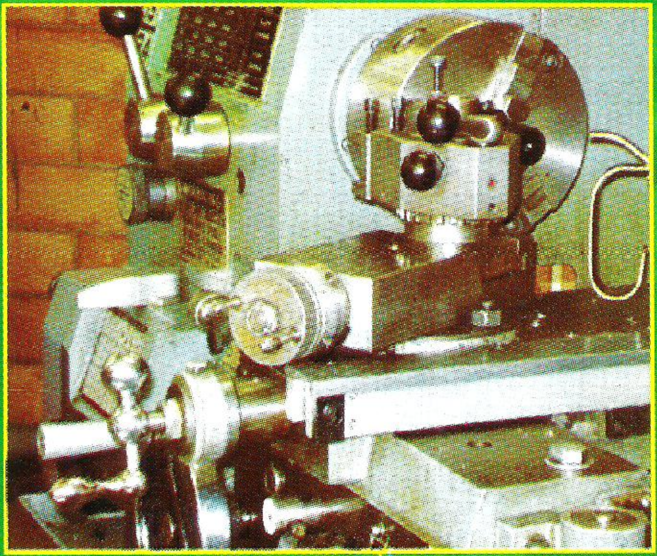
Journal of
NIMechE
Journal of the Nigerian Institution of Mechanical Engineers

VOL. 4, NO. 1 ISSN 2141 - 2987 OCTOBER, 2014



OCTOBER, 2014
ISSN 2141 - 2987

The Nigerian Institution of Mechanical Engineers
(A Division of The Nigerian Society of Engineers)

Journal of the Nigerian Institution of Mechanical Engineers

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The Journal of The Nigerian Institution of Mechanical Engineers publishes well researched, original and high-quality papers from the academia and industry on Mechanical Engineering Science and its applications. The papers may be of a fundamental nature addressing analysis and experiments, reports of advances in Mechanical Engineering theories, techniques, methodologies, applications and practice. Papers may also be of reports of design, development and service experience by practicing engineers in industry. The journal strives to bridge the gaps between Research and Development and practical applications of Mechanical Engineering Knowledge.

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JOURNAL OF
THE NIGERIAN INSTITUTION OF MECHANICAL ENGINEERS
October, 2014 VOL. 4 No. 1 ISSN 2141 - 2987

CONTENTS

PRODUCTION OF CREEP MEASURING APPARATUS FOR LABORATORY USE AS SUSTAINABLE MEASURE IN NIGERIA.

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Abstract. *This paper presents the production of creep measuring apparatus which incorporates heating chamber. Materials used for the production of the apparatus were sourced locally. Method adopted for the production involves machining of the metallic parts on lathe machine and production of the lagging material from fibre glass. All the apparatus components (mild steel, fibre glass, copper wire and hollow cylinder of spiral elements) were machined on the lathe and assembled in the Engineering workshop of the University of Ilorin. The teaching of science and engineering requires not only the theoretical aspects but requires intensive laboratory equipment for practical purposes to impact the essential knowledge in engineering and technology education. The apparatus was produced to compliment the practical needs of students in tertiary institutions. Creep was measured while varying the thermal conditions of the specimens in the heating chamber. The heating chamber temperature was set at 100^0 C, 200^0C and 300^0C with the aid of thermostat which was attached to the heating chamber. Testing of this apparatus showed that it compared well with the imported one at 94.6% efficiency.*

Keywords: laboratory equipment, creep apparatus, crank mechanism, temperature, applied load

INTRODUCTION.

