

DESIGN AND FABRICATION OF COMBINED FATIGUE TESTING MACHINE

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ABSTRACT

Engineering machines and mechanical components are subjected to fluctuating stresses, due to which the failure of component occur below the ultimate tensile strength. this type of failure is called fatigue failure. the machine used for this purpose is fatigue testing machine. this paper describes the design, fabrication of dual fatigue testing machine. This work was undertaken considering the high cost of the presently available fatigue testing machines to design this fatigue testing machine. Specimens are subjected to repeated fluctuating stresses and the no. Of cycles are counted till the breakage of specimen and the results are plotted.

Keywords: Fatigue Failure, Fatigue Stress, S-N Curve, Endurance Limit, Fatigue Testing

I. INTRODUCTION

Fatigue failure occurs when a material is subjected to repeated loading and unloading or fluctuating stresses for some time.

Fatigue failure begins with a small crack. This crack is so minute that it cannot be seen by naked eyes. Due to the development of crack there is variation of cross section and the stress concentration increases. Due to the increase in stress concentration the crack begins to progress rapidly. Unlike other failures, fatigue failure does not give any prediction of the failure of component, the component fails suddenly. This failure is sudden and very dangerous and can lead to fatal accidents. Thus determination of fatigue strength of material is very important which are subjected to cyclic loading.

The fatigue life of component is defined by the total number of stress cycles required to cause failure. Fatigue life can be separated into two stages before final failure of component.

$$N_f = N_i + N_p$$

1.1. Crack initiation (N_i)

Cycles required to initiate crack. Generally results from dislocation pile-ups and/or imperfection such as surface scratches, voids, etc.

1.2 Crack propagation (N_p)

Cycles required to grow the crack in a stable manner to a critical size. Generally controlled stress level. Since most common materials contain flaws, the prediction of crack growth is the most studied aspects of fatigue.

II. WORKING PRICIPLES

2.1 Principle of Rotating Shaft Fatigue Testing Machine

The fibres of the specimen are subjected to alternate tensile & compressive stresses with the help of load applied to the cantilever specimen at one end. As the specimen rotates the fibre undergoes alternate stresses & ultimately fails.

2.2 Principle of Reciprocating Bending Type Fatigue Testing Machine

The specimen is subjected to alternate compression & tension with the help of crank & connecting rod mechanism. The specimen is reciprocated above & below the neutral stress line of the component, finally fails due to alternate stresses.

III. MACHINE DESIGN CONSIDERATION

The machine consists of electric motor, pipe, bearings, drill chuck, sensors, counters, crank & connecting rod assembly, specimens (2 types). The various components will be coupled together according to the CAD model and various theoretical principles of bending which had been thoroughly studied.

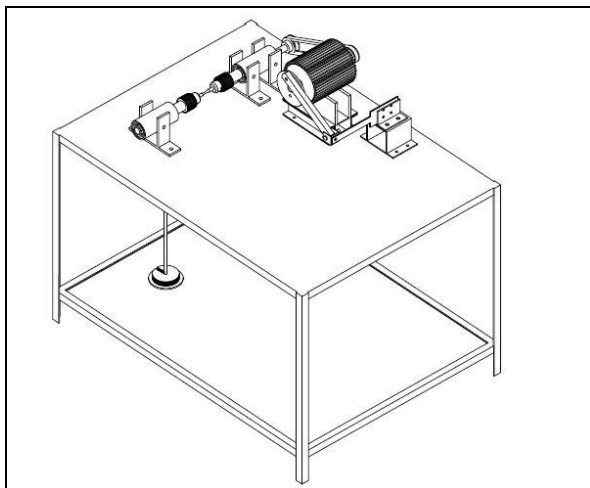


Fig. I. CAD model of combined fatigue testing machine



Fig. II. Fabricated model of combined fatigue testing machine

3.1 Frame and seat of motor

The machine is powered by 0.5 kW, 1Hp and 4200 rpm motor. It supplies the required power for the fatigue testing purpose. The frame and seat of the motor is so designed that there is an ease of adjustment of electric motor and the belt transmitting motion from the electric motor to the shaft. The overall dimensions of the seat of motor come according to the dimensions of motor.

3.2 Motor

III. 2. 1. For rotating type fatigue testing machine

Working speed: 1000 to 2000 rpm

Torque : 4000 to 6000 N.mm

III. 2. 2. For bending type fatigue testing machine

Working speed : 600 to 900 rpm

Torque : 8000 to 10000 N.mm

Select 1 hp motor generating 0.75 Kw power and running at 1440 rpm & 50 Hz.



Fig. III. Motor with pulley and crank

3. 3. Bearing

The bearing selected for this machine is self-sealed spherical roller bearing due to their high load carrying capacity and property to accommodate misalignment and shaft deflection maximum of 0.5 degrees.

