

**Department of Mechanical Engineering**

**ME 222A Laboratory**

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**EXPERIMENT 4**

**FATIGUE BEHAVIOUR OF STEEL**

**Group Number A2**

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**AIM OF THE EXPERIMENT**

* Measure the life cycle of the material (steel rod) under different values of stress
* Study the effect of alternate cyclic stresses on material (steel rod) i.e. Fatigue testing

**IMPORTANCE OF EXPERIMENT**

The majority of the materials when put under varying value of cyclic (stresses) fail below their Yield strength. This happens due to the phenomenon called Fatigue. In Practical life also machines don’t operate at a particular value of stress they are under alternating stresses. So this problem becomes important for the Engineers to estimate the life of the materials being used for building machines and structures like Bridge, machine parts which are under alternating cyclic stresses.

**IMPORTANT TERMINOLOGY**

* **Fatigue:** It is a form of failure that occurs in structures subjected to dynamic and fluctuating stresses (e.g. bridges, aircrafts, machines etc.). Under these Circumstances it is possible for failure to occur at a stress Level considerably lower than the tensile or yield strength for a static load.
* **Cyclic Stresses:**  It is the distribution of forces that change over time in a repetitive fashion.
* **Crack Initiation:** wherein some crack forms at some places where stress concentration is high
* **Crack Propagation:** wherein the crack grows incrementally with each stress cycle.
* **Fatigue Limit:** The limiting stress level or the number of cycles after which the S-N curve becomes horizontal is called the fatigue limit or **Endurance limit**
* **S-N Curve:** It is a curve that represents the variation of Stress and Log of the number of cycles to which the sample material is exposed to.
* **Fatigue Life:** Number of cycles at which failure will occur at some specified stress level as taken from the S-N curve.

**THEORY**

Fatigue is a form of failure that occurs in structures subjected to dynamic and fluctuating stresses. This experiment involves the recording of the cycles required for the failure of a material at alternating values of stresses considerably below it Yield Strength. The Steel rod sample is put under different amount of stresses and the number of cycles required for its failure is recorded. The data containing No of cycles (N) at different Stress values (S) are plotted which is popularly known as the S-N curve. The results come according to our expectation that less number of cycles would be required for failure at high value of stresses as compared to the low value of stress which would require less number of cycles for its failure due to fatigue.

**EXPERIMANTAL CONDITIONS**

Experiment was performed at room conditions. The type load applied was that of sinusoidal nature. The samples were checked to have no prior defects.

**PROCEDURE**

* Analyze the surface of the sample carefully to detect any surface imperfections or marks formed due to machining
* Measure the dimensions of the mild steel sample having no surface

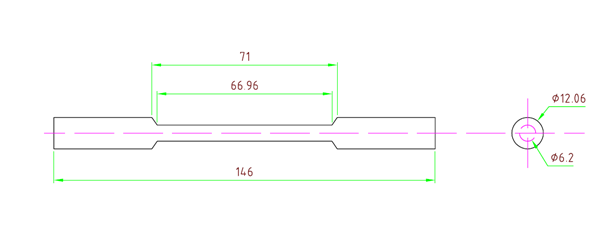
Imperfections

* Mount the mild steel sample tightly in the sample holder to ensure that it passes through the opening provided in the rod on which the loads are attached and the rubber gets affixed perfectly to the holder
* Attach the desired load on the rod after fixating the specimen
* Switch on the fatigue testing machine and carry out the fatigue test by recording the number of cycles for the failure
* Repeat the same five times but taking different values of the load
* Plot the required graph

**MACHINE AND SAMPLE SPECIFICATIONS**

* **Sample:**

Material: Mild Steel



**Figure: Dimensions of the steel rod sample**

* **Machine:**

1. Reverse bending machine: VEE KAY Industries manufacturers and exporters of material testing, scientific and engineering equipment’s for laboratory.
2. Motor Specifications:
   * + VEW AC Induction motor
     + SPEED -2800RPM
     + 220V , 50Hz

**CALCULATIONS**

Force (f) = 4x9.8 N = 39.2 N

Moment (m) = 39.2 x (64+20.02) x 10 ^ (-3) = 3.29 Nm

Inertia about AB (I) = (pi\*r4)/4

Maximum compressive/tensile stress (σmax) = (M x r)/I

= 139.26 MN/m2

σmin = -139.26 MN/m2

σmean =0

σr = 139.26-(-139.26) MN/m2 = 278.52 MN/m2

σa = σr /2 = 139.26 MN/m2

**OBSERVATION TABLES AND GRAPHS**

Observation table for number of cycles and

Corresponding stress generated in the sample

|  |  |  |  |
| --- | --- | --- | --- |
| S. No. | Weight of the load (kg) | Engineering stress  (MPa) | Number of cycles |
| 1. | 4 kg | 139.26 | 5969 |
| 2. | 3.5 kg | 121.98 | 6769 |
| 3. | 3 kg | 104.56 | 12369 |
| 4. | 2.5 kg | 87.13 | 21869 |
| 5. | 2 kg | 69.71 | 40269 |

**FIGURES AND DIAGRAMS**

**DISCUSSION**

The Results section plots the No of cycles (N), as a function of the stress amplitude applied, S. From the above graph (S VS N) we can see that there is marked decrease in No. of cycles (Fatigue) which is according to our theoretical assumptions.

The experiment is very prone to human errors i.e. in recording the number of cycles taken for the material to fracture at a particular stress value. Also there were unavoidable sharp ends which lead to stress concentration at different places which would affect our results and observation and deviate them from the ideal theoretical values.

The difference between the theoretical and experimental values is also because we use 5 different samples. Each sample has been exposed to different environmental conditions and thus behaves differently in the experiment. They have unavoidable differences like density, dimension and physical effects. This problem could be solved by increasing the number of samples for the same load and then taking the average result as the final number of cycles required for the sample to fail.

**CONCLUSION**

The results of this lab indicates that increasing the stress will lead to an increase in the rate of crack propagation which in turn, will reduce the number of cycles that it will take the material to fail due to fatigue. Further, we found that the macroscopic stress-life (No of cycles) analysis of cyclically loading and unloading of materials is accurate in the fatigue life range.

**PRECAUTIONS**

* Machine must be operated carefully.
* Rod must be properly held in the holder so that it does not come out during the experiment
* Care should be taken and a safe distance should be maintained from them while handling the machine.

**REFERENCES**

* Fundamentals of material science and engineering by William D. Callister, jr. 4th edition.
* Wikipedia.org
* William D. Callister, Jr., and David G. Rethwisch, Material Science and Engineering an Introduction, 8th Ed.