REQUIREMENTS OF FABRICATION OF A CREEP TESTING MACHINE FOR HIGH TEMPERATURE APPLICATIONS USING KAOLIN

Vijay Sahu[1], Shameyar Ansari[1], Dheeraj Sagar[2], Gyanendra Singh[2]

[1]*UG students Department of Mechanical Engineering Invertis University Bareilly, (India)*

[2]*Assistant Professor Department of Mechanical Engineering Invertis University Bareilly, (India)*

ABSTRACT

The study involves the requirements fabrication of a machine in order to perform creep test of various materials being used high temperature applications. Maximum applied load on the specimen can be 10KN and test could be carried out at maximum temperature. Machine has leaver loading mechanism for load applications and measure extension up to 55% of gauge length of specimen. All components were design and fabricated separately and then assembled.

This article contains the use of kaolin in the furnace of the machine. Kaolin is a clay mineral material, part of a group of industrial minerals with the chemical composition $Al_2Si_2O_5(OH)_4$ linked through oxygen atoms to one octahedral sheet of alumina (AlO_6) octahedral. Kaolin has a melting temperature about 1850^oc. That is why it can be use as a refractory material in the furnace of creep testing machine.

The machine was able to successfully perform tensile creep test for different materials at various temperature according to ASTM standard.

Keyword: Creep Testing Machine, Design, Fabrication, High Temperature, and Kaolin Material.

I INTRODUCTION

1.1 CREEP

Creep is a time dependent slow deformation of materials under constant stress. The phenomenon usually occurs at stress (less than yield strength) and temperature values and rate of deformation of material is dependent on stress value, material properties, time and temperature. The engineering components in oil refineries and chemical industries and power plants normally operate at temperature around 500^oc. The operative temperature of nuclear power plants and space rockets are even higher temperature around 1000^oc. Creep in system components may have

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catastrophic consequences; therefore by using a tensile method, we are capable of determining the condition and development of creep at any early and non-critical stage. Creep in any material held in three stages:-

- ✓ **PRIMARY CREEP:-**In this stage the creep starts at a rapid rate and slows with time.
- ✓ **SECONDARY CREEP:-**In this stage the creep rate has a relatively uniform rate.
- ✓ **TERTIARY CREEP:-**It has an accelerated creep rate and terminates when the material breaks or ruptures. It is associated with both necking and formation of grain boundary voids.

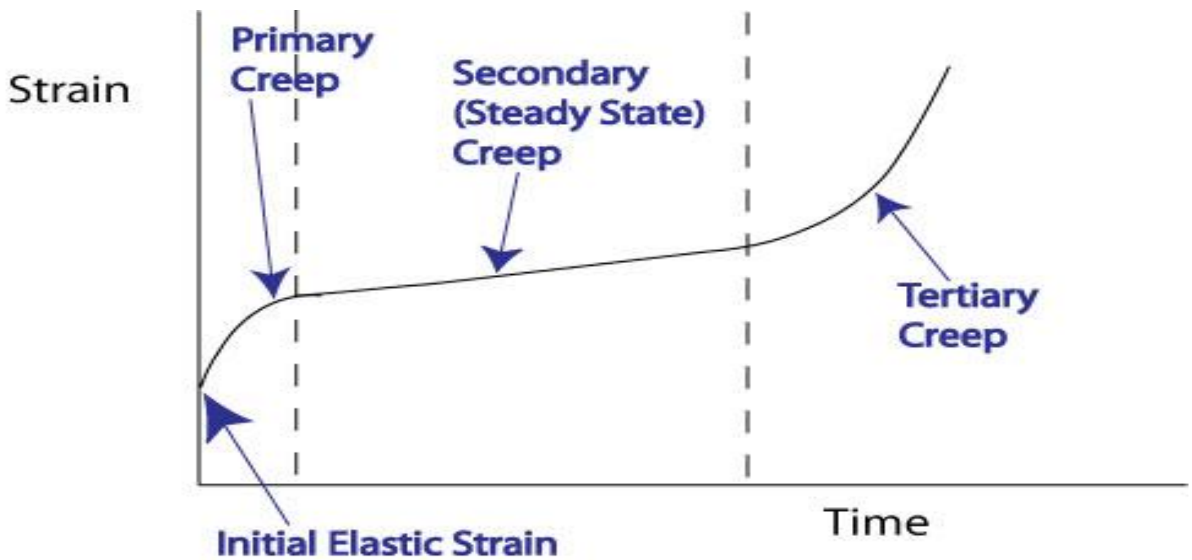

Figure1: (Stages Of Creep)

1.2 Kaolin Material

Kaolin is a clay mineral material, part of a group of industrial minerals with the chemical composition $Al_2Si_2O_5(OH)_4$ linked through oxygen atoms to one octahedral sheet of diameter 0.2-12 µm Alumina (AlO_6) octahedral. Kaolin has a melting temperature about 1850^{o}c. It is white, grayish-white, or slightly colored.

1.3 Sources of Kaolin

Kaolin and the clay mineral kaolin are natural components of the soil and occur widely in ambient air as floating dust. Kaolin formation occurs in three ways:

• Crumbling and transformation of rocks due to the effects of climatic factors (Zettlitz type).

