Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 05, May-2016

Design of Fretting Fatigue Testing Machine

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***Abstract* -In many engineering applications, fretting fatigue wear is more significant than the normal fatigue wear. This is because of life of the component in fretting fatigue wear decreases by the three times its life in normal fatigue wear. This report contains Design of a fretting fatigue testing for general applications. Many experimental set up are designed but all the factors which are affecting the fretting cannot be monitored or controlled in a single test facility. The test facility consists of actuator which provides the constant slip amplitude over wide frequency range. The testing machine is equipped with mechanism that allows gradual application of force at the contact zone. The factors which are responsible for fretting wear are observed and the relation between the factors on fretting wear is evaluated.**

Keywords: Fretting Fatigue, Test Facility, Pneumatic Actuator, Amplitude Of Frequency, Contact Load, Fretting Wear.

1. INTRODUCTION

In today's modern engineering world the main and most serious problem is the failure of the component because of the wear. Fretting fatigue wear is one of the most prominent way of failure. Whenever two bodies are in contact with each other and the relative motion is present between two bodies. If the amplitude of oscillation is small and the frequency of oscillation is high then fretting occur at the contacting surfaces. fretting wear occur at the localized region such as joints .the typical application of fretting wear is aviation industry (at the joints of aircraft).

The fretting wear is different from the unidirectional wear because of the small amplitude and oscillating frequency. The actual mechanism of the fretting wear is described by G. Friedrich and the reasons of fretting wear are observed [3]. Because of the small amplitude of oscillation at the contact zone no lubricant can penetrate into it which
leads to the formation of wear debris which further takes part in the plowing action to cause the severe wear at the vicinity of the contact region.

The main source of oscillation may be outside influence for example oscillations of foundations produces fretting wear in the machines in workshops. Vibrations of diesel engine of ship can create fretting corrosion in the component being shipped. Sometimes the oscillations of the machine component itself can be the source of fretting wear initiation for example clutches, bearings, etc. component which are subjected to oscillatory motion.

Many experiments have been conducted for understanding the effect of various parameters on the fretting fatigue behavior. From this research study it is concluded that the most important factors influencing fretting fatigue are contact pressure or normal load, slip amplitude, frequency of oscillations, environmental conditions etc. In most of this type of research the testing machine used is existing test facility like pin on disk type tribometer.

The aim of this paper is to design and develop the fretting fatigue testing machine in order to study the effect of this listed parameter on fretting fatigue

2. CONCEPT

Before going to actual design it is necessary to study deeply the existing test facilities and need to understand the concept upon which these are designed. To obtain these various test facility which are developed in tribology until now are studied in detail through various literature. Each test facility has different arrangement according to aim it want to pursue. After detailed study of various test facilities more than twenty conceptual designs are prepared out which the most probable solution which will consider all the parameters is selected and modified accordingly time to time in order to achieve the desired performance. Fig.(1) Gives the arrangement of the conceptual design which has been finalized as per [12].

Before going to actual design the main concept on which it is based need to study. The schematic diagram shown in Fig.(1).The contact type used in this arrangement is cylindrical on flat type of contact. The contacting pads are exerting pressure against the specimen. The specimen is oscillating with certain frequency but the amplitude of oscillation is very low. The contact type can be anyone like flat on flat or cylindrical on flat or cylindrical on cylindrical. In our case we two cylindrical specimen, and the flat fatigue pad is used to apply the contacting force.

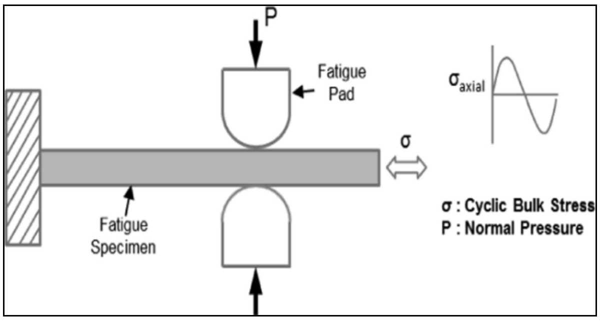

Fig.1 fretting Fatigue Test Specimen as per ASME standard.

3. DESIGN & CONSTRUCTION OF TEST FACILITY

While designing fretting fatigue testing machine the arrangement of different components in the test facility is shown in Fig.[2].

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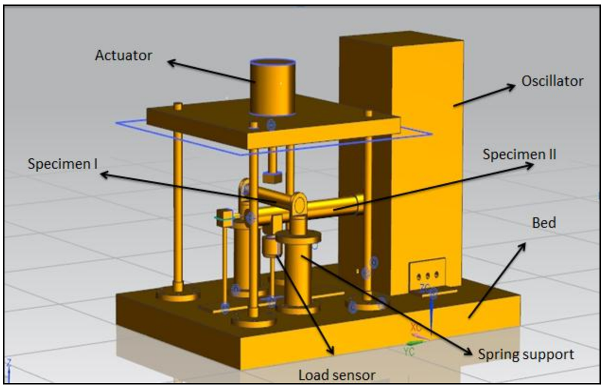

Fig (2) Conceptual design of Test facility

It mainly consist of following components

Sr No	Component Name
1	Pneumatic Actuator
2	Spring support Assembly
3	Load sensor
4	T slot Bed
5	Specimen 1,2
6	Oscillator

Table 1. components of test facilty

There are other component also present in the test facility which are used to support and fix the main component
While designing the overall test facility the input parameter require to design the test facility are listed in table bellow.

