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Simplified Design of Varying Load Creep Testing Machine – A Review

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Abstract

Creep is the most active failure of engineering materials. Materials like iron, steel, aluminium, copper, lead, zinc, their alloys and thermoplastics have many engineering applications .Some engineering elements are always operated at elevated temperature like steam boilers. Due to application of load at elevated temperature, stresses are developed in material, which affects the performance and life of machine elements. To study creep behaviour of materials, different types of creep testing machines has been designed and developed in this field is observed. The important components of creep testing machine includes load system, furnace design, strain measuring device, specimen clamping system, and display unit. Experimentation on creep testing machine includes selection of material, sample dimension, load application, temperature and time. For load application lever mechanism / load hanger is used. Heating chamber / furnace is designed for different capacities, using different insulation materials. Analysis of creep behaviour of different materials like polyethylene-methacrylate (PMMA), polytetrafluoroethylene (Teflon), beryllium, aluminium-6061, and weldment-304 L stainless steel, ferrous and non-ferrous alloys has been carried out by researchers. The aim of this research paper is to identify the failure trends of creep testing machine when used for various materials used in industry. It is observed that the position of lever in the machine is a critical component of study. An attempt has been made in this paper to address the research gap existing in lever mechanism of creep testing machine.

Keywords: Load System, Lever Mechanism, Furnace, Load Application, Temperature and Time. and Display Unit

1. Introduction

Creep is the constant deformation in a material with respect to time, when subjected to load and temperature simultaneously under a constant stress. Creep is very important phenomenon to be studied for many engineering applications. To study creep behaviour of various material different types of creep testing machine are designed and developed. All the existing creep testing machines are designed using lever mechanism as one of the element [1-7]. In this research work different types of creep testing machine which are designed and developed to investigate creep behaviour of different materials has been studied extensively .Due to lever mechanism for constant load application; lever ratio is to be calculated & it is recommended that lever should remain horizontal throughout the experimentation .For that purpose auto-lever –leveling is to be included in the design, which increases the cost of the machine

2. Literature Review

This research paper focuses on the design and performance evaluation of the machine. The machine's design was related to the locally available parts and its cost effectiveness. The machine consist of casing and frame, heating furnace along with grippers, load arm and manual application of load with the help of load hanger. The machine's repeatability, reproducibility, heating capacity, creep elongation with respect to time, load and temperature application were analyzed [1].

The study is related to the design and fabrication of creep testing machine for determining creep curves of different materials at elevated temperature. Approximately 1000kg load was applied at 700°C temperature. In this machine a lever mechanism is used to measure the applied load. The applied load gives the elongation maximum to 55percent in the specimen. The components of the machine were fabricated separately. Creep test was carried out on different materials using ASTM standard E-139-06 [2].

This work is related to the analysis of design of fabricated creep machine and intended to derived creep behaviour results for thermoplastics materials and light metals .It has the four common primary systems. The insulating material for the heating chamber is clay and the maximum temperature of chamber is 300^0c [3].

The Indirect Resistance Electrical Furnaces (IREF) based on analytical and experimental analyses was carried out. The analytical analysis focused on a constant set of equations representing the internal and external flow of heat energy in the furnace, which demonstrated, relatively with the surface area of walls, heat transferring inside the furnace chamber to get a creation mathematical model including the joining between the temperature required design components (furnace walls, thickness and electrical power supply).The experimental analysis has divided in to tow parts; first part based on process number of practice experiments with three prototypes have manufactured in certain engineering dimensions that changed in three different volumes of furnace, which are considered, i.e., chamber volume of furnace is the design dimensions component. The second part of analytical analysis based on use the Simulink program (MATLAB 7.4) compared with experimental results of the manufactured furnaces samples, which showed the direct effect of the design dimensions components on the performance specifications of furnace that involve the required temperature response, temperature stability and the deviation in the setting value of temperature [4].