• Transformation of rocks due to hydrothermal effects (Cornwall type).

• Formation by climatic and hydrothermal effects (mixed type).

1.4 Applications of Kaolin

- ✓ Rubber Manufacturing: kaolin is added in rubber as filler. It provides strength, abrasive resistance, and rigidity to both natural and synthetic rubbers.
- ✓ Ceramics: Kaolin is used in ceramic white ware products, insulators, and refractory (Smoot, this Volume). In white wares, kaolin aids accurate control of molding properties, and adds dry and fired strength, dimensional stability, and a smooth surface finish to the ware.
- ✓ Plastics: The addition of kaolin to thermosetting and thermoplastic mixes gives smoother surfaces, a more attractive finish, good dimensional stability, and high resistance to chemical attack.

In this article the creep test is relatively simple and has been frequently used to characterize the creep behavior of materials at high temperature. The study involves the design and fabrication of every component of creep testing machine in an economic way.

II COMPONENTS OF MACHINE

2.1 Dial Indicator

A dial indicator will be used to measure the elongation of the sample. A dial indicator with measurement sensitivity of 0.001 mm was selected as strain recording device. It is connected at the opposite arm of the loading point of the cantilever beam so as to capture changes in the strain of the test sample. When load is applied to the specimen, strain occurs and relative movement between the gripping points is transmitted through the load beam to the dial indicator. A portable precision hour-minute-second timer was selected to monitor the time dependence of the strains developed on the specimens.

Figure.2:- (Dial Indicator)

2.2 Compound Lever Arm

Of the three loading concepts considered, the compound lever arm was chosen for its relative simplicity and large mechanical advantage because it is used to hold the weight which applies load on the specimen. A mechanical advantage of twenty gives a force of 4,500 N with a 225N weight.

2.3 Shoulder Linkage

The sample of material to be tested for its creep properties is mounted axially to the load using a shoulder coupling. The bending strain must be less than 10% of the axial strain. Having the interface between the upper and lower heads and their corresponding linkages as a smooth spherical surface minimizes the non-axial loading of the sample.

2.4 Heating Element

The furnace has an embedded heating element. It is controlled using pulse-width modulation by way of the imbedded microcontroller. The required temperature is 800 °c, while the design temperature is 1000 °c.

Figure.3:- (Heating Element)

2.5 Weights

Dead weights are used to apply a constant load on the sample and one end of lever is connected with the dead weights. These dead weights are placed in a weight holder which is connected with the one end of lever. Dead weights are cylindrical in shape and different sizes and weights of 1,2,3,5 and 10KN.

2.6 Furnace

Kaolin is selected as lining materials for the design of the furnace of the machine. The choice of the kaolin was influenced by low cost considerations, local availability, and high refractory properties, and low thermal conductivity.

Figure.4:- (Furnace)

2.7 Digital Thermometer

It is an instrument for measuring the temperature inside the furnace. It is attached on the furnace one side of which is under the furnace and the indicator side is outside the furnace to indicate the internal temperature of the furnace.

Figure.5 (Digital Thermometer)

III COMPLETE ASSEMBLY

The complete assembly is shown in figure

Figure.6: - (Complete Assembly Of Creep Testing Machine)

IV MATERIAL SELECTION

Material selection is an important step in this process if designing any physical system. The main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the best material for a given application begins with properties and cost of candidate material. The materials for the components are selected depending upon the type of force or stress acting on the component. Mild Steel is taken as the best suited material for the

V FABRICATION PROCEDURE

The fabrication of the specimen includes the following steps as follows:-

- ✓ The casing for the heating chamber is first positioned and then plastered using a mixture of kaolin and water which serves as binder in accordance with Alaneme *et al*.
- ✓ Grooves are created around the lined refractory bricks for the housing of the heating elements. The heating element is passed through the grooves to allow for efficient and even heat generation.

- ✓ The shoulder linkages, for the mounting of the specimens for testing were then positioned within the chamber with the bottom end bolted firmly at the base of the heating chamber (fixed end) and the top portion of the gripping system connected to the movable load lever arm with the help of a hinge.
- ✓ The electrical connection to the heating element was done and linked to digital thermometer which is placed in a steel box casing by the side of the heating chamber.
- ✓ The heating chamber (furnace) is powered through an industrial switch linked to an AC power source. The progression in heating measured by temperature is monitored with the help of the LED light indicator display or digital thermometer.
- ✓ On completion of the assembly of the various components of the machine, it was cleaned using emery papers to obtain a smooth finish.
- ✓ The external view of the fabricated machine is presented in Figure according to *Kenneth Kanayo* et al.

VI CONCLUSION

The purpose of this work is to provide the requirements of fabrication of creep testing machine to evaluate tensile creep behaviors of engineering materials at high temperatures. Material selection based on practical conditions is done. Analysis shows that maximum principle stress is less than the yield strength of selected materials. This analysis is also economic in comparison to the technologies that are being used in industries for testing of the material creep strength.

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