ISSN: 2321-7782 (Online)
Volume 3, Issue 2, February 2015
International Journal of Advance Research in Computer Science and Management Studies
Research Article / Survey Paper / Case Study
Available online at: www.ijarcsms.com

Analysis the Effect of Impact on Mild steel shafts through Response Surface Methodology for Safety Consideration

Boominathan. N[1]
Research Scholar
Periyar Maniammai University
Thanjavur(TN) - India

Dr. Vijayaraghavan.GK[2]
Principal
Dhaanish Ahmed College of Engineering
Padappai, Chennai .601 301(TN) - India

Dr. Kathiravan. R[3]
Prof.
Aero space Engineering Dept
Periyar Maniammai University
Thanjavur. 613 403(TN) - India

Abstract: Impact is the sudden application of force or load .So it is important to study of its characteristics in various applications, materials for safety consideration. Sudden failure due to the impact action leads to interruption in process, production loss, system failure, accident and development of unsafe working condition. To avoid such things a predesign failure analysis is the must. Unsafe act and unsafe condition are the two main causes of accidents. In this, the unsafe condition starts from the design stage itself. Experimental analysis with system loads (software) is required to make the data as reference. Various factors like material, size, shape, length, groove details, distance of groove from one end will be considered for its effects analization .here the above factors are implied on mild steel hexagonal shafts in impact testing machine and the data are analyzed with response surface methodology in Minitab -version -15 software. This study and analysis are the pre design one and the data are more useful to a Design Engineers for their anytime reference to select an appropriate and optimum value to improve the factor of safety as well as the safety to provide an accident free working environment.

Keywords: impact test, safe impact load.

