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A Comparative Study Of Fatigue Failure Due To Acceleration Pulse Loading Over Constant Speed Loading Cycle By Experimentation With Cantilever Beam.

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Abstract

This research paper deals with experimentation of a circular steel rod with specific geometry, for comparative study of fatigue failure test under constant speed and accelerated pulse speed. Two identical specimens are tested at different loadings for same testing procedure and same machine, one for constant speed cycle and other for accelerated speed. It found that the component subjected to accelerated pulse failing earlier than the constant speed loading cycle. In the daily life use 90% of mechanical components are subjected to acceleration and retardation during starting and stopping, applying breaks etc. This process causes to early or sudden failure of component than its fatigue life based on constant speed compared to acceleration.

Keywords: Fatigue Failure, Horizontal Spindle Machine, Constant Speed and Accelerated Pulse Speed.

Introduction

Fatigue is a form of failure that occurs in structures subjected to dynamic and fluctuating stresses. Under this circumstance it is possible for failure to occur at a stress level considerably lower than tensile or yield strength for static load. The term ‘fatigue’ is being used because such type of failure usually happened after a long period of repeated stress. Almost 90% of metallic materials, polymers and ceramics are vulnerable to this type of failure. Even though this failure is slow in coming but the disastrous fatigue failure can happen very sudden.

In general, steel alloys which are subjected to a cyclic stress level below the endurance limit will not fail in fatigue. Mainly researcher conducted test for fatigue life of specimen subjected to speed.[5] This property is commonly known as "infinite life". Most steel alloys exhibit the infinite life property, but it is interesting to observe that most aluminum alloys as well as steels which have been case-hardened by carburizing, do not exhibit an infinite-life cyclic stress level.

Fatigue failure occur in three stages, first stage, small crack initiate at the surface where the stress is at maximum, and include surface defects such as scratches or pits, sharp corners due to poor design or manufacture, grain boundaries, or dislocation concentration. In the second stage, the crack gradually propagates as the load continues to cycle. Finally, a sudden fracture of the material occurs when the remaining cross-section of the material is too small to support the applied load. So, components fail by fatigue because even through the overall applied stresses may remain below the yield strength.

Historically, the majority of fatigue research has been directed towards problems involving uniaxial stress states. However, many critical engineering components, such as crankshafts, axles, turbine blades, and notched components, are routinely subjected to cyclic multi axial stress states.[2,3] Basically, the bending load applied to the specimen will affect the number of load cycles to failure. Lower bending load will result in higher load cycles to failure. The time consumed for the specimen to break is longer as well. Fatigue limit is the point where the bending load value does not bring failure to the specimen anymore.

The specimen is rotated to some extend where it will break due to the rotation. The number of load cycles to every failure is recorded. The value of the fatigue limit is obtained through calculations based on the raw data. In short, any value of bending load applied to the sample which is higher than the fatigue limit value will result in the failure of respective sample. This is one of many ways that could be used in order to determine the endurance of materials. Fatigue tests are made with the object of determining the relationship between the stress range and the number of times it can be applied before causing failure.

Factors That Can Affect The Fatigue Limit

- As the amount of load increase, the number of cycle recorded before specimen fails is decrease.

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We can say that the load is inversely proportional to the number of cycle.

- The bigger radius of fillet will decrease the stress concentration on the specimen. So the bigger radius will increase the fatigue limit.
- The rough surface of specimen also can cause the specimen fail faster. This is because of the stress concentration occurred on a lot of sharp corner on the specimen.
- If the specimen which is easily corrode, is exposed to corrosive environment, its fatigue resistance will decrease as when the specimen is corrode, the specimen will have many flaws.

These six fractional factors are applied to the laboratory value of the material endurance limit to determine the allowable cyclic stress for an actual part:

Real Cyclic Stress =

$$(k_a \times k_b \times k_c \times k_d \times k_e \times k_f) \times EL$$

In order to design for satisfactory fatigue life (prior to testing actual components), good practice requires that the "laboratory" Endurance Limit value be reduced by several adjustment factors.

Experimental Setup

The experimental setup consist of a horizontal spindle machine having a jaw type end for holding a specimen end as shown in figure.

