Bellingeri, L. Cristofolini, and A. Toni. Acomparative study on di®erentmetho ds of automatic meshgeneration of human femurs. Medical Engineering &Physics,20:1-10, 1998.
2. Sinha, A.; Kumar, A.; Garg, A.; Bhargava, A.; Mishra, A.K.; Sharma, B.; Mishra, B.; Thakur, S.S.; and Kumar, V. (January-June 2009) : Finite Element Method of Femur Bone,International Journal of Computer Science and System Analysis, Volume 3, Number 1, pp 13-16.
3. Chakraborty, Debabrata, Manish Ranjan, and Anil Kumar. "Dynamic Analysis Of Functionally Graded Shell Structure Using Finite Element Method." *space* 1: 2.
4. Informations available at http://en.wikipedia.org/wiki/Femur.
5. Informations available at http://education.yahoo.com/reference/gray/subjects/subject/59.
6. Kant,T., Ravichandran, R.V., Pandya, B.N., Mallikarjuna, B.N., 1988, "Finite element transient dynamic analysis of isotropic and fibre reinforced composite plates using a higher-order theory", Composite Structures 9(4):319-34291.
7. Raji Nareliya, Veerendra Kumar, "Biomechanical Analysis of human femur bone." International Journal of Engineering Science and Technology (IJEST)
8. Somkid Amornsamankul, Benchawan Wiwatanapataphee, Kamonchat Kaorapapong, "Three-Dimensional Simulation of the Femur Bone Using Finite Element Method"Selected Topics in APPLIED COMPUTER SCIENCE.
9. T.M. Keaveny, E. Guo, E.F. Wachtel, T.A. McMahon, and W.C. Hayes. Trabecular bone exhibits fully linear elastic behavior and yields at low strains. J. Biomechanics , 27:1127-1136, 1994.
10. Giannoudis, P.V.; Dinopoulos, H.; Tsiridis, E. (2005). Bone substitutes: an update. Injury, Vol.36, Suppl. No. 3, pp. S20- S27, ISSN 0020-1383.
11. http://en.wikipedia.org/wiki/Titanium_alloy
12. Chung, U.; Itaka, K.; Nishiyama, N.; Takato, T.; Kawaguchi, H.; Nakamura, K.; Kataoka, K. (2007). Scaffolds for Skeletal Regeneration. NanoBio Technology, Vol.3, No.2, pp. 104-106, ISSN 1550-7033.

13. C.N. Elias, J.H.C. Lima, R. Valiev, and M.A. Meyers, "Biomedical Applications of Titanium and its Alloys" Biological Materials Science.

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Glance of Hydroforming of Tubular Structure and Sheet Metal with Varing Blank Holding Loads by FEA & FTI

By Rakesh Jadhav & Tippa Bhimasankara Rao

Nirma Institute of Science and Technology

Abstract - Hydroforming is a cost-effective way of shaping ductile metals suchas aluminium, brass, low alloysteel, 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*

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Glance of Hydroforming of Tubular Structure and Sheet Metal with Varing Blank Holding Loads by FEA & FTI

Rakesh Jadhav [α] & Tippa Bhimasankara Rao [σ]

Abstract - Hydroforming is a cost-effective way of shaping ductile metals suchas aluminium, brass, low alloysteel, 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.

I. 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 auto-mobile 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

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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.

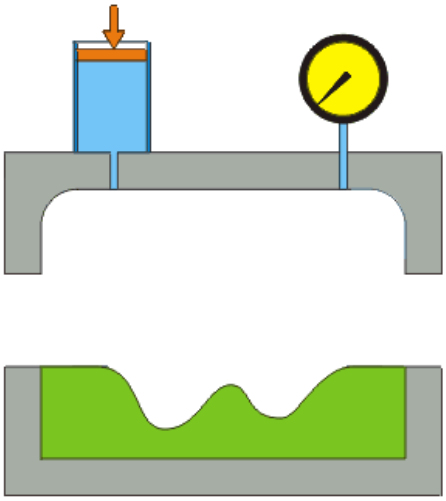


Figure 1

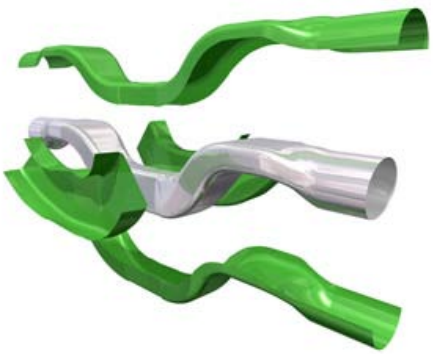


Figure 2

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.

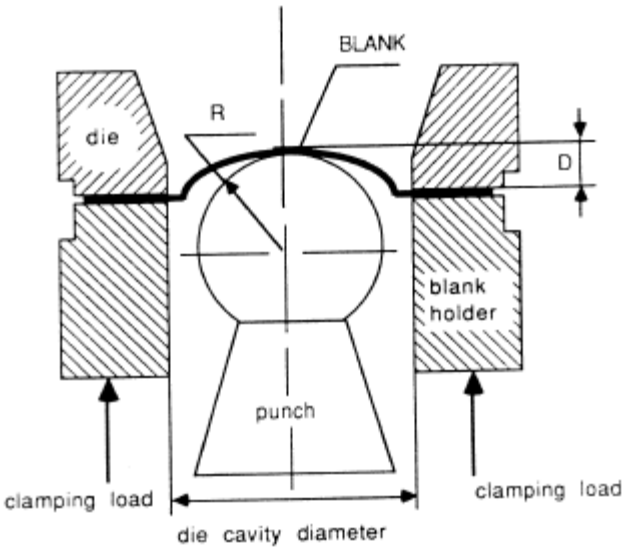


Figure 3 : Schematic illustration of Erichsen Test

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 + Llr, y).s is the curvature coordinate.