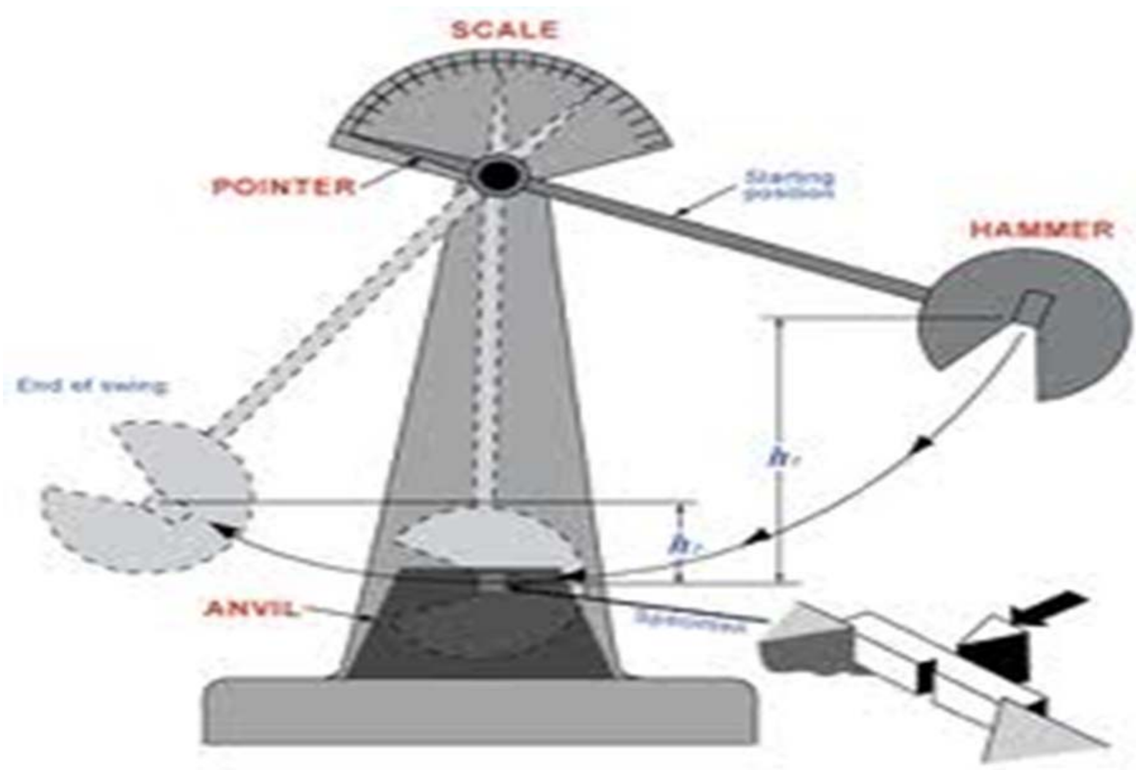
I. INTRODUCTION

Most of the engineering components affects by various forces in its application. The forces are depending on the load, distance and type of its application.Static and dynamic load are the general categories. Each has its own effect on the other member in which it is applied.Static load gives the effect of buckling, fracture etc. Dynamic load has the effect of displacements, sudden fracture, and deformation of structures.Material testing is essential to select the appropriate material to fabricate a component .Some testing parameters are required to select the material in the design itself. In this study we select the impact effect on various materials, especially in mild steel. ASTME in its Tool Engineer's Hand Book [20] stresses about the importance of the Fatigue failure studies and analysis. It also insists that these types of study and analysis are required to improve the safety measures and to develop a safety environment in the pre design stage itself. R.S. Khurmi [10] in his 'Strength of material book' told a sequential procedure for the fatigue test to observe the behavior of materials under various parameters. Wikipedia [21], the free encyclopedia tells that the fatigue failure is an unexpected and catastrophic failure in use and the three stages of failure occurs. It defines the fatigue and gives the details about the causes for fatigue failures, its various types, and gives the details about fatigue life. Engineers edge Solution by Design [7] website gives examples of fatigue failures. One is breaking a thin steel rod or wire with hands after bending it back and forth several times in the same place. Another one is an unbalanced pump impeller resulting in vibration that can cause fatigue failure. It also clearly states that the fundamental requirements during design and manufacturing for avoiding fatigue failure are different for different cases and should be considered during the design phase itself. R.Narayanasamy and P.Padmanabhan [14] published an article which had an experimented plan based on the central composite plan and the experimental results were analysed by MINITAB software – version 13. ASTME (American Society of Tool and Manufacturing Engineers) Tool Engineers Hand Book Edition 2 (Section 90 pp17) gives an important note to the design Engineers as follows: "Experience has shown that notches, sharp changes of section and other forms of stress raisers are dangerous to metals in applications involving repeated stress. Some Engineers neglect to take stress raisers into consideration in design and inspection with the result that a number of avoidable fatigue failures occur. From this statement it is clearly observed that a pre design analysis of fatigue failure needs before design". From the sugar mill roll shaft failure analysis of M.J.Reid[18], one can easily understand the importance of design factors. In his theoretical analysis of shaft failures he concentrated on the shaft stresses and fatigue stress concentration factors have been carried out to determine the present shaft design, machine properties, material specifications and the shell assembly techniques. He made his first concentrations on the shaft design factors. This study and analysis are the pre design one and the data are more useful to a Design Engineers for their anytime reference to select an appropriate and optimum value to improve the factor of safety as well as the safety to provide an accident free working environment. M.B. Ali, S. Abdullah says[1] in his article , Dynamic fracture properties of most engineering materials are generally assessed using the charpy test. The dynamic responses of the standard charpy impact machine are studied by running experiments using strain gauges and a specific data acquisition system in order to obtain the impact response and for this reason, the numerical analysis by means of the finite element method has been used to obtain the findings. Arja Saarenheimos[2] tells In order to obtain reliable numerical results the used methods and models should be verified against experimental data. The objective of this paper is to study the accuracy and capability of numerical methods in analysing reinforced concrete structures under soft missile impacts. Yong Zhang [22] says Vehicle impact can be considered as a highly nonlinear dynamic process, where high strength steel severely Deforms under different strain rates and also suffered from thermal softening. However, its constitutive material parameters may not consider the abovementioned effects in uniaxial tensile tests. Since accuracy and reliability Of finite element predictions largely rely on material constitutive model, thus an accurate material model, which takes deformation rate and thermal effects into account, has to be established for a more accurate numerical simulation. In this respect, the Johnson–Cook (JC) constitutive model considers the effects of high-strain rate. Mohd Shahiddin Suhadi, [13] tells this paper presents the effect of high strain rate loading to tensile strength for mild steel by using Hopkinson bar technique. The behavior of material at high strain rates is important for application such as structural impact, automotive safety engineering and metalworking. In automotive industries, mild steel has been used as material in some of component. Due to dynamic condition occurrence during vehicle crash it is important to analyze the strength of component. R. W. Armstrong [3] says Almost from the earliest time of stress–strain measurements being reported for the conventional strain rate (and temperature) dependences of the deformation and fracturing behaviors of metals and alloys, there were concerns about the connection of such measurements with the higher strain rate properties of the same materials.