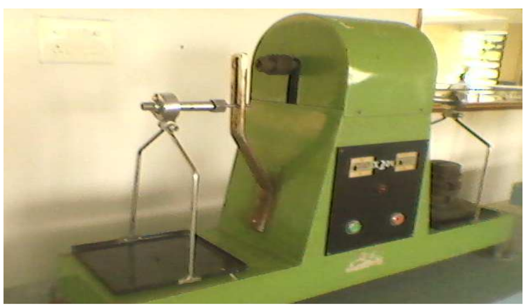

Fig -1. Horizontal Spindle Machine

The spindle is rotating by an electic motor 2880 RPM, single phase. The loading pan is connected to free end of specimen by ball bearing mounting holder. The specific amount of load is placed in the pan for every test. The stopping switch is mounted on the machine base just below the loading pan in the form of actuating type pined arrangement. When the test situation reaches to endurance limit, the specimen breaks and the pan falls with the weight on the stop button to stop the machine.

Fig-2 Specimen Breaks

The respective time and cycles are noted to know the fatigue failure of that specimen.

Procedure

In this experiment, five specimens with the same fillet radius and fillet surface roughness are provided for constant speed test and acceleration pulse test. Respective results are obtained as time period required for failure.

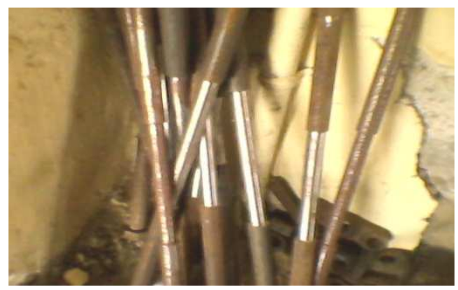

Fig-3. Specimens

A cyclic load is applied to the specimen until it breaks in order to measure the fatigue resistance of the material. The fatigue life is indicated by the number of cycles to failure. The fatigue testing is mostly conducted by using a rotating beam fatigue tester.

The machine can record the number of cycles to failure with the counter. The number of cycles to failure indicates the life span of the specimen.

- The counter is reset to zero and the loading pan is loaded to 10,15,20,25 kg etc., for each test on the pan.
- The power is switched ON and the switch button is pressed to start the test.
- The number of load cycles on the counter is recorded once fracture occurs or specimen breaks.
- The lock nut and load is loosened. The failed specimen is removed from the tester and the fracture surfaces are examined.

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Fig-4.

- The procedures are repeated for the next specimen with the same loading and next sized specimen.

Observation Table

Table 1.1 Observation Table For Constant Speed Loading Cycle.

S.N.	Load, kg.	No. Of Cycle For Constant Speed X 10^5	Time ,min.
1	10	20.58	57
2	15	20.34	53
3	20	19.83	48
4	25	19.56	45
5	30	19.32	43

Table 1.2 Observation Table For Accelerated Speed Loading Cycle.

S.N.	Load, kg.	Acceleration rate rps	Time ,min.
1	10	48	52
2	15	48	50
3	20	48	47
4	25	48	43
5	30	48	40

Conclusion

The fatigue limit is important for machines and engineering components design which are subjected to accelerative starting or retardative stopping procedure. This is because if we know what is fatigue limit of one material, we will know what is the maximum allowable load per infinite cycle of that can be sustained by the material under accelerated loading. Fatigue limit also can be a reference for material choosing in engineering design. Using fatigue limit we can approximately determine other mechanical property like ultimate tensile strength. Redesigning the specimen and its loading conditions so that it is safe to operate for unlimited life span.

Followings are the conclusions from the test conducted.

- Redesign of the specimen can prevent the earlier failure due to accelerated loading speed and stress development, by introducing a seventh factor in the equation of EL.
- Increase the fillet radius of the specimen. It will increase comparatively the fatigue limit and lifespan of the specimen. This is because the bigger the fillet radius the bigger load needed for specimen to fail.
- Improve the surface finish of the specimen. The surface of the specimen play important rule in order to determine the fatigue limit. The poor surface finish will result the cracks and the specimen will fail early than its true fatigue limit.
- Improve surface by surface treatment to avoid crack on the specimen. The fatigue failure is the initiation and growth of cracks in the material. Fracture will occur when cracks grow large and the un cracked cross-sectional area no longer sustained the applied load.

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