The bearing allows the mounting of components on the shaft.

D = 25 mm

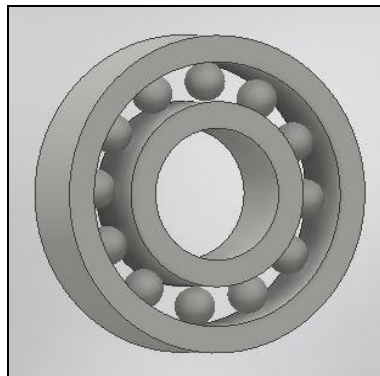


Fig. IV. Model of bearing

3. 4. Assembly of Shaft Drill Chuck and Bearings

After selection of bearing and designing of shaft, the assembly of these was made to transmit power from motor to the specimen.

We have,

$$T = (\tau * \Pi * D^3) / 16$$

So Here,

D = 25mm.



Fig. V. Assembly of shaft, bearings and drill chuck

3. 5. Crank and connecting rod mechanism

This is used to hold the specimen for the reciprocating fatigue testing machine and impart reciprocating motion to the specimen.

This assembly of the crank and connecting rod gives the required no. of cycles the component undergoes before the failure of the specimen.

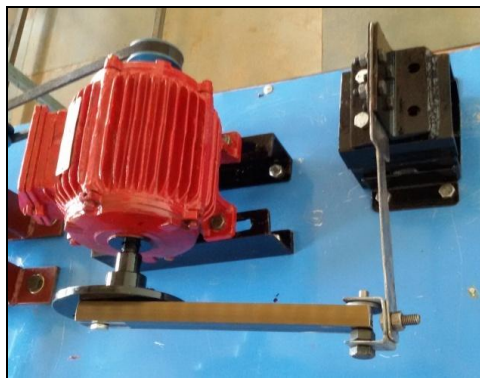


Fig. VI. Crank and connecting rod assembly

3. 6. Clamps

Different clamps were designed for the holding of shaft, bearings and drill chuck assembly, adjustable seat clamp of the motor and specimen. The purpose of the clamps is to hold parts into proper position.

The motor and other parts were firmly tightened on the clamps using nut and bolts.



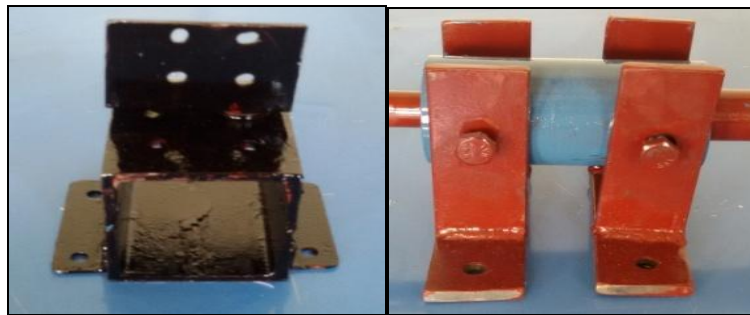


Fig. VII. Various clamps used

3. 7. Belt And Pulley

The pulley selected for transmission of power from motor to the shaft.

Internal diameter : 25 mm (Equal to diameter of motor shaft)

External diameter : 60 mm

The belt selected for the power transmission of 0.75 KW is of following dimensions.

Cross section : V-Section

Total length : 30 inches (762 mm)

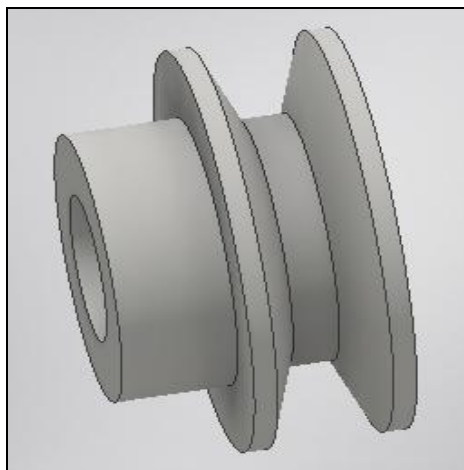


Fig. VIII. A. Model of pulley

3. 8. Sensors and counters

The sensor is used to sense the number of revolutions before the failure of specimen. The sensor sends signals in the form of pulses to the counter which counts the no. of pulses to display on the screen. This data along with the load applied is used to plot the S-N curve.

3. 9. Specimens

The specimen selected is according to the standards. The basic dimension of both types of fatigue testing mechanism is shown in figures.