Effect Of Impact On Structures

The effect of impact on steel and concrete structures varies widely because of the inherent material characterstics.While steel being a ductile material, often shows only permanent deformation, the damage potential to a concrete member is more, because of the brittleness of concrete. For accidental impacts it is not expected that a structure will be designed extra strong at prohibitive cost to remain 100% safe against all sorts of possible impacts should be done and structures should be strong enough to withstand soft impacts that have usually more probability of occurrences. On the other hand, induced impacts cannot be avoided, as in the case of hammer foundations, forging machines and pile driving. For all such cases a proper assessment should be made to find out the following data: ●Nature of impact ●Duration and frequency of the impact ●The pulse shape and force of the impact Energy transferred to the structures or to the soil foundation system ●Likely response behavior of the proposed structure Proportioning of structural members subjected to impact and vibration is usually done by increasing the dynamic load by suitable percentage and added to the dead load to find an equivalent static load. A constant working stress as applicable for the dead load is allowed in the design. Thus equivalent static load=static load (as per the most critical combination) of static and dynamic load) +Impact factor x Dynamic loads producing impact and vibration).

II. EXPERIMENTAL SETUP



An Impact test is a dynamic test conducted on a selected specimen which is usually notched. The specimen is struck and broken by a single blow in a specially designed machine.

This chapter illustrates the experiment setup, procedure and the energy absorbed in an impact test. An Impact testing machine with the following parameters is selected in this case and it is mentioned below.

Machine Properties

Make	:	M TOTAL
Model	:	IT – 30
Maximum Capacity	:	300 J
Maximum Scale graduation	:	2 J
Overall size	:	1.1x.45x1.65m
Net weight	:	375

The following factors to be considered in Impact Failure analysis ●Material ●Shape ●Size ●Surface finish ●Nature of work and Process ●Skill and experience ●Method of working (Smooth and Rough)

Specimen Details

MATERIAL Designation Chemical composition Carbon Manganese	: : : :	Plain Carbon Steel C 40, cold drawn 0.35 – 0.45 % 0.60 – 0.90 %
SHAPE	:	Square
SIZE Thickness Length	 : :	 10mm 100mm, 125mm and 150mm

III. PROCEDURE

Measure the length (l) and breathe (b) and depth (d) of the given specimen. Measure the position of the both from one and depth of gauge and top width of groove in the given specimen. Lift the pendulum and keep it in the position in the Izod scale. Adjust the points to coincide with initial position in the Izod scale. Place the specimen vertically and clamp properly supported position such that the groove is direct to striking face. Release the pendulum again using the lever and note down the final reading in the Izod scale. Find the impact strength of the given specimen by using the following relations.

Initial energy of pendulum= Potential energy at height H Weight= WH = Kinetic energy for striking the specimen Remaining energy after fracture = kinetic energy spent in carrying pendulum weight to a vertical height 'h' after fracture = wh . Energy consumed in fracture of specimen=Initial energy-remaining energy fracture= WH=wh = W(H-h). The same procedure is followed for all specimens in these experiments. The observed data are tabulated for analysis.

Experimentation and Prediction

The deformation for various possible combinations of the dimensions of the process parameters are obtained with the help of an experimental set up which is explained in the previous chapter and the same is predicted with the help of response surface methodology. Considering five parameters namely diameter, rotation, length, grid and the tensile load 52 numerical experiments have been carried out to determine the torque value to the failure of the particular specimen. The actual values of the parameters, the measured and predicted values of the torque are shown in Table 7. There is an average error of 10.36% in the predicted value.