Beryllium is an important material to be used in the blanket of fusion reactors. It acts as a neutron multiplier that allows tritium production. In order to use this material effectively, some data on creep and swelling behavior are needed. This paper describes preliminary microstructural investigations and the qualification of a creep set-up that will be used to measure creep of highly irradiated beryllium from the BR2 research reactor matrix [5].
This paper deals with the creep behaviour of polypropylene materials. The creep of polypropylene materials is due to time and stress induced in the material. Different species of polypropylene materials were tested. For different stress values, the time – tensile elongation were acquired. The result also shows that at constant creep rates the compliance of polypropylene material decreases with their crystalline .A slightly high creep rate were observed in rubber- toughened polypropylene material due to softening effect of rubber particles in polypropylene matrix [6].
MMC (Metal matrix composites) are metals reinforced with other metal, ceramic or organic compounds. They are made by dispersing the reinforcements in the metal matrix. Reinforcements are usually done to improve the properties of the base metal like strength, stiffness, conductivity, etc. Aluminium and its alloys have attracted most attention as base metal in metal matrix composites [7]. Aluminium MMCs are widely used in aircraft, aerospace, automobiles and various other fields [8]. The reinforcements should be stable in the given working temperature and non-reactive too. The most commonly used reinforcements are Silicon Carbide (SiC) and Aluminium Oxide (Al2O3). SiC reinforcement increases the tensile strength, hardness, density and wear resistance of Al and its alloys [9]. The particle distribution plays a very vital role in the properties of the Al MMC and is improved by intensive shearing.Al2O3 reinforcement has good compressive strength and wear resistance. Boron Carbide is one of hardest known elements. It has high elastic modulus and fracture toughness. The addition of Boron Carbide (B4C) in Al matrix increases the hardness, but does not improve the wear resistance significantly [10]. Fibers are the important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Zircon is usually used as hybrid reinforcement. It increases the wear resistance significantly. In the last decade, the use of fly ash reinforcements has been increased due to their low cost and availability as waste by-product in thermal power plants. It increases the electromagnetic shielding effect of the Al MMC [11].

3. Research Gap

The research gap was identified through various literatures. After referring the above problems in existing machine, it has been proposed to design a new machine while taking care of above problems and also cost effectives of operation

- For testing of creep phenomenon for a material, the load acting on the specimen should be constant for the whole test duration. For this, lever arm should be kept horizontal throughout the experimentation. But in existing design lever is not maintained in horizontal position due to constant elongation in the specimen. For this automatic lever leveling is highly recommended which increases the cost of machine.
- The second problem was related to the power ratio of lever arm. Power ratio is the ratio of load acting physically to the load acting on specimen. Initially power ratio is calculated for lever arm but due to constant tilting of lever arm the current value of power ratio changes continuously hence because of this phenomenon the load acting on the specimen changes continuously.
- As we have discussed above for the position of horizontal lever, there was no mechanism added in the apparatus to maintain the lever arm horizontal.
- For creep testing, the load acting should be in vertical direction constantly. But as the position of horizontal lever arm changes, it makes an angle with load acting in downward direction. Because of this x- coordinate and y- coordinate of acting load is formed. As the time passes, the angle between lever arm and applied load increases. Hence the x-coordinate of load goes on increasing and y coordinate goes on decreasing. Because of this, the load acting on the specimen reduces as time passes.

4. Research Methodology

The following machine components will be designed for proposed machine.

Material Selection		
Machine Component	**Material Selected**	**Criteria for Selection**
Base part	**MS,C-section (300mmX120mmX60mm, 5mm thick)**	High strength , good machinability, Good weldability, resistance to heat, low cost, ease of availability, light weight
Column	MS,T-section (length-300mm,flange-40mm,flange thikness-5mm,web-40mm,web thickness-5mm)	
Column Support Plate	MS Flat(length-300mm,width-40mm,thickness-5mm)	
Rectangular Top Plate	MS Flat (300mm X 40mm X 5mm thick)	High strength , good machinability, good weldability, resistance to heat, low cost, ease of availability, light weight
Extended Top Plate	MS,L-section (50mm X 50mm X130mm,thickness-5mm)	
Bracket for Load Cell		
Heating Chamber	MS Flat tin sheet	High strength ,