Parameter	Value
Noraml load	300 N - 10000 N
Specimen pipe dia	2"
Coefficient of Friction	0.7
Input Pressure	6 bar

Table 2. Input parameters for the test facilty

While designing the test facility one of the important critrea is applying the normal load.this is because we have to test the frettinng at different normal load condition at the contact . for the application of the normal load the linear pneumatic actuator is used. The input parameter for the pneumatic actuator is 6 bar of Pressure and it has to develop the maximum of 10000 N of force. for obtaining maximum force of 10000 N the dia of the cylinder of the pneumatic actuator need to be calculated as follows.

The force exerted by a single acting pneumatic cylinder can be expressed as

$$F = p\,A$$
$$= p\,\pi\,D^2 / 4$$

Where
F = force exerted (N)
p = gauge pressure (N/m^2, Pa)
A = full bore area (m^2)
D= full bore piston diameter (m)

Therefore we can write as

$$10000 = (6*10^5)\,p\,D^2/4$$
$$D=146 \text{ mm}$$

Therefore obtained dimension of the cylinder bore is 146 mm, selecting the next slandered size cylinder of diameter 180 mm. Now we require the stroke length of the piston rod to be 80 mm. once the cylinder bore size and the stroke length of the actuator are fixed the other dimension can be selected from the manufacturer catalogue.

For spring support the main condition is that it has to support the force applied by the pneumatic actuator at all condition without fail. Or achieving this design of spring is as shown below

Total axial load = 10000
Spring index= 6
Factor of safety = 2
τ= 700
Now,
Wahl factor K= {(4C-1)/(4C-4)}+{0.625/C}
Therefore K= 1.2525
For wire diameter

$$\tau = K * [8PC/\pi d^2]$$

Where P= total axial load

Therefore dia. of wire (d) =16.53 mm
Selecting the next standard diameter as 18 mm

$$C= d/D$$

Where D= mean coil diameter

$$\text{So } D= 108 \text{ mm}$$

In order to find out the no of active turns in spring coil consider the total permitted deflection =100 mm
Therefore

$$\delta = [(8PD^3N) / (Gd^4)]$$
$$N= 8.47 \approx 9 \text{ Turns}$$

Considering the square and ground end so no.of inactive coil = 2

Total no of turns of spring
Active turns + Inactive Turns = 11

after calculating this, remaining parameters of spring support are easily obtained. Following table gives the list of parameters of pneumatic actuator and spring support.

Parameter	Value
Cylinder dia.	180 mm
Rod dia.	40 mm
Stroke length	80 mm
Spring index	6
Total no of turns	11
Wire dia.	18mm
Mean dia.	108 mm
Free length	330 mm
Pitch	33 mm

Table 3. Designed parameters obtained as per the input requirement

International Journal of Engineering Research & Technology (IJERT)
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The next major task was to design the load and friction sensor which can meet our requirement. The total weight on load cell is determined at full load condition

Dead load = weight of pipe material along with the fluid filled in it

Rated capacity = [(Impact coefficient of force * applied load +dead load cell weight) / (no of load cells)]
=12077.334 N

Therefore load cell of capacity 15 KN compressive load cell is most suitable for our test facility.

Similarly all the necessary calculations are done in order to select the friction load cell. But here the frictional load cell must be bidirectional. So the 'S' type load cell is selected of capacity 12 KN.

The oscillator is hydraulic oscillator which is designed already for the output of o to 7 mm of amplitude. Pipe specimen is 2" nominal diameter pipe.

After finishing the task of the calculation the next task is to prepare 3 dimensional model of the calculated parts and prepare assembly of all he part to produce the # dimensional view of fretting fatigue test facility. The modeling and assembly of test facility is carried out in unigraphics (NX 9) software.

The below fig shows the 3D model of test facility

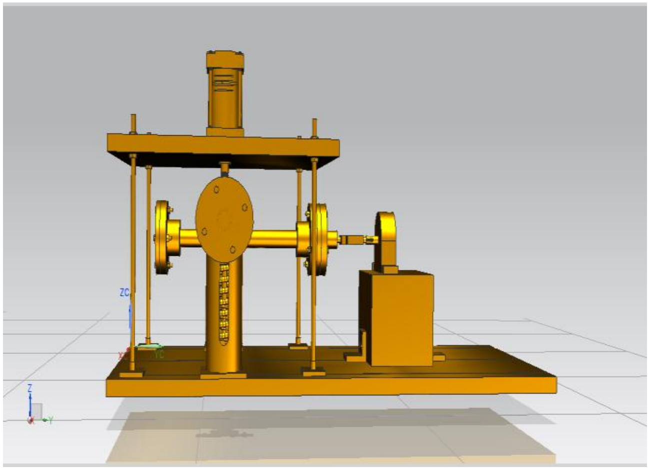

Fig [3] Side view of test facility

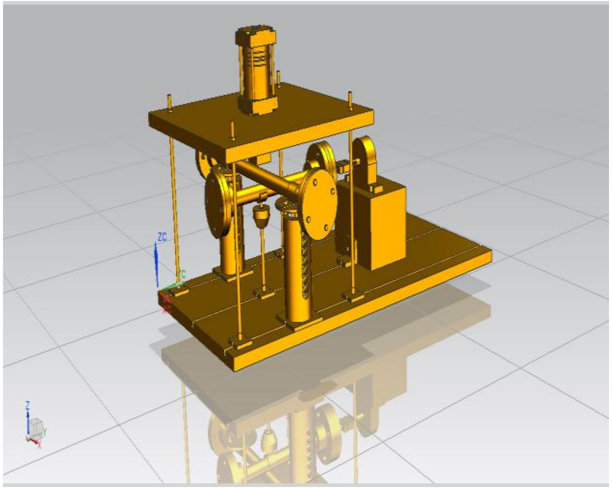

Fig [4] 3d model of test facility

The Fretting fatigue parameters such as contact pressure, oscillating frequency, slip amplitude, pipe internal pressure etc. are varied and its effect on the other parameter is evaluated.

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