Development of Mathematical Model For Impact

The response function representing the deformation can be expressed as

Y = *f* {length (l),Groove Distance from center of piece (c), Depth of v groove (d) , Width of v groove (w) and the Angle of V groove (α) }

$$Y = f\ (l, r, d, w, \alpha) \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

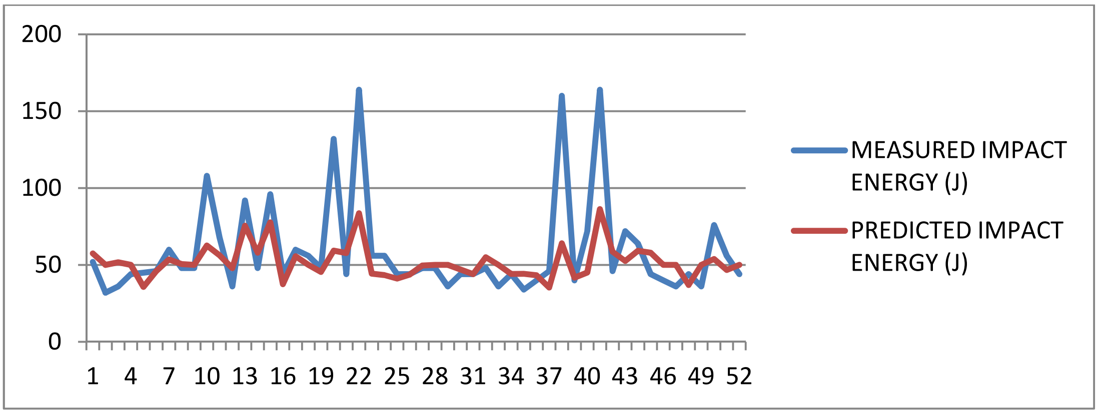
Where Y is response or yield. The values of the co – efficient of the polynomial were calculated by the regression method and were reported in Table 6 for torque mode. The magnitude of the regression co – efficient is a good indication of the parameters. The experimental data were analyzed using the software MINITAB version 17 which gives the output in tabular form and was used to calculate the values of these co – efficient. For the required response, all the 52 values for Impact effect and the second order general mathematical model for the 5 factors are given to the software as input. The significance of co – efficient was evaluated.

Developed Final Model for Impact

The final mathematical model of Impact mode as determined by above analysis in natural scale is given below: Regression Equation in Uncoded Units IMPACT ENERGY (J)^-1 = 0.01279 - 0.000116 LENGTH + 0.000043 GROOVE DISTANCE FROM MIDDEL - 0.002010 DEPTH - 0.000185 WIDTH - 0.000176 ANGLE …………………………… (2)

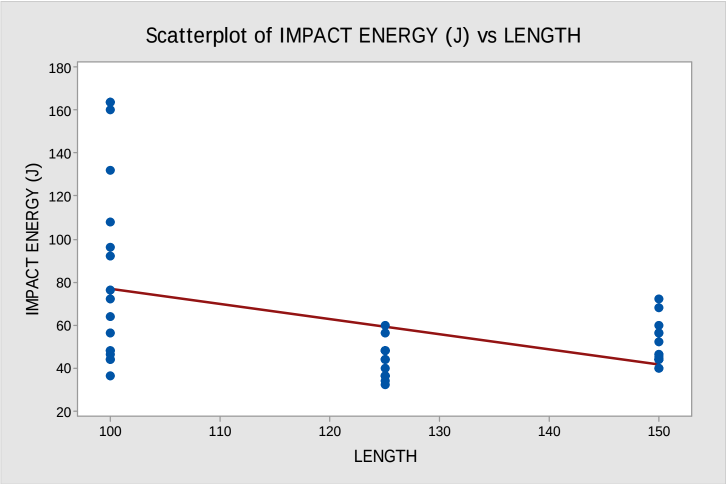
The analysis of variance for this second order regression model was calculated with the aid of the software. The Impact has been mainly influenced by linear and interaction terms. The test of adequacy for the predicting response surface equations has been carried out by Fisher's variance ratio test known as F – test. As per this technique, the estimated F value for the predicting equations is much greater than 1.92. Hence, it is assured that the established predicting equation gives an excellent fitting to the observed data for a confidence level of 95 %. So the developed model is accepted.