T is the surface normal.
E is the circumferential coordinate

Three principle strains are:
Circumferential strain Ea = loge [(r+r)/r]
meridional tangential strain Es = loge [ds/dr]
Through thickness strain Et = loge (t/t0)
meridional tangential strain Es = loge [ds/dr]
Through thickness strain Et = loge (t/t0)

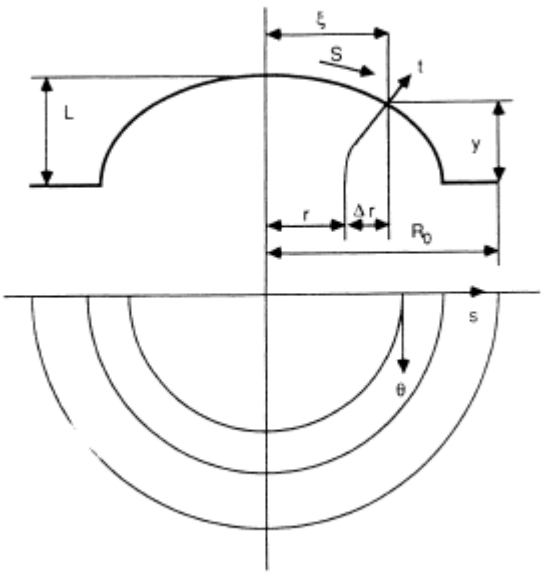


Figure 4 : Coordinates and displacement in axisymmetric sheet forming process

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 £a * is zero. But, once the draw-in occurs, the E * becomes compressive and numerically larger. Hence, reflect the actual local draw-in quality.

Lets see al introduced a draw-in parameter q> by measuring the movement of the flange. In Fig (5), DD is the die opening line;

BB is the blank outline
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 (Ac / AD)
Ac and AD denote respectively the area inside the circle of CC
and DD. <p reflects the overall draw-in quantity.

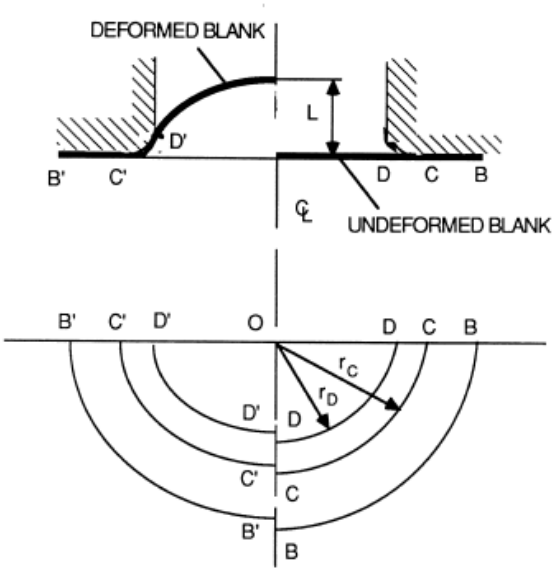
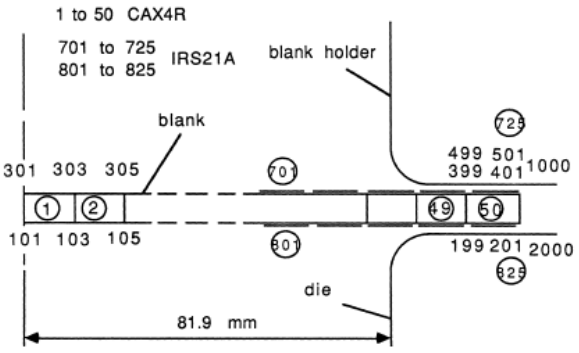


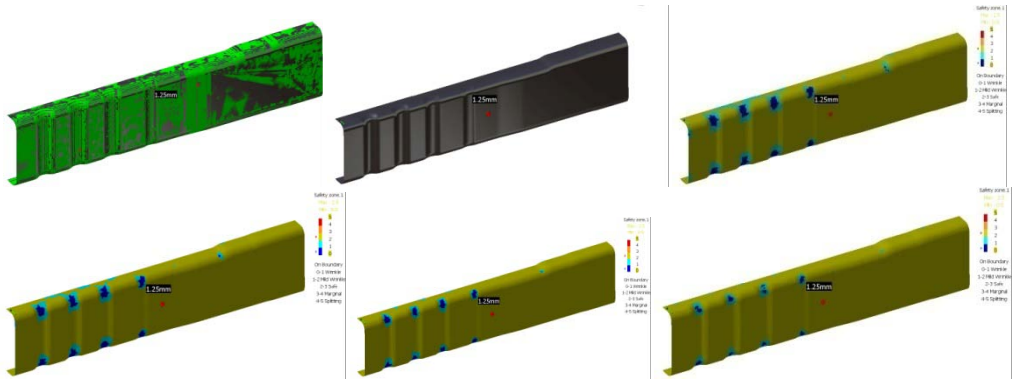
Figure 5 : Flange movement during the Blanking Process

IV. Calculations & Simulation

Finite Element Modelling:-



Result (a): Simulation in FTI software-



Result (b):- Simulation in FEA-

£ = mIn[1- exp(-ne)] + k
Where E is the true strain defined as
£ =2/9 [(£1 - £2)2 + (£2 - £3)2 + (£3 - £1)2]0.5
o is the true strain
o=1, * [({j1- {j2)2 + ({j2- {j3)2 + (~- {j1)2]O.S

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 thelimiting of thickness strain at critical section Et * 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

1. Kaftanoglu, B. and Alexander, J.M., "An Investigation of the Erichsen Test," Journal of the Institute of Metals, Vol. 90, 1962, pp 457-470.
2. Shang, H.M., Chau, F.S., Tay, C.J. and Toh, S.L., "Modeling of the Hydroforming of Sheet Materials Clamped With Varying Blank Holding Loads," Transactions of the ASME, Vol. 109, 1987, pp 92-97

3. Lee, P.K., Choi, C.Y. and Hsu, T.C., "Effect of Draw-In on Formability inAxisymmetrical Sheet Metal Forming," J. Of Engineering for Industry, Nov., 1973, pp 925-930.
4. Wang N.M. and Budiansky, B., "Analysis of sheet Metal Stamping by a Finite Element Method," Journal of Applied Mechanics, Vol. 45, 1978, pp 72-81.

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

By Suraj Choudhary & Parveen Saini
Galaxy Global Group of Institutions

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*

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Keywords : *EDM, taguchi design orthogonal array.*

I. 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 ofwork piece is removed by erosion effect by the electricspark. 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

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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-soldified 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 of 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 3.1 : Constant input parameters

S.No	Parameter	Set Value
1	Polarity	Positive
2	Machining Time	15 minute
3	Pulse off	5μs
4	Open circuit voltage	80±5%
5	Dielectric	EDM oil
6	Dielectric Pressure	0.2 Kg/cm^2
7	Diameter of electrodes	10mm

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 3.2 : Composition of stainless steel 316

C(%)	Mn	Si	P	S	Cr	Mo	Ni	N
0.08	2	0.75	0.045	0.03	18	3	14	0.10

The composition for the stainless steel 316 shown inTable No.3.2. The work piece dimensions for the experiment were Φ60 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

Tensile stress (MPa)	Yield stress (MPa)	Rockwell hardness (HRB)	Brinell hardness (HB)
515	205	95	217