Fig. IX. 1. Rotating shaft fatigue testing specimen before failure



Fig. IX. 2. Rotating shaft fatigue testing specimen after failure

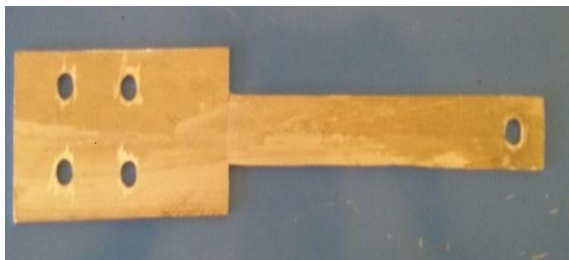


Fig. X. 1. Bending fatigue testing machine specimen before failure



Fig. X. 2. Bending fatigue testing machine specimen after failure

3. 10. Controls of machine

The machine is controlled using two switches, one is to turn on the whole system and the other turns on/off the motor to start and stop the experiment. The control unit consists of the control switches and the digital counters to display the number of revolution the specimen undergoes before failure.

IV. RESULTS

Table I. Observations of rotating type FTM with constant load

Materials	Specimen No.	Speed (rpm)	Load (kg)	Periodic Time (min)	Revolutions (8*10 ⁴)	Fatigue stress (ksi)
MS	1	1347	4	5	0.67	35.16
	2	1347	4	12.5	1.68	32.398
	3	1349	4	17.5	2.36	31.43
AL	1	1346	4	5	0.67	16.37
	2	1346	4	7	0.94	15.58
	3	1350	4	9	1.21	15.01

Table II. Observations of rotating type FTM with increasing load

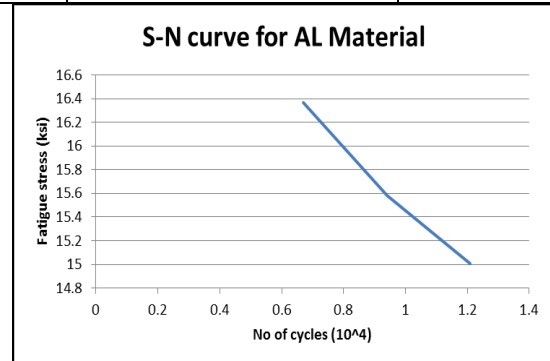
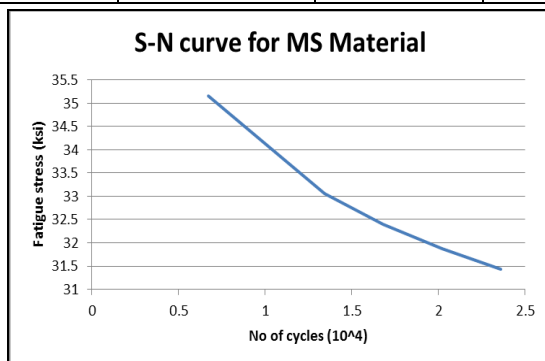
Materials	Specimen No.	Speed (rpm)	Load (kg)	Failure Time (min)	Revolutions (8×10^4)
MS	1	1346	4	19 min 26sec	2.61
	2	1352	6	15 min 09sec	2.04
	3	1347	9	7 min 36 sec	1.02
AL	1	1350	4	12 min 38 sec	1.7
	2	1348	6	9 min 02 sec	1.21
	3	1347	9	5 min 46 sec	0.77

Table III. Observations of bending type FTM with constant Stroke

Materials	Specimen No.	Speed (rpm)	Stroke (mm)	Periodic Time (min)	Revolutions (8×10^4)	Fatigue stress (ksi)
MS	1	848	30	5	0.42	34.04
	2	844	30	10	0.84	33.66
	3	846	30	12.5	1.05	32.51
AL	1	848	30	3	0.25	16.02
	2	844	30	5	0.42	15.23
	3	846	30	7	0.59	14.47

Table IV. Observations of bending type FTM with increasing stroke

Materials	Specimen No.	Speed (rpm)	Stroke (mm)	Failure Time (min)	Revolutions (8×10^4)
MS	1	848	30	12min 34 sec	1.06
	2	844	40	9 min 45 sec	0.82
	3	846	50	7 min 26sec	0.63
AL	1	848	30	7 min 34 sec	0.64
	2	844	40	5 min 41 sec	0.48
	3	846	50	3 min 56 sec	0.33



V. ADVANTAGES

- The machine designed is compact and efficient.
- The machine utilises two types of mechanism for the fatigue testing.
- The machine is more economical than the presently available machines in the market.

VI. CONCLUSION

From above observation it is concluded that for short cycle fatigue testing, we can get endurance limit of Mild Steel material (as its endurance limit lies in " $\times 10^4$ ") But we cannot get endurance limit of Aluminium material as it is very sensitive to temperature change & also its endurance limit lies in " $\times 10^6$ " which is not possible to get in short cycle fatigue testing.

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