Most often, some of the equipment required for the laboratory works are not available in this country and where available they are mostly obsolete. Procurement of laboratory equipment are usually expensive therefore making very many higher intuitions of learning depend on the few obsolete ones or seek external funding to equip the laboratories. Lack of current laboratory equipment throws a big challenge to stakeholders in the educational institutions particularly the Mechanical engineers. Creep is deformation of material under a constant load or stress and is sometimes termed a silent killer. It is the tendency of a solid material to slowly deform permanently under the influence of loads. The deformation occurs as a result of long time application of the load even below the yield stress of the material [1]. When materials are subjected to heat while in service, the effect of creep becomes more significant for long time periods of load application [1,2]. Creep is a function of material properties, time of exposure, operating temperature and applied load. It is the measurement of the increase of strain on a material with time under constant load. It is a method of investigating the result of an

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In engineering design, materials that will support the design loads without failure for the service life at the required temperature are sought and used [5, 6]. Creep is an important consideration in the ooperations of three types of high temperature applications: (i) Displacement-limited applications, in which precise dimensions or small clearances must be maintained such as in turbine rotors or jet engines, (ii) Rupture-limited applications, in which precise dimensions are not essential but fracture must be avoided such as in high-pressure steam tubes and pipes and (iii) Stress-relaxation-limited applications, which is an initial tension relaxes with time as in suspended cables and tightened bolts.

This work developed the creep response of aluminium at different temperatures. Heating chamber was incorporated into the heating chamber in which the specimen was inserted for the study of the effect of temperature when the material is loaded. The apparatus could also be used to measure creep at room temperature when the heating chamber is at "OFF" position.

The apparatus was used to evaluate the response of material to creep when loaded for non-ferrous metals at different temperatures with time.

The heating chamber can be regulated with the attached thermostat to a maximum temperature of 300^0C.

MATERIALS AND METHOD.

Material selection.

The materials used for the development of the apparatus were sourced locally. These materials consist of mild steel, fibre glass and copper wire. The heating chamber is a hollow cylinder having the outer casing covered with aluminium sheet metal and attached to it is a thermostat that regulates the heating temperature. Fibre glass was packed at the space between the inner and outer casings of the heating chamber to conserve heat. The rest of the apparatus was fabricated using mild steel and sheet metal. The lever was made of galvanised steel. The heating element was a spiral type and installed in the inner grooves of the heating chamber.

Description of the apparatus.

Creep measuring apparatus works on the principle of lever action of applied load on the specimen. The lever arm was notched to receive the edge of the fulcrum which is at the top of the column that was rigidly attached to the base. Specimens were loaded in tension and griped at both ends as shown in figure. 1. The heating chamber was set to required temperatures using the thermostat. The lower stirrup is attached to the bottom beam with a screw stud to allow height adjustment during set up. The upper grip pivot was attached to the lever arm. The weigh anger was bolted to the opposite end of the lever arm. The tip of the dial indicator attached to the front bar was aligned on the top flat edge of the upper stirrup. The dial indicator was set to zero. The weight was suspended from the hanger and supported so that the specimen in the chamber was not initially loaded. After setting the thermostat to the required temperature and waiting for few minutes to make sure that the specimen attained uniform temperature, the load was then lowered slowly on the lever.

The apparatus is a rectangular shaped object comprising of two main parts: the top mechanism and the rigid base plate. The top mechanism is made up of the support beam, lever arm, front bars, rear bars and base plate which was bent to shape to give room for the accommodation of the cover base plate figure 1. It also forms the handle with which the apparatus can be carried or lifted. The cover base plate serves as the rigid base on which the top mechanism rests. On it was attached the dial indicator and the stand for keeping the weights when operating the apparatus. The major parts consist of the following as seen from figure 1.

i. **Rigid support plate**: it acts as rigid support base for the apparatus and is made of low carbon sheet metal. The handle through which the apparatus can be carried is attached to it. The cover base plate serves as the rigid base on which the apparatus rests.

ii. **The mechanism**: this consist of the following components,

a. The heating chamber: Shown in figure 1 is a hollow cylinder mounted on the surface of the apparatus with a thermostat. It contains the heating elements through which the inner cavity is heated to required temperature. Fibre glass was packed in the annular space between the inner and outer space of the chamber. figure. 2 shows the schematic diagram of the heating chamber. The specimen is suspended in the cavity of the chambers while the temperature is regulated through the indicator. Under the action of the weight, the specimen embedded in the chamber undergoes strain. The value of extension with time is measured on the dial indicator as seen in figure 1. The graph of strain with time is then plotted.

b. The lever arms: They were made of galvanized steel, the upper one carried the weight (load) and the other supported the test specimen.

c. The support beams: this holds the galvanized steel lever arm and the heating chamber in position to resist relative movement.

d. The grips: This is made of low carbon steel metal sheet which is bent accurately to hold the specimen in position while it is inside the heating chamber.

e. The dial indicator: Shown in figure. 1 is a sensitive measuring instrument of 0.01mm accuracy.