Table 3.4 : Physical and electrical properties for Stainless steel 316

Density (Kg/m3)	Elastic Modulus (GPa)	Thermal Conductivity (W/m.K) at 100˚C	Specific heat 0-100˚C (J/Kg.K)	Electrical Restivity (nΩ.m)
8000	193	16.3	500	740

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

L_9 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 $MSD_{HB} = \frac{1}{r}\sum_{i=1}^{r}(\frac{1}{y_i^2})$

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

r = no. of trials

y_i = thei^{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_{HB} = Mean Square deviation for lower the better response

Table 4.1: Factors & their levels for experiments

Factors	Levels			Observed Values
	Level 1	Level 2	Level 3	
Electrode Material	Copper	Brass	Graphite	1. Material removal rate (gms) 2. Surface roughness (μm)
Current, Amp	10	18	30	
Pulse-on, μs	35	50	65	

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

Experiment No.	Electrode Material	Current (Amp)	Pulse on (μs)	Material Removal Rate (gms)			S/N ratio for MRR	Surface Roughness (μm)			S/N ratio of SR
				1	2	3		1	2	3	
1	Copper	10	35	1.44	1.42	1.55	3.3273	9.96	9.99	10.13	-20.0233
2	Copper	18	50	2.82	2.78	2.77	8.9109	10.38	10.47	10.53	-20.3908
3	Copper	30	65	4.14	4.22	4.15	12.4008	11.02	10.86	10.82	-20.7488
4	Brass	10	50	0.28	0.29	0.3	-10.7624	6.20	6.26	6.23	-15.8898
5	Brass	18	65	0.48	0.46	0.5	-6.3909	6.86	6.88	6.92	-16.7602
6	Brass	30	35	0.71	0.75	0.79	-2.5235	5.45	5.39	5.41	-14.6747
7	Graphite	10	65	0.58	0.54	0.59	-4.9018	5.36	5.32	5.40	-14.5835
8	Graphite	18	35	1.86	1.88	2.02	5.6487	12.77	12.84	12.76	-22.1374
9	Graphite	30	50	2.66	2.61	2.56	8.3296	11.1	11.21	11.01	-20.9119

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

Level	Electrode material	Current	Pulse-on
1	8.213	-4.1123	2.1508
2	-6.5589	2.7229	2.1594
3	3.0255	6.0689	0.3694
Delta	14.7719	10.1812	1.79
Rank	1	2	3

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

Level	Electrode material	Current	Pulse-on
1	2.81	0.7767	1.38
2	0.5067	1.73	1.8967
3	1.7	2.51	1.74
Delta	2.3033	1.733	0.5167
Rank	1	2	3

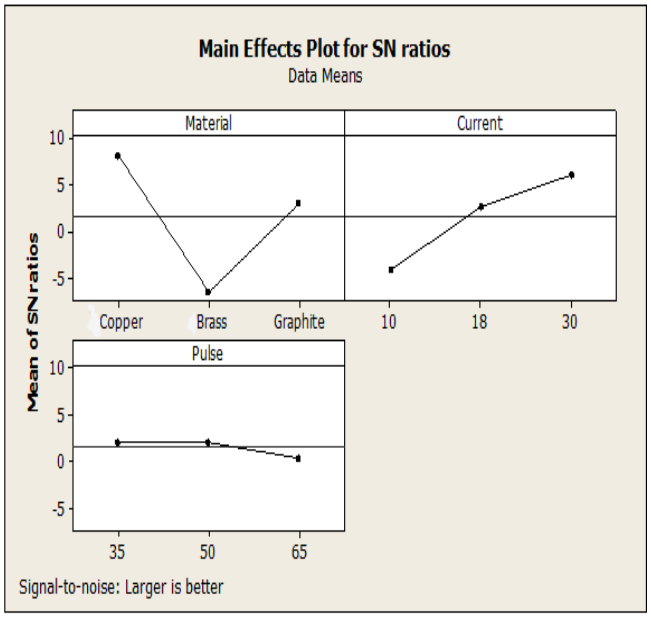

Figure No. 5.1 : Main effects plot of S/N ratio for MRR

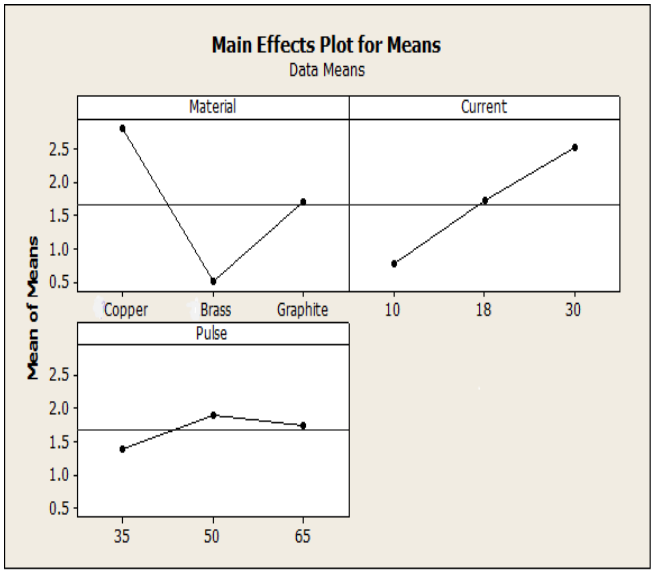

Figure No. 5.2 : Main effects plot of mean value for MRR

Table No. 5.4 : Analysis of variance and F test for MRR

Source	Sum of squares	Degree of freedom	Mean square	F^{value}
Material	7.9615	2	3.9807	8.27
Current	4.5217	2	2.2608	4.69
Pulse-on	0.4211	2	0.2105	0.44
Error	0.9631	2	0.4815	
Total	13.8674	8		

Table No. 5.5 : Average effect response table of S/N ratio for SR

Level	Electrode material	Current	Pulse-on
1	-20.39	-16.83	-18.94
2	-15.78	-19.76	-19.06
3	-19.21	-18.78	-17.37
Delta	4.61	2.93	1.70
Rank	1	2	3

Table No. 5.6 : Average effect response table of raw data for SR

Level	Electrode material	Current	Pulse-on
1	10.460	7.203	9.410
2	6.180	10.047	9.267
3	9.753	9.143	7.717
Delta	4.280	2.843	1.693
Rank	1	2	3

