DESIGN OF A CREEP TESTING MACHINE FOR INDUSTRIAL ROPE

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ABSTRACT

With the advent of man -made fibres, ropes are finding many challenging applications such as -- mooring oil rigs, in depth upto 2,000 meters, with an expected lifetime of 20 years, - or building suspension bridges with larger spans. Ropes are subjected to varieties of forces and deformations in these applications which ultimately lead to their failure. Though textile ropes are favoured than steel ropes due to various reasons, such as light weight, higher strength to weight ratio, less susceptible to corrosion. One property in which it lags behind is its tendency to creep under sustained loading condition. The creep behavior of these ropes is thus of critical concern. In this work we are designing a creep testing machines which shall help study the creep behavior of textile ropes. The design has been described in this paper. The actual machine is under construction and results on it shall be available soon.

Key words: Textile Ropes, Creep behavior.

1. INTRODUCTION

Rope has been in use for a long time and has played an useful role in the progress of civilization. Earlier ropes were made of natural fibres. Now manufactured fibres have successfully challenged the natural fibres and now gradually replacing steel rope in many applications.

Through the centuries natural fibre ropes have been used for many purposes, such as in shipping farming, primitive bridges, climbing around the home -- and even as art forms. With the advent of man -made fibres, ropes are finding newer more challenging applications such as -- mooring oil rigs, costing billions of dollars, in depth upto 2,000 meters, with an expected lifetime of 20 years, - or building suspension bridges with larger spans [Hearle, 1996]. Ropes are subjected to varieties of forces and deformations in these applications which ultimately lead to their failure. Though textile ropes are favoured than steel ropes due to various reasons, such as light weight, higher strength to weight ratio, less susceptible to corrosion. One property in which it lags behind is its tendency to creep under sustained loading condition.

Creep is the extension with time under an applied load and may even lead to possible rupture of the specimen when a load is applied for a prolonged time. Besides this the performance may get affected due to the continued deformation [Hearle, 1986].

It therefore becomes important to know the creep characteristics of a rope before its actual use. To study this property of commercial rope, a suitable instrument needs to be designed. The reported work describe the designing of such an instrument. The design of a creeep tester for textile ropes poses unique challenges as the creep properties of textile ropes are very different from those of steel ropes. The main difference is on two fronts, viz, the time dependence of the deformation is larger and the total elongation is much higher. The rope can extend by as much as 50%.

2. SPECIFICATIONS OF THE MACHINE

The creep testing instrument should be capable of measuring creep of industrial textile rope in varying load condition for a rope diametre in the range of 4 to 18mm. The effective length of the rope to be tested shall be 1 metre. The loading is expected to be upto 1 ton and the instrument should be capable of giving time- extension data. This shall cover the range of ropes of interest. It is proposed that subsequent to the the initial investigations into the creep behavior the range of the machine shall be extended later on to cover a wider variety of ropes. A larger / new machine shall then be designed.

3. THE DESIGN REQUIREMENTS

The ropes shall be wound between two jaws. These jaws are supposed to grip the two ends of the sample rope investigation under loaded state. Therefore, it should sustain a large amount of stress for a long period of time holding the rope of diameter in the range from 4 mm. to 18 mm. The rope should not slip out of the jaw in any condition and there should be a distinguished reference point in the jaw from which the gauge length is to be considered.

The load applied should not fluctuate with time and act instantaneously on the rope when the instrument is switched on. The load should be also adjustable depending upon the requirement.

The extension recording should be realistic with time and show correctly the level of extension of rope. As the limit of extension % of rope varies depending on the construction, type of fibre used, the extension measurement system should be capable of measuring the extension in wide range i.e., 0 - 500 mm. for 1meter of rope sample. No external source should or fluctuate the measurement system as the time of testing is fairly long (i.e., voltage fluctuation ,the microprocessor used should be able to work for 24 hours or so, etc.). It should not get damaged, in case the rope breaks suddenly or slip out of the jaw in course of time.

The load should get released and act instantaneously and the transfer of load should be performed smoothly and without much noise.