Operation of the apparatus

The apparatus operates on the lever action as the load is applied on the specimen, aluminium as in Table 1 [7]. The lever arm is notched to receive the edge of the fulcrum which is at the top of the column rigidly attached to the base. Specimens were loaded in tension usually at constant load in the heating chamber attached to the front bar. The heating chamber was maintained at constant temperature with a thermostatically controlled heater with the specimen bolted at the two ends of the stirrups for self alignment. The lower stirrup is attached to the bottom beam with a screw stud to allow height adjustment during set up while the upper grip pivots on the lever arm. The weigh anger is bolted to the opposite end of the lever arm. The tip of the dial indicator attached to the front bar was aligned on the top flat edge of the upper stirrup. The dial indicator is set to zero, the weight was suspended from the weight hanger and supported so that the specimen in the chamber is not loaded. After heating the specimen to the desired temperature, the hanger is lowered slowly to apply the load. Deflections from the dial indicator were taken at time interval.

EXPERIMENTAL TEST.

Assessment of creep in materials.

Creep was measured while varying the thermal conditions of the specimens in the heating chamber. The heating chamber temperature was set at 100^0 C, 200^0C and 300^0C with the aid of thermostat which was attached to the heating chamber. Material dislocations are being generated continuously in the primary dislocations being generated is exactly equal to the number of dislocation being annealed out. This dynamic equilibrium causes the metal to creep at a constant rate. Eventually, the creep rate increases and the specimen fails due to localized necking of the specimen (or component), void and micro crack formation at the grain boundaries and various metallurgical effects such as coarsening of precipitates. Objects which are subject to creep spend most of the effect of creep in the secondary stage. It follows that the materials undergoing creep should have a secondary creep rate as possible. Secondary creep rate determines the life of a given component and depends on several variables, the most important of which are stress and temperature which the materials are subjected to in service.

The secondary creep rate is expressed as:

$$\varepsilon = A\sigma^n e - \frac{E}{RT} \qquad (1)$$

Where,

E	the activation energy for creep in the material,
R	the universal gas constant (8.31J/molK),
T	operating temperature and

A and n constants.

Equation (1) shows the dependence on loading stress and the temperature the component is subjected.

The natural logarithms of the equation give:

$$\ln \varepsilon = \ln A + n \ln \sigma RT \qquad (2)$$

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RESULTS AND DISCUSSION.

Effect of temperature on the strains.

Figure 3 shows the graph of strains against time using the developed creep apparatus. On the graph is the results obtained for situation when the specimens were exposed to temperatures of 100^0C, 200^0C and 300^0C. At room temperature, the strains produced were minimal as compared to when the material was at higher temperature and remained almost constant after 5 minutes of application. When the temperature was raised, there was sharp increase in the strain produced in the specimens within the first 40 minutes. Above this time, the pattern of increase in the strain remained similar at all the set temperatures. The higher the exposed temperatures of the specimens, the higher the strains obtained as seen on figure 3.

As the temperature was increased, there was corresponding increase in the strains produced in the specimens. At temperature of 300^0C, the strain produced was 3.6×10^{-3} when exposed for 90 min as against 2.3×10^{-3} recorded at set temperature of 100^0C.

Comparison of Apparatus.

Comparison of results obtained with the existing creep apparatus without heating chamber showed that the pattern of creep obtained was similar at room temperature for the same specimen as seen in figure. 4. This showed that the developed creep measuring apparatus (DCMA) with heating chamber can be made use of in the laboratories to measure creep behaviour of materials. Within the first 50 minutes, the pattern of strains was the same. Further exposure showed that the developed creep apparatus produced less strain than the existing one by 5.36%.