Impact Comparison



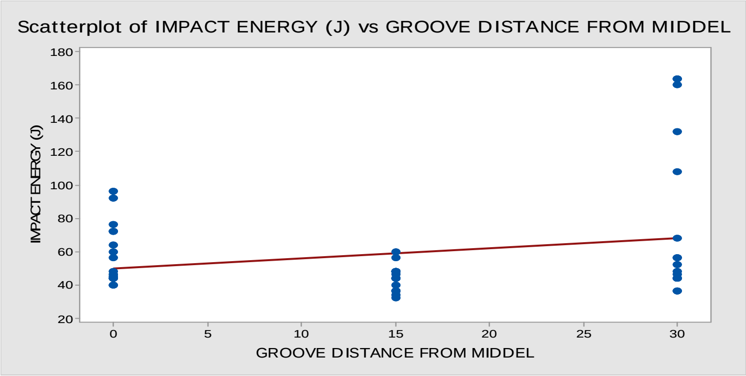
This graph illustrates that the measured value almost coincides with the predicted value. By this it is confirmed that the measured value is safe and reliable. The predicted value 89.64% closer to the actual value.

Direct Effects



Variation of Impact Energy with respect to the Length of the shaft

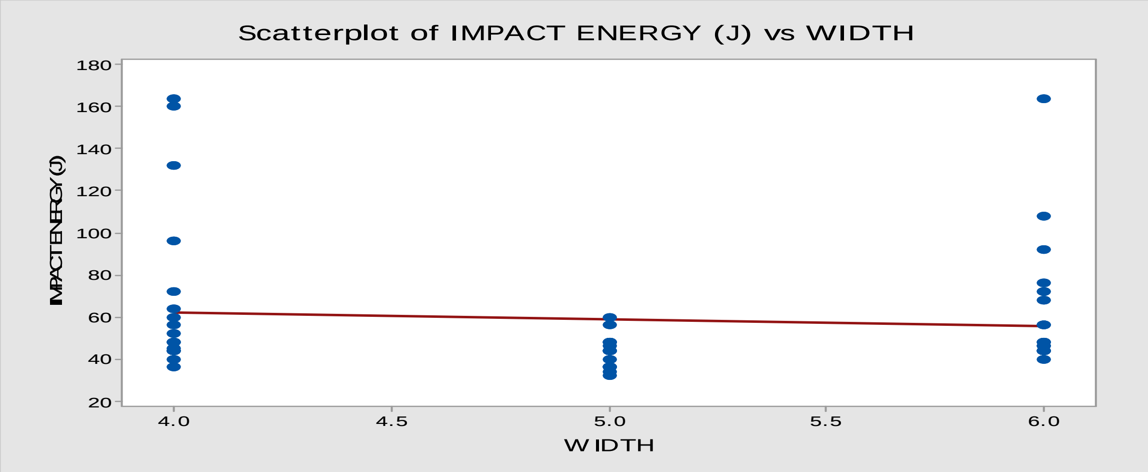
This figure shows that the Length is indirectly proportional to the Impact Value. Here the 100 mm Length withstand higher impact strength.



X-axis – Groove Distance from middle in mm Y-axis – Impact Energy in joules

Variation of Impact Energy with respect to the Groove distance.

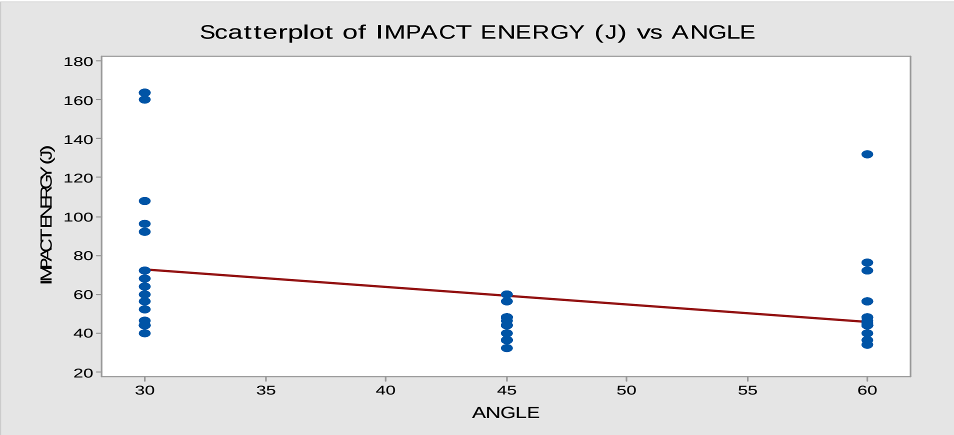
It shows that the Groove distance of the shaft From middle 30 mm absorbs more impact Energy compare to center and 15mm.