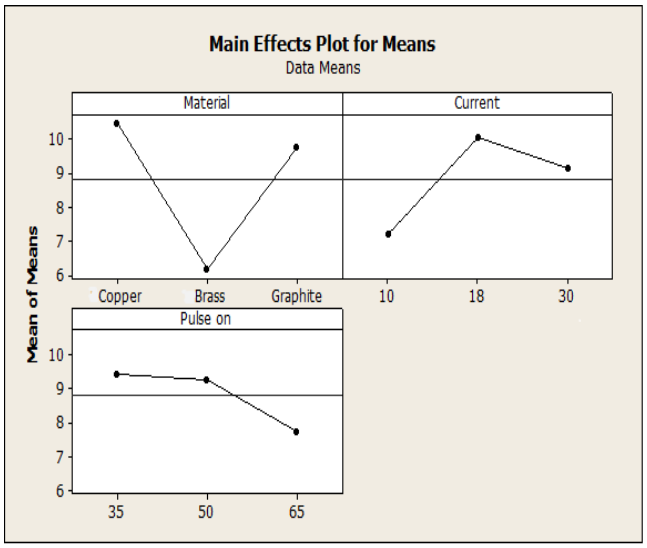

Figure No. 5.3: Main effects plot of mean value for SR

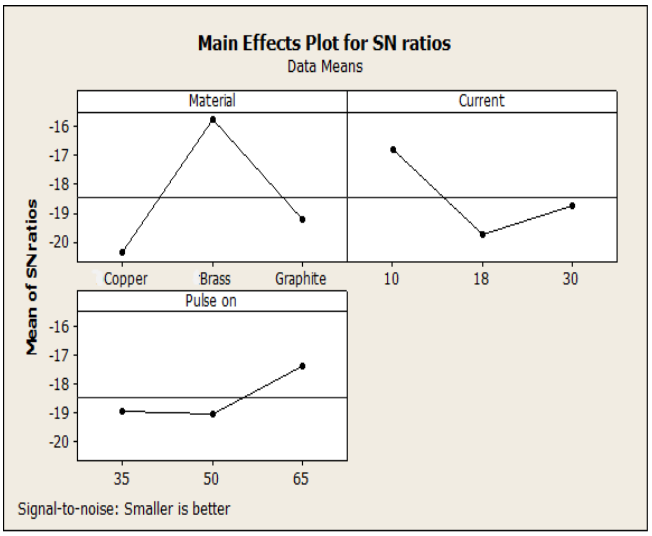

Figure No 5.4 : Main effects plot of S/N ratio for SR

Table No. 5.7 : Analysis of variance and F test for SR

Source	Sum of squares	Degree of freedom	Mean square	F_{value}
Material	31.586	2	15.793	2.28
Current	12.664	2	6.332	0.91
Pulse	5.290	2	2.645	0.38
Error	13.880	2	6.940	
Total	63.421	8		

VI. Results & Analysis

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 facor for the MRR and Rank 3 means lowest contribution facor 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 $F_{critical}$ 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:

$n_{opt} = n_m + \sum_i^a (\bar{n}_i - n_m)$

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.

n_{opt} = 1.5598 + (8.213 – 1.5598) + (6.0689 – 1.5598) + (2.1594 – 1.5598) = 13.3217

$$\text{Corresponding value of MRR} = y^2_{opt} = \frac{1}{10^{\frac{-n_{opt}}{10}}}$$

$$y^2_{opt} = \frac{1}{10^{\frac{-13.3217}{10}}}$$

$$y_{opt} = 4.65$$

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:

n_{opt} = -18.458 + (-15.78 + 18.458) + (-16.83 + 18.458) + (-17.37 + 18.458) = -13.064

$$\text{Corresponding value of SR} = y^2_{opt} = 10^{\frac{-n_{opt}}{10}}$$

$$y^2_{opt} = 10^{\frac{13.064}{10}}$$

$$y_{opt} = 4.49$$

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

1. Haron, C.H., Deros, B.M., Ginting, A. and Fauziah, M. (2001), "Investigation on influence of machining parameters when machining tool steel using EDM", Journal of Materials Processing Technology, Vol. 116, pp. 84-87.
2. Kojima, H., Kunieda, M. and Nishiwaki, N. (1992), "Understanding discharge location movement during EDM", Proceedings International Symposium Electro machining, Vol. 10, pp. 144.
3. Dewangan, S.K. (2010), "Experimental Investigation of Machining Parameters for EDM using U- shaped Electrode of AISI P20 Tool Steel", NIT Rourkela, pp. 4-6.
4. Jianxin, D. and Taichiu, L. (2002), "Effect of ultrasonic surface finishing on the strength and thermal shock behavior of the EDM ceramic composite", International Journal of Machine Tools & Manufacture, Vol.42, pp. 245-250.
5. Han, F. and Kunieda, M. (2004), "Development of parallel spark electrical discharge machining", Precision Engineering, Vol. 28, pp. 65-72.
6. Hassan, M.A., Tomadi, S.H., and Khalid, A.G. (2009), "Analysis of the Influence of EDM Parameters on Surface Quality, Material Removal Rate and Electrode Wear of Tungsten Carbide", Proceedings of the International Multi Conference of Engineers and Computer Scientists, Vol II.
7. Rose, J. P. (1996), "Taguchi techniques for quality engineering", 2nd Edition, Mc-Graw Hill, pp. 23-138.
8. Trivedi, K.S. (2008), "Probability & statistics with reliability, queuing and computer science applications", PHI learning private limited, New Delhi. pp. 561-566.
9. Patel, K.P. (2012), "Experimental analysis on surface roughness of CNC END Milling process using Taguchi design Method", International journal of Engineering science and Technology, Vol. 4, No. 2, pp. 540-545.

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The Characteristics of Torsionally Flexible Metal Coupling

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Abstract - The paper presents construction I.metal couplingIntroduction 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*

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The Characteristics of Torsionally Flexible Metal Coupling

Dr. Hab. Inż. Krzysztof Filipowicz

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.

I. 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.

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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.

II. The Construction of Torsionally Flexible Metal Couplings

One of the constructional forms of bidirectional torsionally flexible metal coupling is shown in figure 1.