CONCLUSION.

Results obtained from this apparatus were compared with those obtained from the existing creep apparatus without heating chamber at 30°C and found that there was no significant deviation from both results. In general, result from this work confirmed that developed creep measuring apparatus (DCMA) recorded 96% of the existing creep apparatus (ECA) which shows that with massive production, its efficiency will increase.

This is an indication that DCMA with heating chamber can be operated within the acceptable standards. This apparatus can equally be produced locally for other institutions and marketed in the country.

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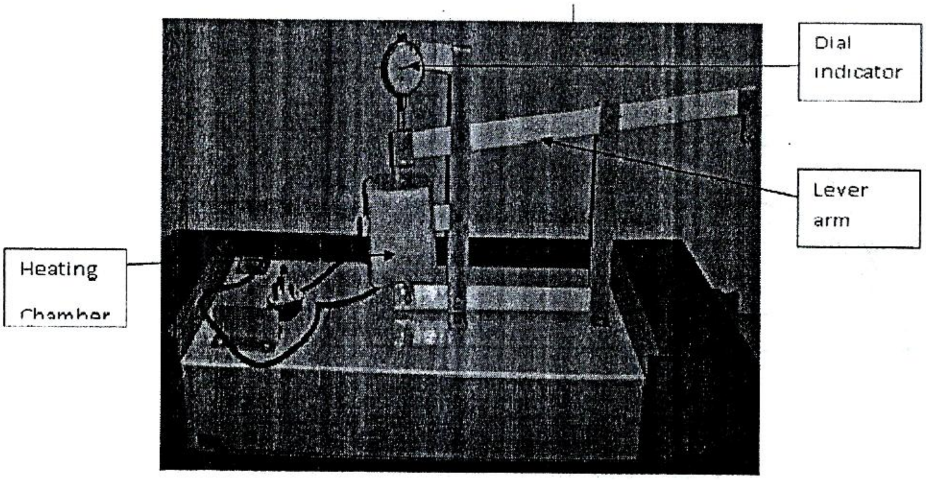

Fig. 1 View of the creep measuring apparatus with heating chamber.