X-axis – width of the groove in mmY-axis – Impact Energy in joules

Variation of Impact Energy with respect to the width of the Groove.

Here it is found that the width of the groove not give any major variation in the absorbed impact energy.

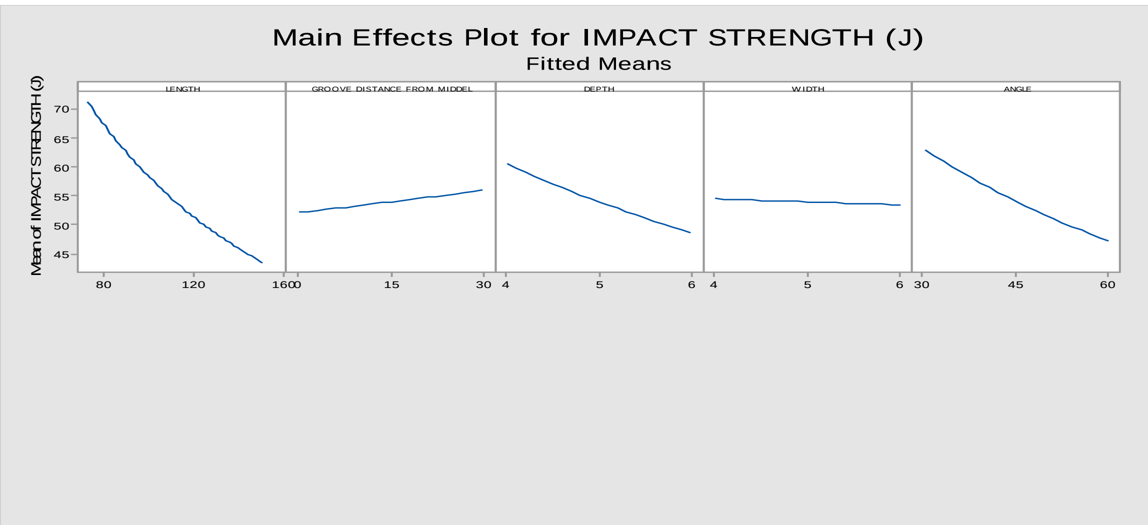


X-axis – Angle of the groove in Degree   Y-axis – Impact Energy in joules

Variation of Impact Energy with respect to the Angle of the Groove

This figure shows that the Impact energy absorbed huge in lesser angle of groove. The wide angle absorbs only less impact energy.

Interaction Effects



Main Effect Plot for Impact Energy

From this Main Effect Plot for Impact Energy, it is observed that the influence of the parameters on the Impact Effect is given below.

1. The length of the shaft indirectly proportional to the impact energy.
2. The groove distance also affects the impact value the higher distance grove from middle of the specimen absorbs maximum energy.
3. The depth of the groove in directly proportional to the impact energy.
4. The width of the groove does not give any major changes in the impact value.
5. The angle of the groove in directly proportional to the impact energy.

IV. Analysis of Variance

Response Surface Regression: NOISE IMPACT verses LENGTH, A/F, GROOVE, ANGLE….

