Design and Fabrication of Simply Supported Impact Fatigue Life Testing Machine

Jayant Gidwani[1], Rajkumar Sharma[2], Shadab Mansuri[3], Shubham Yadav[4], Vikram Rawat[5]
[1, 2, 3, 4, 5] Department of Mechanical Engineering
[1, 2, 3, 4, 5] Swami Vivekananda College Of Engineering, India

Abstract- *The aim of this work is to design and fabrication of simply supported impact fatigue life testing machine. In industries, many engineering machines and mechanical components are subjected to stresses, taking place at relatively high frequencies and under these conditions failure is bound to occur . And this led to the invention of a impact fatigue life testing machine. In view of effective design that will not fail accidentally, this research is conceived. This testing machine will determine the life of materials under the action of impact load. Specimens are subjected to impact loading of specific magnitude while the cycles are counted to destruction and results have been estimated.*

Keywords- Impact fatigue, impact fatigue life testing machine, Failure, Impact loading, Life of material.

I. INTRODUCTION

Failure of machine parts and structural members have often been caused by the repetition of impulsive loads. Such failure is named impact fatigue. It is a serious problem for design and maintenance engineers who have to assess structural integrity against repeated impact loading. Several types of testing machine have been developed in order to simulate in the laboratory impact fatigue under working conditions. The conditions of stress wave shape and speed are highly dependent on the machine and specimen systems, and those of previously used machines are rather restricted. Furthermore, there is no generally accepted mechanical parameter which controls material failure due to impact fatigue. This machine do away the conventional design containing rotating specimen and introduce a new way to apply the load i.e. impact loading. This type of loading greatly improves the machine to be cost effective. It is expected that on completion the machine would be found reliable and affordable by research institutes, universities, and companies that are involved in materials development and durability analysis.

II. EXPERIMENTAL SETUP

2.1 Components

The various components used in our experimental setup are;

- Electric Motor, (Single Phase; 2HP; 1440rpm)
- Circular Disc,(5mm thick; 240mm dia.)
- Hammer, as loading arrangement (weight- 2.6kg)
- Pedestal Bearing (25mm dia)
- Autotransformer, used as a voltage regulator

Figure 1: Electric Motor

Figure 2: Circular Disc

Figure 3: Hammer

Figure 4: Pedestal Bearing

Figure 5: Autotransformer

2.2 Experimental setup design and considerations

The fatigue-testing machine is of the simply supported beam type. The specimen functions as a single beam loaded at midpoint. Loading is provided by the means of hammer arrangement. An electric motor is used to drive the hammer with the help of a circular disc mounted on the motor shaft which acts as a cam whereas hammer acts as a follower.

Figure 6: Experimental Setup

The hammer arrangement strikes the specimen vertically downwards at its midpoint creating a impact fatigue force. The whole assembly is mounted on the frame which provides support.

In the study of the mechanics of solids, an energy balance approximation is used to estimate the required static load. That approximation assumes that all of the kinetic energy of the moving mass is converted, with an efficiency of η, to strain energy in the body. If you assume that no noise, or heat, or inelastic response, and neglect the mass of the struck member then η=1 and the collision is 100% efficient which is ideal. There are several observation which are supported by handbook equations that provide corrections to the elementary theory based on the ratio of the striking mass to the member mass. Those corrections seldom give an efficiency of less than $\boldsymbol{\eta}$**=0.95**

In the case of a weight dropped vertically from a height, h, the vertical Impact Factor is given by,

$$n = 1 + \sqrt{1 + \frac{2h\eta}{\delta static}}$$

where $\delta static$ is the deflection of the member due to a static force (W) applied at the impact point in the impact direction.

2.3 Design calculation

Rated power of motor P = 2HP = 2×746
= 1492 KW.
Rated RPM of motor, N =1440 rpm.

Torque on motor shaft, T = $\frac{P\times 60}{2\pi N} = \frac{1492\times 60}{2\times 3.14\times 1440}$ = 9.89 KN-m

Testing,

Required rpm, N = 245rpm, voltage =90 V, current = 11.4 amp
Obtained Toque = V×I = 90×11.4 = 1026 N-m
Required power for testing, P = $\frac{2\pi NT}{60}$ = 26.31 KW

Here we have taken following data,
Aluminium is taken as test specimen whose Modulus of Elasticity, E = 69 GPa
= 69×10^9 N/m^2

Tensile test performed on the specimen,
Length of specimen, L = 200 mm
Diameter of specimen, d =10 mm
Cross section area of specimen , A = 78.5 mm^2
Load applied on the specimen , F = 20.4 kN =20400 N

So the tensile result of the test is,
Total stress $\boldsymbol{\sigma} = \frac{F}{A} = \frac{20400}{78.5}$ = 259.87 N/mm^2

Moment of inertia of specimen,
I = $\frac{\pi}{64} \times d^4$ = 490.625 mm^4

The static deflection of the specimen under the weight of the 2.6-kg mass is,

$$\delta_{st} = \frac{(mg)\times L^3}{48EI} = \frac{(2.6\times 9.81)\times(0.2)^3}{48(69\times 10^9)\times(4.90\times 10^{-14})} = 1.25 \text{ m} = 1250 \text{ mm}$$

