EXPERIMENTAL INVESTIGATION OF FATIGUE STRENGTH OF DIFFERENT MATERIALS USING SINGLE SPINDLE SIMPLY SUPPORTED FATIGUE TESTING MACHINE

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Abstract— *Fatigue behaviour of a material is determined by experiments which are largely time consuming and required a large number of samples, so this is the one of difficulty to determine fatigue limit. This work is to reduce the time for determining the fatigue limit. In this work a Single Spindle Simply Supported fatigue testing machine is developed for determining the fatigue limit of a material. Fatigue test in this machine is done by applying cyclic load (generally below its ultimate tensile strength) on specimens of a material until fracture occurs and noting the number of cycles for which fracture takes place. Specimens of three materials namely Aluminium, Brass and Mild steel were tested and S-n curve are plotted in this machine. The results show that the fatigue strength of different materials can be easily done on this machine without need of major alterations.*

Keywords— Fatigue; Spindle; Strength etc.,

1. INTRODUCTION

Fatigue is the condition whereby a material cracks or fails as a result of repeated (cyclic) stresses applied below the ultimate strength of the material. Failure of rotating machine parts have often been caused by the repetitive reversed bending loads. Such failure is named as fatigue. Fatigue failures generally occurs in three stages namely crack initiation, crack propagation and fast fracture. Fatigue failures occurs below the ultimate tensile strength of a material and hence it is considered to be a very serious problem for design and maintenance engineers.

Several types of testing machine have been developed in order to simulate fatigue caused by cyclic loading in the laboratory. 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. Also, there is no generally accepted parameter which controls material failure due to fatigue. The different methods developed for testing the fatigue strength are:

I. The Stress-Life Method
II. The Strain-Life Method
III. The Linear-Elastic Fracture Mechanics Method

2. LITERATURE REVIEW

Many researchers have conducted experimental investigations on fatigue testing machine.J. T. P. Yaoand et. al. [1] examined low-cycle fatigue of metals on the basis of type of test, crack propagation, stress concentration, cyclic rate material property change. They concluded that currently no general analysis method is applicable to all types of low-cycle fatigue test conditions. They also found that the shape of the load-time curve is an important factor during analysis of low-cycle fatigue tests and the extent of the time effect on low-cycle fatigue behaviour, is still unexplored. Soon-bok Lee [2] has discussed about the development of a multi axial fatigue testing machine. This machine achieved the objective with very simple mechanisms (vector sum of two crank throws of eccentric disks yield bending moments; vector differences, twisting moments), but with more computation in setting the desired parameters. Bending data and torsion data produces by the machine were in good agreement with the data by a conventional fatigue testing machine.J. David Baldwin et. al. [3] experimentally recorded the results of strain gages mounted on two wheelchair frames (one manual, one power) which were run on a double roller fatigue machine. Rectangular strain rosettes were attached to the frames near the cross tube center pin and on the side frame behind the front caster. Two analyses have been performed on the recorded strain data. Strain data from Von Mises criterion shows that peak stresses were frequently twice the mean value. Also, prediction of the number of fatigue cycles for failure were made by using a strain-based fatigue analysis. Y. Furuya et. al. [7] have worked on fatigue test at various range of frequency. Fatigue tests were carried out at frequencies of 100 Hz, 600 Hz, and 20 kHz for low-temperature-tempered JISSNCM439 steel. Almost all specimens were broken from internal inclusions and frequency effects were not found on the giga cycle fatigue properties. The fatigue limit appeared at over 109 cycles.K. Klarecki et. al. [10] have presented diagnostic investigation of a fatigue-testing machine.During the operation of the fatigue-testing machine accelerated wear of the disc cam was determined. The disc cam wear appeared as regular streaks on the active face of the cam.S. Abdullah et. al. [13] have analyzed the fatigue cycle sequence effects in the wavelet-based fatigue data editing algorithm, called Wavelet Bump Extraction (WBE). Bump segments were extracted at the ±10% r.m.s. and kurtosis difference between the mission and original signals, retaining the vibration signal energy and fatigue damage. He concluded that there was a close agreement between the Effective Strain Damage (ESD) model and experiments. Hiroshi