The frame should be able to sustain a huge amount of load and no part should bend with time. It should be well balanced and should not tilt, as a large amount of force acts instantaneously as the instrument is started. The design of the frame should be suitable for an operator while mounting the jaws in the frame and it should occupy minimum space.

4. THE PROPOSED DESIGN

The proposed design consists of the 5 essential elements as follows:

1. One pair of jaws
2. Load application system
3. Extension monitoring system
4. Load release system
5. Frame

The jaws generally used in case of rope testing has some limitations. Three jaws used typically for rope testing are shown in Figures 1, 2 & 3. In bollard type of jaw there is possibility that the sample rope can break at the point it leaves the jaw [Brunnschweiler, 1953]. The wedge grip cannot guarantee a no slip situation and in case of 'cor -de -chasse' grip there is no such clear cut reference point from which the gauge length can be considered.

Considering the limitations of the above jaws, the new design of the jaw (fig. 4) used in the instrument has some unique features as depicted below :

1. Suitable for testing any rope of diameter in the range from 4 mm. to 18 mm.
2. Reduced slippage possibility because of the extensive wraps over the grooved cylinder and the grip of the specially designed corrugated face of the frame.
3. Being made of steel and due to its robust construction, it can withstand a huge amount of stress with virtually no distortion.
4. Threading of the rope for testing is very easy and take less time.
5. Well defined reference point in the jaw for the gauge length to be considered as the rope leaves the jaw.

The jaws are essentially friction based and the rope shall be clamped between the toothed faces in the front and then wound around a circular shaft with grooves. The two plates shall be clamped togteher by a set of screws in order to get the necessary resistance.

A system of pulleys and steel ropes has been used to derive a cumulative mechanical advantage of 1 : 2 for load application. This will decrease the total force to be handled at the application point. An alternative method of force application was thought of that uses a hydraulic system. This pulley based mechnical system was finally chosen for its simplicity. The hydraulic system can be used in the later versions of the machine.

The system applies a simple but convenient way of load amplification by pulley principle(Figures 5 & 6). In the system the B & B` pulleys work as amplification pulley. One end of the steel ropes are firmly attached to the ground and the other end which pass over the pulleys B & B`, C & C` and D & D`, hold a dead weight.The rod on which the pulleys B & B` are mounted, are connected to the movable jaw through a chain / metallic rope. As the dead weight is made to act on the pulleys, the movable jaw will be pulled which will cause the rope to stretch. Since, the magnitude of the dead weight does not change with time, the load acting on the rope would remain constant throughout the test.

Since the mechanical advantage is 2.0, the movement of the dead weight shall be twice the extension of the rope. This can also be seen easily from Figure 6. At steady state, let the extension of the textile rope under investigation be X. It will cause the pulleys B & B` also to descend by X. Therefore, a length of X from each limb of the rope passing over pulley B & B` will be available for the dead weight to descend. So, the dead weight will come down by 2X.

An inherent disadvantage of the system is that there shall be some frictional loss in the pulleys, and as a result the complete force shall not be available at the rope being tested. In order to take care of this problem, it is being planned to introduce a load cell in series with the rope being tested. This shall help us measure the actual load being experienced by the rope after accounting for frictional losses.

A linear variable differential transformer (L.V.D.T) will be attached to monitor the extension of the movable jaw with time. An interfacing system will interprete / record the signal over the period of elongation. Currently it is planned to attach the LVDT at on eend only However, there is a possibility of slip at the jaws. In order to account for the slip as well, marks shall be made at both ends of the rope and two LVDTs shall be used to measure the relative motion between the two points.

The complete machine has been designed and is under fabrication. The instrument is going to be used for studying the creep behavior of textile ropes. as we mentioned earlier, textile ropes undergo a significant amount of creep i.e., their elongation changes significantly with time. However, their creep behavior has not been studied extensively and no data is available regarding the same. The design of this creep testing machine shall go a long way in studying this behavior and this work is a step in that direction.

5. REFERENCES

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