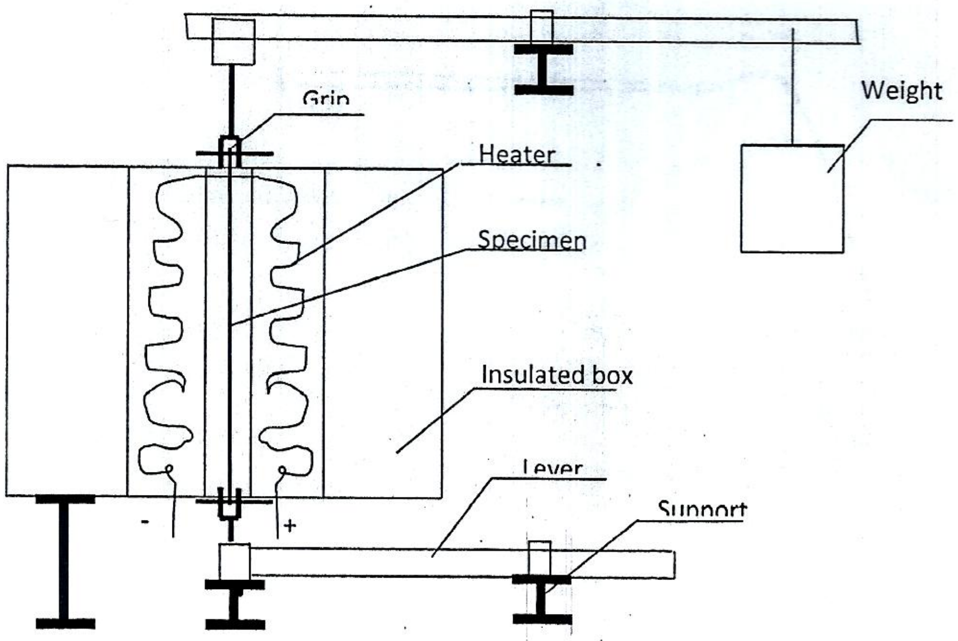

Fig.2 Schematic diagram of creep apparatus showing the heating chamber

Table 1 Composition of aluminum used as specimen

Al	Cu	Si	Mn	P	Ni	Cr	Zn	S
99.847	0	0.06	0.003	0.003	0.001	0	0. 03	0. 002

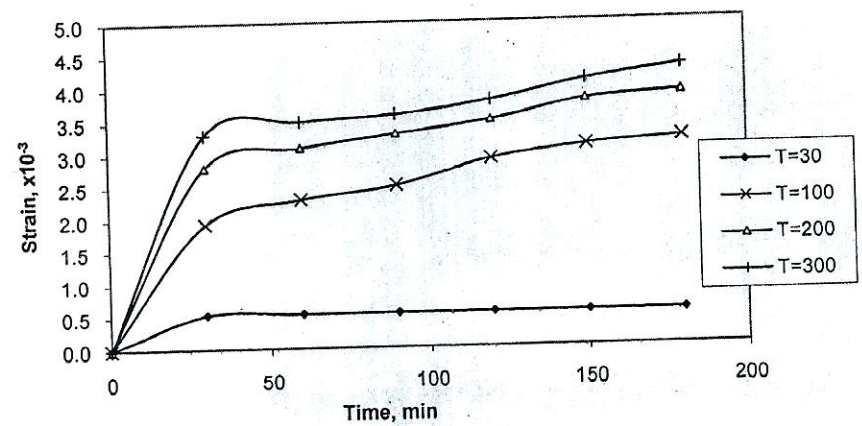

Fig. 3. Effect of set temperature on strains with varying temperatures

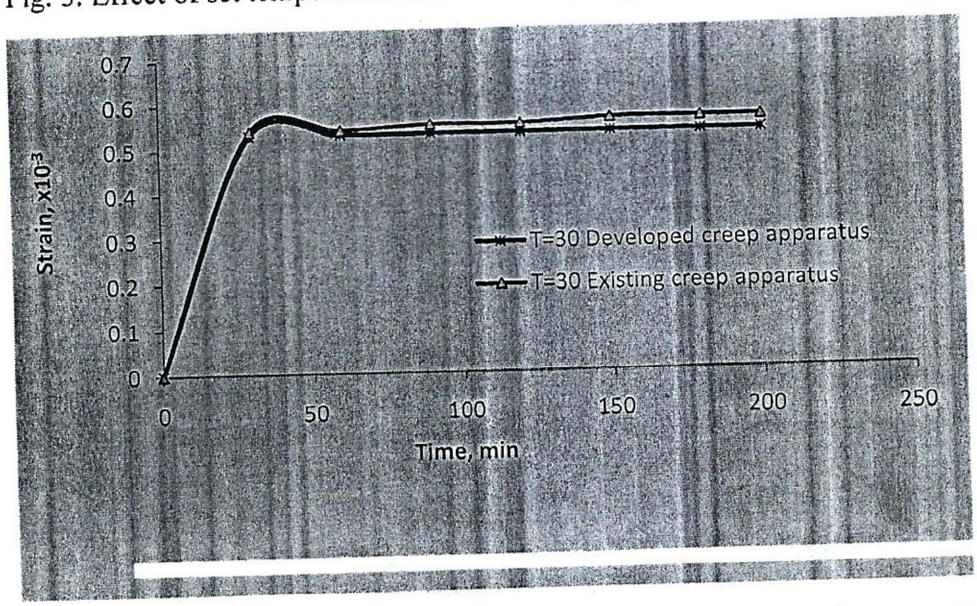

Figure. 4 Comparison of developed with the existing creep measuring apparatus at temperature of 30°C