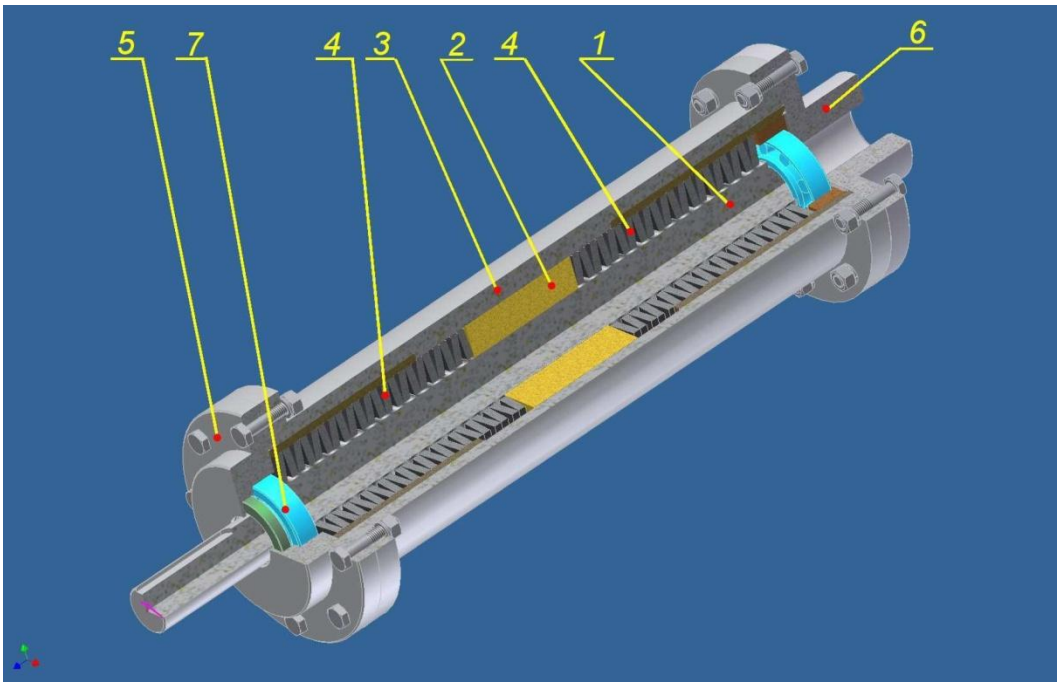

Figure 1 : Two-way- flexible torsional metal coupling prototype construction. 1 – Screw-threaded coupling shaft, 2 – Splinded sliding sleeve with internal screw thread, 3 – Housing with cut splines, 4 – Disk spring set, 5 – Cover plate, 6 – Coupling hub, 7 – Cone bearings

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 φ between the active and the passive element of the coupling. The changes of the torque in this case should be very slow.

$$M_{obr} = f(\varphi) \quad (1)$$

Where: M_{obr}– The torque moment on the flexible coupling, Nm, φ - 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} = 100Nm. At the same time the relative angular displacement of the coupling elements φ_{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 φ_{stat} is carried out with and without the load. The aim of this procedure is to determine the histeresis loop which presents the value of the mechanical energy damping in the coupling.

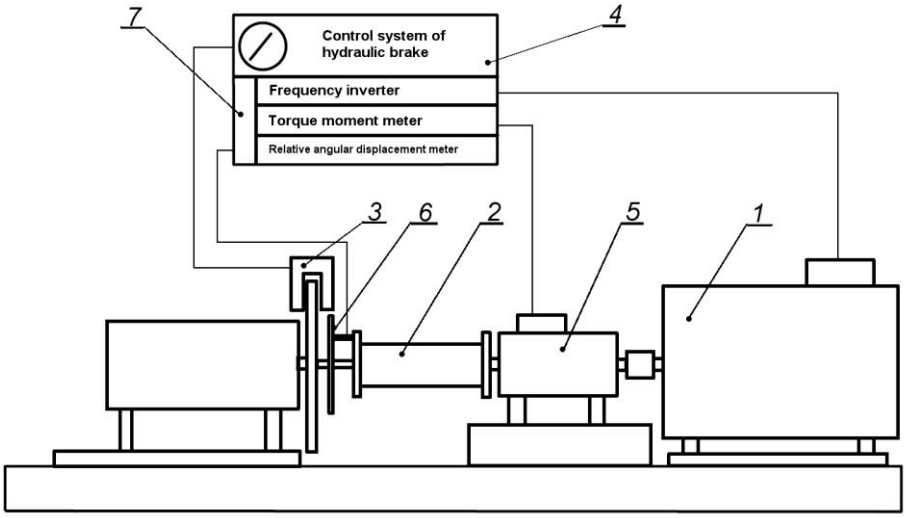

Figure 2 : The testing stand used to test the mechanical couplings, where: 1 – Electric motor, 2 – Tested flexible coupling, 3 – Hydraulic disc brake, 4 – Control system of hydraulic brake, 5 – Torque meter, 6 – Disc with an angular scale, 7 – Measuring-recording set

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

Coupling Number	Type of disc springs DIN 2093	The number of springs in the pack	The arrangement of the pack
1	40 x 20,4 x 2,5	5	<<<<< >>>>>
2	40 x 20,4 x 2,5	4	<<<< >>>>
3	40 x 20,4 x 2,25	4	<<<< >>>>
4	40 x 20,4 x 2	4	<<<< >>>>

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:

$$k = \frac{M_{stat}}{\varphi_{stat}} \qquad (2)$$

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

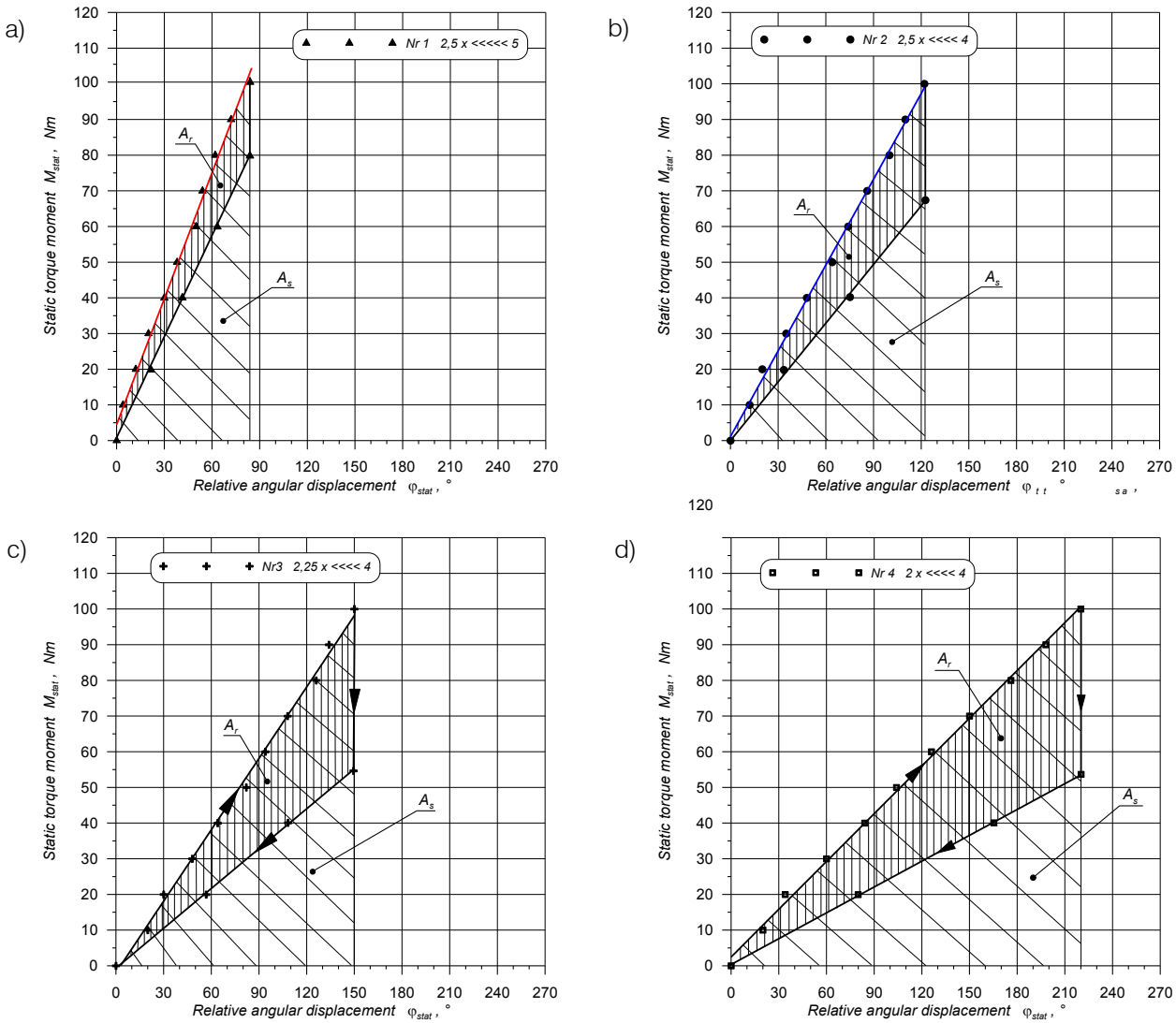

Figure 3 : The illustration of some static characteristics of torsionally flexible metal coupling, where: a – Coupling no. 1, b – Coupling no. 2, c – Coupling no. 3, d – Coupling no. 4

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:

$$\psi = \frac{A_r}{A_s} \qquad (3)$$

Where:

A_r – damping during one working cycle, Nm · degrees.
A_s – elastic strain during one work cycle, Nm · degrees.

The obtained torsional rigidity coefficients as well as the damping coefficient for the tested options of the torsionally flexible metal coupling are presented in Table 2.

Table 2 : The obtained torsional rigidity coefficient k and the damping coefficient ψ

Coupling Number	Type of disc springs	The torsional rigidity coefficient k, Nm/°	The damping coefficient ψ
1	40 x 20,4 x 2,5	1,77	0,20
2	40 x 20,4 x 2,5	0,80	0,33
3	40 x 20,4 x 2,25	0,67	0,45
4	40 x 20,4 x 2	0,45	0,47

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

1. Filipowicz K: Driving with Flexible Couplings. MSD Motion System Design. Penton Media Inc. New York USA, 2/2009, pp. 34-36.
2. Filipowicz K.: Nowe rozwiązania konstrukcyjne metalowych sprzęgieł podatnych skrętnie do napędów maszyn roboczych ciężkich. Mechanik, nr. 7, 2008, pp.615-620.
3. Filipowicz K.: New solutions of driving systems with the torsionally flexible metal coupling. Transport Problems – International Scientific Journal. Wydawnictwo Politechniki Śląskiej, T.3, Zeszyt 4, Część II, Gliwice 2008, s.5-11.
4. Kowal A., Filipowicz K.: Metalowe sprzęgła podatne skrętnie do maszyn górniczych. Gliwice: Wydawnictwo Politechniki Śląskiej, 2007.

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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
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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 earlies.

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

GJRE-A Classification : FOR Code: 091106

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Failure Mode, Effects and Criticality Analysis of Load Haul Dump Vehicles (100t) in Open Cast Mines

NL Narayana [α], Dr. NVS Raju [σ], Chaithanya. K [ρ] & Dr. P. Ram Reddy [ω]

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

I. 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, reconditioning, 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.

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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).

$$RPN = (S) * (O) * (D)$$

Criticality Ranking Accoring To RPN

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

Failure Number	Failure Classification	Maintenance Policy
1	Catastrophic	Replace the equipment
2, 3 & 4	Critical Failure	Complete overhaul
5, 6 & 7	Marginal	Repair the component
8, 9 & 10	Minor	Inspect daily

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

1. MIL-STD-1629A - Procedures for performing a failure mode effect and criticality analysis. Department of Defense (USA). 24 November 1980
2. Raju N V S, *Plant Maintenance & Reliability Engineering*, CENGAGE Learning
3. Magne Vollan Aarset, *How to Identify a Bathtub Hazard Rate*, IEEE TRANSACTIONS ON RELIABILITY, VOL. R-36, NO. 1, 1987 APRIL, pp 106 - 108
4. Roy Billington, Ronald N Allan, *Reliability Evaluation of Engineering Systems*, Plenum Press, *N. Y,* 1984
5. B Bergman, B Klefsjo, *The total time on test concept and its use in reliability theory*, Oper. Res., vol 32, pp 596-606.
6. B Bergman, B Klefsjo, *A graphical method applicable to age replacement problems*, IEEE Trans. Reliability, vol R-31, 1982 0.2 - Dec, pp 478-481.
7. Failure Modes, Effects, and Criticality Analysis (FMECA). National Aeronautics and Space Administration JPL. PD–AD–1307. Retrieved 2010-03-13
8. Procedure for Failure Mode, Effects and Criticality Analysis (FMECA). National Aeronautics and Space Administration. 1966. RA–006–013–1A. Retrieved 2010-03-13
9. Kumar, U., *Reliability centered maintenance — A tool for higher profitability. Maintenance. Maintenance,* Vol.5, 1990
10. Peng Wang, David W. Coit, *Repairable Systems Reliability Trend Tests and Evaluation,* IEEE Trans. Reliability, vol R-31, 1980 Apr, pp 78-88
11. Military Standard (1981), MIL-HDBK-189, Reliability Growth Management
12. Jasper L. Coetzee, *The role of NHPP models in the practical analysis of maintenance failure data*,

Reliability Engineering and System Safety 56 (1997), Elsevier Science Limited, pp 161-168