Here h = 85 mm, $\eta = 0.95$, So the impact factor is,

$$n = 1 + \sqrt{1 + \frac{2h\eta}{\delta static}} = 1 + \sqrt{1 + \frac{2\times 85\times(.95)}{1250}} = 2.06$$

The maximum dynamic $load_{max}$ is obtained by multiplying the static load by the impact factor:
$Load_{max}$ = n(mg) = 2.06(2.6× 9.81) = 52.54 N

Now,
$Load_{max}$ = 52.54 N

Cross section area of specimen, $A = \pi r^2$ = 78.5 mm^2
Normal cyclic stress on the specimen , $\sigma = \frac{F}{A} = \frac{52.54}{78.5}$ = 0.6692 N/mm^2

Evaluated time for testing = 40 min. = 40×60 = 2400 sec.
No. of stroke observed in test = 2400×4 = 9600

III. RESULT AND DISCUSSION

Test performed on the Aluminium specimen revealed that the impact breaking point stress of the specimen having diameter = 10 mm and length = 200 mm is 6.336 KN and the life of the specimen is 9600 strokes of the hammer.

IV. CONCLUSION

This research was centered on the design and fabrication of a low–cost simply supported impact fatigue life testing machine. The design principle is based on the adaptation of the technical theory of impact loading. On completion and testing, it was observed that the machine has the potential of estimating the fatigue life of material subjected to impact loads. It was also observed that the machine has the advantages of ease of operation and maintenance, and is safe for use.

ACKNOWLEDGEMENT

We would like to acknowledge the sincere support provided by Asst. Prof. Jayant Gidwani , Professor & HOD, Mechanical Engineering Dept, Swami Vivekananda College Of engineering, in completion of the project. Words alone cannot express the gratitude I have towards fabrication workshop staff Kuchekar sir, Gopal sir ,Vikram sir and Nitin sir Mechanical Engineering Dept, Swami Vivekananda College Of Engineering in helping me to do my project work.

REFRENCES

[1] J. Rosler, H. Harders, M. Baker, Mechanical Behaviour of Engineering Materials – Metals, Ceramics, Polymers, and Composites, Springer, Germany, 2007, pp 333 –375.

[2] W. Soboyejo, Mechanical Property of Materials, Princeton University, USA, 2002, pp 468-480.

[3] K. K. Alaneme, S. M. Hong, Indrani Sen, E. Fleury, and U. Ramamurty, Effect of Copper Addition on the Fracture and Fatigue Crack Growth Behaviour of Solution Heat-Treated SUS 304H Austenitic Steel, Materials Science and Engineering: A 2010, 527: 4600 – 4604.

[4] M. Topic, R. B. Tait, C. Allen, The Fatigue Behaviour of metastable (AISI – 304) Austenitic Stainless Steel Wires, International Journal of Fatigue, 2007, 29: 656 – 665.

[5] Y. Akiniwa, S. Stanzl –Tschegg, H. Mayer, M. Wakita, and K. Tanaka, Fatigue Strength of Spring Steel under Axial and Torsional Loading in the very High Cycle Regime, International Journal of Fatigue, 2008, 30: 2057 – 2063.

[6] D. Brandolisio, G. Poelman, G. De Corte, J. Symynck, M. Juwet, and F. De Bal, Rotating Bending Machine for High Cycle Fatigue Testing, Department of Mechanical Engineering, KaHo Technological University Sint-Lieven Ghent, Belgium, 2007.

[7] ASTM E 9 - 99. Manual on fatigue testing. In : Annual Book of ASTM Standards, ASTM International, 1999.

[8] J. Hannah, and M. J. Hillier, Applied Mechanics, Third Edition, Longman, England, 1999, pp 341 – 372.

[9] N. H. Cook, Mechanics and Materials for Design, Mc Graw – Hill International Edition, Singapore, 1987, pp 238 – 255.

[10] Findley And Hintz (1943), Lubin And Winans (1944), Moore And Kommers (1927), Roos (1912), Schick (1934), Seanger And Tarr (1938), Stanton (1906), Chapter III - Fatigue Testing machines And Equipments, Page No. 46.

[11] Failure of Materials in Mechanical Design: Analysis, Prediction, Prevention - Jack A. Collins - Google Books.

[12] https://www.scribd.com/doc/302933243/1-1-pdf

[13] Prof. J.E. Akin, Rice University, Impact Load Factors for Static Analysis.

[14] Stanton, T. E. (1906) Fatigue testing machine, Engineering 82, 33-57.

[15] Matumura, 1'. (1915) Repeated impact testing machine, J. Japan SOC. mech. Engrs 18, 91-97.

[16] Taira, S., Iguchi, H. and Tanaka, K. (1979) Development of impact fatigue testing machine and some test results, Proc. 22nd Japan Cong. Muter. Res. 22, 181-186.