Hohjoet. al. [15] have developed a multi fatigue testing system; in this the test efficiency is twelve times greater than that of the conventional fatigue testing system. He concluded that the evaluation period for the fatigue properties of materials could be remarkably shortened in comparison with the conventional fatigue testing system. Okrajni et. al. [16] explained low cycle fatigue life at high temperatures under gradual loading about creep resistant in steels. The results of low-cycle fatigue could be useful in problems of quality assessment of the examined steels and in analysis of the influence of the character of loading on the material behavior. Akiyoshi Onuki et. al. [17] found small fatigue damage in the midst stage of the fatigue life during his tests. This new sensor was supposed to be available to determine the inner defect of metals, as one of NDT methods. D. Brandolisio et. al. [18] have developed and built an innovative rotating bending (RB) fatigue testing machine. This new apparatus had covered most of the commercial available machines in testing possibilities, due to its wide range in force, rotational speed and dimensional flexibility. Furthermore it needs to have an open and versatile acquisition for measurements, with the synchronization ability for a controllable bending moment. Bonno Pel [23] have introduced interactive metal fatigue (IMF).In this research, the magnetic change caused by the fatigue was detected as the MDK value, and determined. He also showed the possibility to determine the inner defects and proposed the method to estimate the residual life stage of the fatigue. Vipin Varghese [26] determined the efficiency of the machine by testing the specimens at stresses lower than material's ultimate strength followed by subsequent tests at a stress that is less that than earlier test. Yongming Liu et. al. [28] presented a new multiaxial high-cycle fatigue damage model based on the critical plane applied on a railroad wheel.In this work, the fatigue life of the railroad wheel under stochastic loading is simulated, accounting for both spatial and temporal randomness of the fatigue damage.

3. Methodology

This design is based on theory of bending applied to a simply supported elastic beam. This machine is designed to test fatigue strength of a simply supported, rotating specimen by applying completely reversed bending load. The rotation and simultaneous bending on which the fatigue machine operates ensures that the bending stresses which leads to stretch the upper layers of the specimen and compress the bottom layers as is applicable in stationary beams; is evenly distributed around the entire circumference of the specimen. This rotation is continued until failure occurs.

4. Description of Experimental setup

The actual view of assembly of single spindle simply supported fatigue machine is shown in Fig 4.1The various components used are: ball bearings, bearing housing, bearing hub, frame, electric motor, speed counter, pulleys, clamping devices speed belt, shaft, chucks, bolts and nuts.

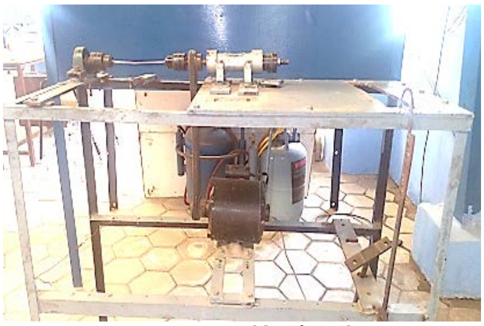


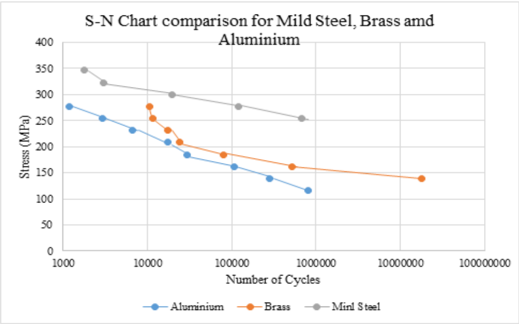
Figure 4.1 Assembly of Machine

5. Results and Discussion

During the test, four specimens of 6mm diameter have been taken at each stress level viz. 2.7MPa, 2MPa, 1.38 MPa and 0.6 MPa. The material of these specimen are Aluminium, brass and MS. After several hours of testing each specimen separately, the results were obtained for test specimens of aluminium, brass and MS. These results were compared and are shown in table 4.1. The comparison of S-N curve for aluminium, brass and MS is shown in graph 4.1. The result analysis shows that, the fatigue limit of MS is highest as compared to the aluminium and brass.

TABLE 4.1 COMPARATIVE STRESS, NUMBER OF CYCLE RELATION FOR BRASS, ALUMINIUM, MS

Load (in Kg-f)	Stress (in MPa)	No. of cycle (Al) (in r.p.m.)	No of cycle (Brass) (in r.p.m.)	No. of cycle (MS) (in r.p.m.)
1.	370.08	-	-	606
2.	346.95	-	-	1820
3.	323.14	-	-	3010
4.	300.13	-	-	20000
5.	277.56	1,200	10,588	1,20,000
6.	254.43	3,000	11,765	6,80,000
7.	231.3	6,800	17,641	……………….
8.	208.17	22,000	23,529	………………
9.	185.04	80,000	29,411	………………
10.	161.91	5,20,000	1,05,882	………………
11.	138.78	18000000	282352	………………
12.	115.65	420000000	796470	……………….



Graph 4.1 S-N Comparative Curve for Aluminium, Brass and Steel.

6. Conclusion

The single spindle simply supported type rotating bending fatigue testing machine enables the evaluation of the stress life fatigue behaviour of the tested material through the plotting of bending stress against number of cycles from which the fatigue limit/fatigue strength of the test material can be determined. The working of the Single Spindle Simply supported type rotating bending fatigue testing machine is easy to learn. Hence the operation of the machine does not require any specialized training. The testing of specimen could be started by following very simple steps for placing the test specimen in between clamps/chucks and then turning on the switch.

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