Design of low heat treatment furnace for tension creep testing machine

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Abstract

This paper involves development of a low heat-treatment furnacefor determining the creep behavior of thermoplastics and light metals that creeps easily. The Bison sheet is used as an insulating material for the furnace. The selection of insulation is considered on the basis of availability and cost. The thermal conductivity of the bison sheet is 0.087 Watt per meter per degree Celsius. The furnace is made of Tin and design to attain a maximum temperature of 200° C on the digital temperature indicator.

Keywords: Heat,Furnace , temperature,

Introduction:

Success in today's market plays requires improvements in efficiency, quality and accuracy of testing facilities and testing equipments. Testing is an essential part of any engineering activity, it is necessary at any point in the engineering process .Aluminium, Iron, Steel and their alloys are the metals that are mostly used for production of appliances, devices and buildings. Recent developments associated with an innovative view of thermoplastics in structural applications demand accurate engineering data. More specifically the assessment of structural performance requires data that spans appropriate ranges of stress, time, and temperature and strain rate. Creep testing machine are predominantly used to measure how a given material perform under constant load, at elevated temperature. The primary use of creep testing machine is to enable students generate values for creep time curve. At high temperature, stresses imposed on metal components produce a continuously increasing strain even if they are below yield point ,and results in a phenomenon is known as Creep.

Stages of Creep:-

- Primary Creep: - In this stage the deformation occurs and resistance to creep increases until the next stage.
- Secondary Creep: - In this stage the ratio between strain and time is constant.

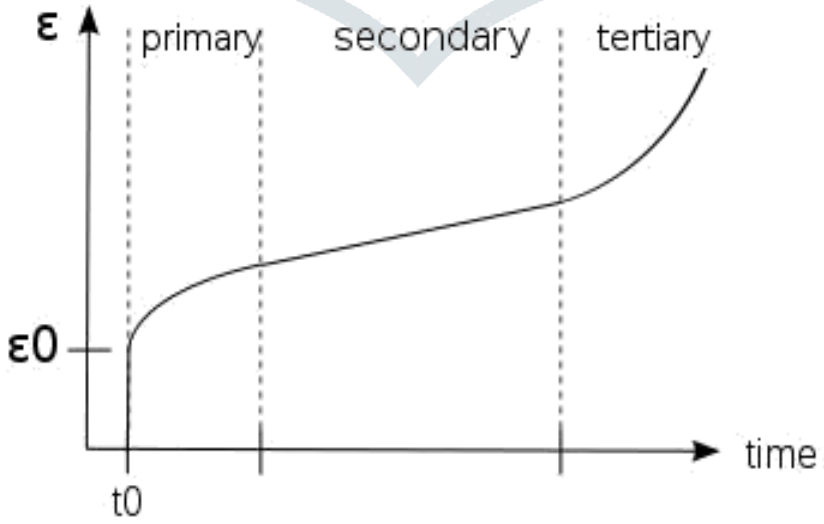

Fig.1. Stages of Creep

As the main aim of our project is to find the creep behavior of various engineering metals with the help of tension creep testing machine,furnace is the most important component of the setup. The furnace is a heat chamber in which electrical energy is converted into heat energy with the help of a coil.The components of the furnace are as follows:

- The Heating element
- Outer Casing
- Insulating Materials
- Grippers
- Digital Temperature Indicator

The dimensions of the furnace are assumed as follows:-Outer Length = 152mm
Outer Breadth = 128mm Outer Height = 224 mm
Inner Length = 124 mm Inner Breadth = 115mm Inner
Height = 200mm

Methodology:

In our project i.e. tension creep testing apparatus, we are using furnace for maximum temperature upto 200° C and the outer surface temperature is 30° C for testing the specimen is fixed on the grippers of furnace which are used to hold the specimen in testing period. The lower gripper is fixed and the upper gripper is movable. After fixing the test specimen, desired load is applied via turn buckle. When the desired load is achieved, required temperature is set inside the furnace by the help of digital temperature controller. The temperature can be maintain for different required time spans. Because of high temperature, high load and long-time duration, creep phenomena is generated in the test specimen and elongation of length is produced as a result. Hence, we can fluctuate time, temperature, load on test specimen for gaining different varying parameters. The movable grip is attached to the furnace by drilling a hole in the upper face of furnace.

Design And Calculations

In our study our main aim is to achieve the maximum inside furnace temperature of about 200°C and outside temperature is assumed to be 30°C. So calculating the convective heat transfer coefficient of inside and outside of the furnace respectively.

Taking properties at the required temperatures from data book such as density(ρ),specific heat(Cp),thermal conductivity(k), kinematic viscosity(υ), prandtl number(Pr).

At To=30°C.

Taking properties calculate Grasshoff number by

using formula $Gr = \frac{3}{\upsilon 2}$ x

Gr_L=241.62x10^6 (at x=L=224mm)

Gr_LxPr = 169.37x10^6

Calculating Nusselt no, Nu=0.59x(Gr_LxPr)$^{0.25}$

Nu=67.30

Nu=$\frac{h}{}$

h_o= 9.00 w/m-K

Similarly, at Ti=200° C

Gr_L=23.17x10^6

Gr_L*Pr=15.76x10^6

Nu=37.17

hi=7.30 w/m-k

Calculating heat dissipated through wall of the furnace

Q_w = To −Ti

$$\frac{1}{A_{1xh_i}} + \frac{L}{k A_2} + \frac{1}{A_{3+h}}$$

Where $A_1 = 0.124m^2$

$A_2 = 0.15m^2$

$A_3 = 0.164m^2$

K=0.087(from data book for bison sheet)

Q_w= 60 watt

Calculating heat dissipated through grippers, selecting cast steel as a material for gripper as it can sustain the required temperature

Volume=$\Pi x r^2 x h$

Where $r = 35x10^{-3}m$

$h = 70x10^{-3}m$

Volume=$2.69x10^{-4}m^3$

Density=7753 kg/m^3

Specific heat= 486 J/kg-K

$Q_g = mC_p\Delta T$

Assuming t=15 minutes

M= $2.31x10^{-3}$

Q_g=191.45 watt

The specimen to tested is in the form of I section.

Therefore, selecting Teflon as the material for specimen as its creep temperature is 130.72°C.which is in the range.

Dimensions of I section are:-

Length= 2mm

Width= 30mm

Height= 50mm

Flange thickness= 10mm

Web thickness= 10mm

Volume=$2x10^{-6}$ m^3

Density= 2200 kg/m^3

Specific heat= 970 J/kg-K

$Q_s = mC_p\Delta T$

Q_s=0.80 watt

Adding all the heat dissipated

Q_T=252.25 watt

This energy is absorbed by the elements of the furnace,hence we have to consider heating coil having wattage close to the obtained result.

Conclusion

The purpose of this project was to design a low heat treatment furnace to evaluate tensile creep behavior of engineering material at low temperature and **also** to evaluate tensile creep at room temperature . calculation were made to design furnace to achieive maximaum temperature 200^{o}c inside the furnace and 30^{o}c out side temperature. Using this furnace creep curves of strain verses time on a thermoplastic material can be plotted at a minimum stress lever and temperature of 20^{o}c, 30^{o}c ,40^{o}c ,50^{o}c ,60^{o}c on a load of 1kg,2kg,3kg,4kg respectively .

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