Source	DF	Adj SS	Adj MS	F – Value	P - Value
Model	5	1183.12	236.62	13.85	0.000
Linear	5	1183.12	236.62	13.85	0.000
LENGTH (m)	1	1020.19	1020.19	59.72	0.000
A/F (mm)	1	140.14	140.14	8.20	0.006
GROOVE (v)	1	0.18	0.18	0.01	0.920
ANGLE (deg)	1	19.74	19.74	1.16	0.288
DEPTH (mm)	1	2.31	2.31	0.14	0.715
Error	46	785.86	17.08	-	-
Lack-of-Fit	36	740.22	20.56	4.51	0.008
Pure Error	10	45.64	4.56	-	-
Total	**51**	**1968.98**	**-**	-	-

Significant at 5 % level, SS – Sum of squares, DF – Degrees of Freedom, MS – Mean Square F-Ratio = MS lack of Fit / MS of error F (Table Value) = 2.54

Safety Consideration

Any failure analysis ends with a safety consideration. Since failure is an unexpected, catastrophic event it is to be considered as one of the major factor in safety aspects. Sudden failure leads to interruption in process, production loss, system failure, accident and development of unsafe working condition. To avoid such things a predesigned failure analysis is the must. Unsafe act and unsafe condition are the two main causes of accidents. In this, the unsafe condition starts from the design stage itself. ASTME (American Society of Tool and Manufacturing Engineers) Tool Engineers Hand Book Edition 2 (Section 90 pp17) gives an important note to the design Engineers as follows: "Experience has shown that notches, sharp changes of section and other forms of stress raisers are dangerous to metals in applications involving repeated stress. Some Engineers neglect to take stress raisers into consideration in design and inspection with the result that a number of avoidable failures occur. From this statement it is clearly observed that a pre design analysis of failure needs before design. This study and analysis are the pre design one and the data are more useful to a Design Engineers for their anytime reference to select an appropriate and optimum value to improve the factor of safety as well as the safety to provide an accident free working environment.

V. Conclusions

Impact values to failure for the various lengths of mild steel shafts. A design Engineer can use these recorded values for his design calculations to improve the safety aspects of his design, by this, the life of the equipments as well as the performance of the process and outputs.

- A statistical analysis has been performed to study the individual as well as the interaction effect of parameters on impact and found that the individual effects and interaction effects are highly significant.
- The effect of various parameters such as the length (l), the Groove Distance from center of piece (d), the Depth of v groove (D) the width of v groove (w) and the Angle of V groove (α) on Impact Effect has been studied based on the developed mathematical model.
- The adequacy of the models has been tested by F-test which indicates that the developed response surface equation is in good agreement with the observed data.As there is a good convergence between the experimental values and the mathematical models, the mathematical models possess high predict to power in practical situations.
- The average percentage of error between the measured value and the predicted value is observed as 89.6% which proves that the measured values are very close to the predicted value.
- Any Impact value can be calculated for any value of the parameters within the experimentation range.
- The factor of safety can be increased in the design stage itself. It will ensure the work environmental safety also.

Nomenclature

E_i	Initial Energy
V	Impact velocity
E_r	Energy after upture
E_{ab}	Energy absorbed by the specimen
α	Angle of fall
β	Angle of rise
R	Pendulum arm
W	Weight
m	mass
g	gravitational force
l	length
b	breadth
d	depth

References

1. Ali M.B , Abdullah S. 'Evaluating charpy impact signals using power spectrum densities" International Journal of Mechanical and Materials Engineering (IJMME), Vol.6 (2011), No.1, 92-101
2. Arja Saarenheimo, Markku Tuomala- Rakenteiden Mekaniikka 'Experimental and Numerical Studies on Projectile Impacts' (Journal of Structural Mechanics) Vol. 42, No 1, pp. 1-37, 2009
3. Armstrong R. W. 1 and S. M. Walley2 'High strain rate properties of metals and alloys'Institute of materials ASM international 2008
4. Bhattacarjee S.K'Safety management in construction"khanna publishers Page(128-143) 2011
5. S.K. Bhaumik et al 'Fatigue failure of a hollow power transmission shaft', Engineering Failure Analysis 9 (2002) 457–467. 2001
6. Dieter, G.E., Mechanical metallurgy, I metric edition, McGraw-Hill, ISBN 0-07-100406-8. 1988
7. Engineers edge solution by design Article pp 1 of 2, 2008
8. Hashemi, S. Foundations of materials science and engineering, 4th edition, McGraw Hill, ISBN 007-125690-3. 2006
9. John Draper, 'New ideas in fatigue analysis safe technology Ltd. 2002