13. Ascher H Feingold, *Repairable Systems Reliability*, Marcel Dekker, 1984
14. Barlow R E, Campo R, *Total Time on Test Processes and Applications to Failure Data Analysis*, Reliability and Fault Tree Analysis, SIAM, Philadelphia, U.S.A, 1975
15. Charles E Ebeling, *An Introduction to Reliability and Maintainability Engineering*, McGraw-Hill International Editions, Singapore, *1997*
16. Lawless J F. *Statistical Models and Methods for Lifetime Data*, John Wiley & Sons, 1982
17. TM 5-698-4, Technical Manual, Failure Modes, Effects and Criticality Analysis (FMECA) for Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) Facilities, Department of the Army, Washington, DC.
18. K.R.M.Rao, P.V.N.Prasad, A.Ramesh, 'Long Wall Mining System Availability as a Stochastic Process', *Platinum Jubilee Symposium on Productivity Improvement in Indian Mining industry,* Institute of Technology, Banaras Hindu University, Varanasi, India, January 1999
19. Ulf Westberg, Bengt Klefsjo", 'Applications of the Piecewise Exponential Estimator for the Maintenance Policy Block Replacement with Minimal Repair, *IAPQR Transactions,* 20, 197-210, 1995
20. Uday Kumar, Bengt Klefsjo", '*Reliability Analysis of Hydraulic Systems of LHD Machines Using the Power Law Process'*, Proceedings of Society of Reliability Engineers, SRE Symposium, Stavanger, Norway, 179-191, October 1989
21. K.R.M.Rao, P.V.N.Prasad, '*Models for Replacement and Overhaul of Repairable Equipment — Dozers in Open Cast Mines — Case Studies*', Proceedings of MGMI International Conference on Management of Mining Machinery, Calcutta, July 1999.
22. K.R.M.Rao, P.V.N.Prasad, '*Graphical Methods for Analyzing Reliability of Repairable Equipment and Maintenance Planning*', IEEE Reliability Society, Proceedings, Annual Reliability and Maintainability Symposium, IEEE, U.S.A, 2001
23. R.E.Barlow, B.Davis, '*Analysis of Time Between Failures for Repairable Components'*, Research Report, University of California, California, 1977.
24. P.V.N. Prasad, K.R.M. Rao, '*Age Replacement Policy of Censored Data Using TTT Plots*', Third International Conference on Mathematical Models in Reliability, Norway, June 2002
25. P.V.N. Prasad, K.R.M. Rao, '*Maintenance Planning of Dozer Engines Using TTT Plots'*, Sixth International Conference on Engineering Design and Automation, Hawaii, U.S.A, August 2002

Appendix

FMECA of all 100 Ton Dumpers

F No	Failure Name	frequency	time	occurrence	severity	detection	RPN
1	Radiator Leak	30	1987	0.1863	0.3447	0.4	0.0257
2	Engine Failures	23	967	0.1429	0.1678	1	0.0240
3	Suspension Failure	21	945	0.1304	0.1639	0.7	0.0150
4	Brake Failures	25	482	0.1553	0.0836	0.9	0.0117
5	Air compressor failures	20	633	0.1242	0.1098	0.6	0.0082
6	Cylinder Failure	12	1188	0.0745	0.2061	0.3	0.0046
7	Steering problems	13	256	0.0807	0.0444	0.8	0.0029
8	Bolts and studs failure	14	666	0.0870	0.1155	0.2	0.0020
9	Bucket & wear plate damage	14	255	0.0870	0.0442	0.5	0.0019
10	Hose failure and hoist failure	19	372	0.1180	0.0645	0.1	0.0008

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

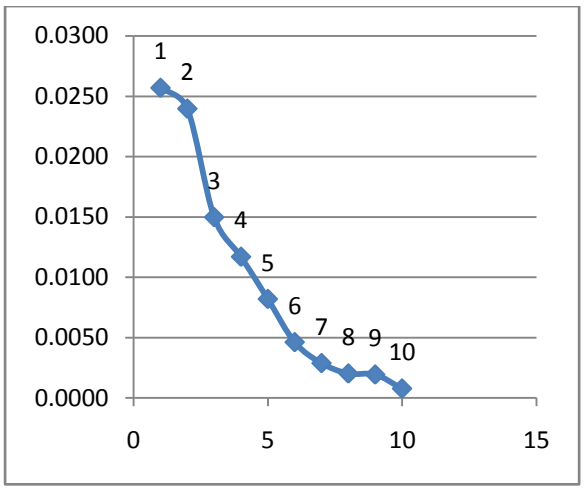

Figure 1 : Failure number Vs RPN of 100 T Dumpers

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

F No	Failure Name	frequency	time	occurrence	severity	detection	RPN
1	Gears failure	3	936	0.0789	0.4522	0.5	0.0178
2	brake failures	5	202	0.1316	0.0976	0.9	0.0116
3	radiator leaks	7	236	0.1842	0.1140	0.4	0.0084
4	Railings damage	4	96	0.1053	0.0464	1	0.0049
5	steering problems	3	96	0.0789	0.0464	0.8	0.0029
6	pivot, bolts and studs failure	4	270	0.1053	0.1304	0.1	0.0014
7	cylinder failure	3	136	0.0789	0.0657	0.2	0.0010
8	Bucket damage	4	44	0.1053	0.0213	0.3	0.0007
9	tyre problems	3	22	0.0789	0.0106	0.7	0.0006
10	suspension failure	2	32	0.0526	0.0155	0.6	0.0005

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

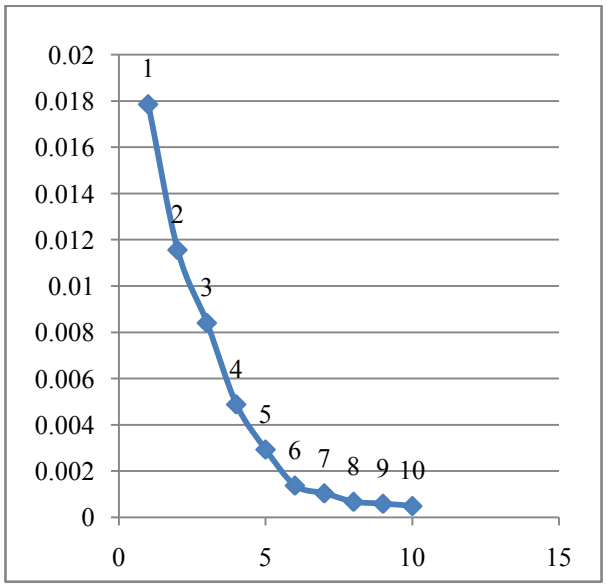

Figure 2 : Failure number Vs RPN of CD – 302 Dumper

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

F No	Failure Name	Frequency	time	occurrence	severity	detection	RPN
1	radiator leaks	8	136	0.2667	0.1276	0.4	0.0136
2	Engine failures	2	195	0.0667	0.1829	1	0.0122
3	water boiling in radiator	4	108	0.1333	0.1013	0.8	0.0108
4	suspension failure	4	243	0.1333	0.2280	0.3	0.0091
5	cylinder failure	2	113	0.0667	0.1060	0.6	0.0042
6	pivot, bolts and studs failure	2	93	0.0667	0.0872	0.5	0.0029
7	clutch failure	2	19	0.0667	0.0178	0.9	0.0011
8	Gears failure	1	47	0.0333	0.0441	0.7	0.0010
9	hose failure and hoist failure	3	90	0.1000	0.0844	0.1	0.0008
10	Bucket damage	2	22	0.0667	0.0206	0.2	0.0003