10. R.S.Khurmi, 'Strength of Materials,' S.Chand Publications reprint Multicolor Edition pp 842. 2010

11. Kiyoshi Ono1, Kengo Anami2' Charpy Impact Tests With Test Specimens Made With Stop-Hole-Size Cores'osoka university.

12. Material Engineering Component failure museum website.

13. Mohd Shahiddin Suhadi, Rakhmad Arief Siregar 'The Effect of High Loading Rate to Tensile Strength for Mild Steel by Using Hopkinson Bar Technique' Proceedings of International Conference on Applications and Design in Mechanical Engineering (ICADME) 11 – 13 October 2009.

14. R.Narayanasamy, P.Padmanabhan, 'Application of response surface methodology for predicting bend force during air bending process in interstitial free steel sheet', Journal article Springer – Verlag London Limited 2008.

15. Neville Sachs,'Root cause failure analysis - Understanding mechanical failures', The Plant Maintenance Resource Center Copyright 1996-2009.

16. Noble, B., Tensile and impact properties of metals and polymers, TQ education and trainingled product division, Sheffield, England. 1996

17. Raghuwansdh.B.S – Workshop Technology vol-1 –l rai&cog Publications Page(98-101)

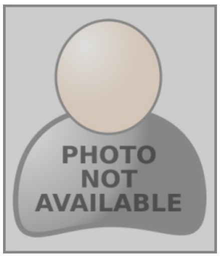
18. M. I. Reid, 'Analysis of the causes of recent roll shaft failures in natal sugar mills', The South African Sugar Technologists' Association pp. 74-78. 1988

19. S. Rusz, L. Cizek, P. Filipec, M. Pastrnak,'Fatigue failure of micro-alloyed 23MnB4 steel Journal of Achievements in Materials and Manufacturing Engineering,' volume 31 issue 2. 2008

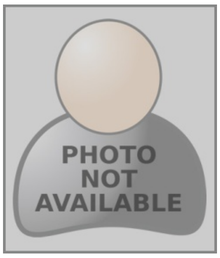
20. Tool Engineers Hand Book(ASTME) American Society of Tool & Manufacturing Section 90 pp 17

21. Yong Zhang1, Guangyong Sun2_3_4, Guangyao Li2' Identification of Material Parameters for High Strength Steel Under Impact Loading'vol 1 Huaqiao university,Xiamen.

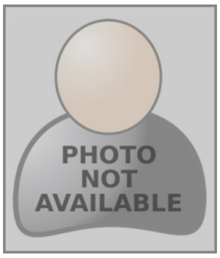
AUTHOR(S) PROFILE



N.BOOMINATHAN completed his under graduation in Mechanical Engineering at Thiagarajar College of Engineering, Madurai Kamaraj University during 1980 and his post graduation in Industrial Safety Engineering at Bharath Niketan Engineering College, Anna University during 2010. Now he is doing his research work at Periyar Maniammai University, Thanjavur in industrial noise control area. He has 25 years vast experience in both machine shop and fabrication shop activities and seven years of teaching experience in Engineering colleges.



Dr. G.K.VIJAYARAGHAVAN obtained his Bachelor Degree of Mechanical Engineering at University of Madras in 1997 and his Master degree in Machine design at IIT, Madras in 2003. He has completed his Ph.D in 2010 at NIT, Durgapur, and West Bengal. He is a well known personality among engineering colleges through his technical books. He is the author of many technical books and his article is published in many reputed international and national journals, He guides many research and PG projects. Now he extends his teaching profession as a faculty in Abudhabi



Dr. R.KATHIRAVAN has completed his Bachelor degree of Engineering at Mohamed sathak Engineering college, Madurai Kamaraj University during 1991 – 1994 and his Master degree in Thermal Power Engineering at Annamalqi University in 2001 and finally he is awarded his Ph.D at IIT, Roorkee during 2006 – 2010. He published many valuable articles in reputed international and National journals and attended many national and international conferences. Now he is the Professor/ HOD of Aerospace engineering department, Periyar Maniammai University, Thanjavur.