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

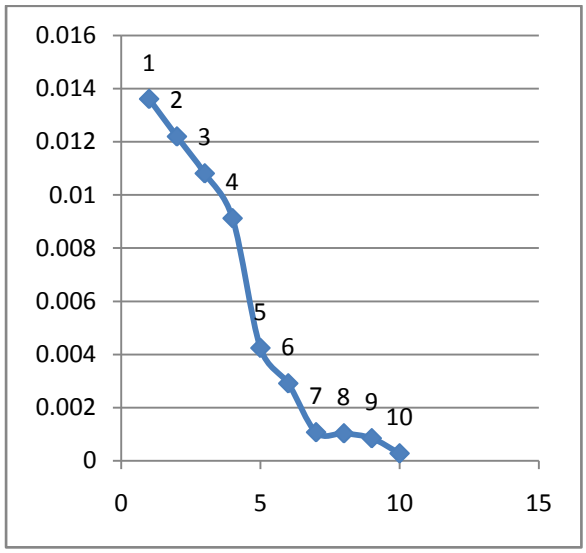

Figure 3 : Failure number Vs RPN of CD – 303 Dumper

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

F No	Failure Name	frequency	time	occurrence	severity	detection	RPN
1	Engine failures	3	131	0.1429	0.2323	1	0.0332
2	leaks and liquid change	4	213	0.1905	0.3777	0.2	0.0144
3	air compressor broken	2	67	0.0952	0.1188	0.7	0.0079
4	tyre problems	2	23	0.0952	0.0408	0.8	0.0031
5	Railings damage	2	33	0.0952	0.0585	0.5	0.0028
6	transmission failure	2	26	0.0952	0.0461	0.4	0.0018
7	belt and pulley failure	2	16	0.0952	0.0284	0.6	0.0016
8	rock ejector damaged	2	33	0.0952	0.0585	0.1	0.0006
9	brake failures	1	7	0.0476	0.0124	0.9	0.0005
10	Bucket damage	1	15	0.0476	0.0266	0.3	0.0004

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

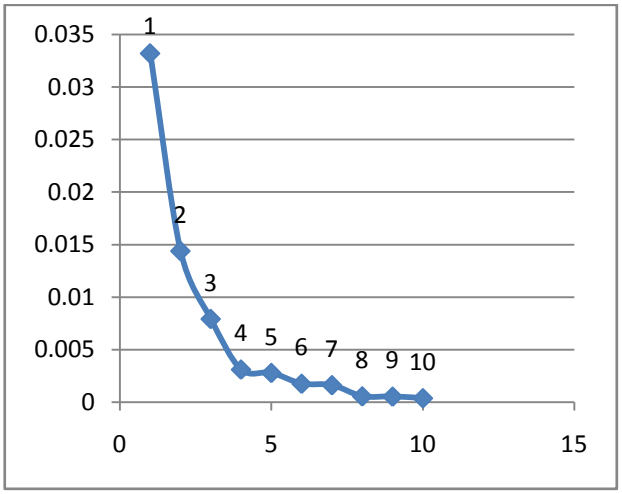

Figure 4 : Failure number Vs RPN of CD – 305 Dumper

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

F No	Failure Name	Frequency	time	occurrence	severity	detection	RPN
1	radiator leaks	4	78	0.2222	0.1785	0.3	0.0119
2	Bucket damage	2	58	0.1111	0.1327	0.4	0.0059
3	not taking load	1	51	0.0556	0.1167	0.7	0.0045
4	brake failures	1	31	0.0556	0.0709	0.8	0.0032
5	pivot, bolts and studs failure	2	116	0.1111	0.2654	0.1	0.0029
6	steering box failures	2	16	0.1111	0.0366	0.5	0.0020
7	steering problems	1	15	0.0556	0.0343	0.9	0.0017
8	hose failure and hoist failure	3	45	0.1667	0.1030	0.1	0.0017
9	Engine failures	1	12	0.0556	0.0275	1	0.0015
10	tyre problems	1	15	0.0556	0.0343	0.6	0.0011

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

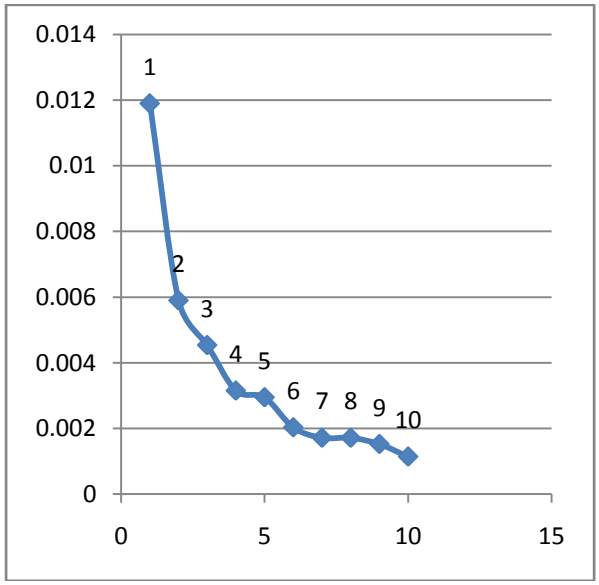

Figure 5 : Failure number Vs RPN of CD – 306 Dumper

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.

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4. Manuscript's Category,

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- 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:

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Abstract:

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

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

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

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

Approach:

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

Introduction:

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

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

Approach:

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- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
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- 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.

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- Report the method (not particulars of each process that engaged the same methodology)
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- 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.
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What to keep away from

- Resources and methods are not a set of information.
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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.

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- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
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- Present a background, such as by describing the question that was addressed by creation an exacting study.
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Approach

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- 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.
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Approach:

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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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