Corrosion resistance Protected oxide layer thermal conductivity of the tin is 66.8 watts per meter-kelvin	(Outer Length = 152mm Outer Breadth = 128mm Outer Height = 224 mm Inner Length = 128 mm Inner Breadth = 116mm Inner Height = 200mm thickness-2mm)	good machinability, good weldability, resistance to heat, low cost, ease of availability, light weight
Bracket for Pulley	MS Flat (54mm X 30mm thickness-5mm) MS wire	
Load wire		
Test piece grip-Clevis Couplings type (upper and lower grip) and connecting shaft	MS Flat –semicircular cylindrical solid (Lower grip Diameter-50mm, Height-40mm Upper grip Diameter-50mm, Height-30mm)	High strength , good heat treatment properties, high wear resistant properties good machinability, good weldability, resistance to heat, low cost, ease of availability, light weight
Heating Element	250W-240V heating element	Readily available and relatively cheap
Insulating Material Thermal resistance for 12mm thickness is 0.0461Mts x K / W Kelvin per watt	12mm thickness Bison Panel is produced by an irreversible process combining cement and wood particles into a chemically stable building material.	Fire resistance, weather resistance, resistance to termite & vermin attack, sound insulation, chemically stable, dimensionally stable, wood workability, smooth surface
Temperature measuring device	Thermocouple	High temperature sensitivity
Temperature controller P.I.D & SSR	Digital display	Easy temperature display, high sensitivity.
Load cell	500 N	High load sensitivity
Turnbuckle	M8 designated	For maximum load
Tension helical spring	SAE6145- oil quenched and drawn 425^{o}c	For maximum load of 500N
Data acquisition system	LCD display	Output can be recorded automatically giving time, load, temperature, strain

Table 1: Material Selection

5. CAD Model of Proposed Machine
The CAD model of the proposed machine

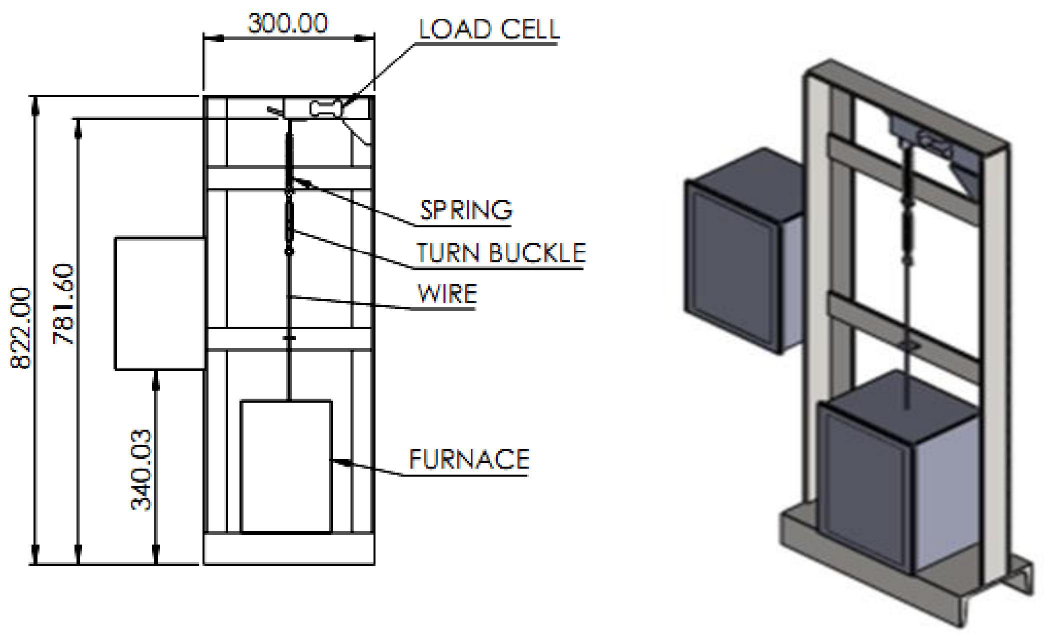

Figure 1: CAD model of proposed machine

6. Conclusion
While performing creep test on Tension Creep Testing Machine, the first step is to fix the Specimen in the furnace. The specimen needs to be fixed in between the grippers with the help of all allen key. As the two grippers fixed and movable, the movable gripper is connected to the hot pull rod along with the adjustable pointer. After fixing the specimen in the furnace, the pointer is set to zero position on the scale. This is the initial stage in which the test material is not under any kind of load. When the power supply is switched on, the temperature sensor inside the furnace will indicate the temperature on digital temperature indicator along with the load which is zero. The hot poll rod is connected to turnbuckle via wire rope. Thus when the coupler of the turnbuckle is rotated in clockwise direction, the two ends of the coupler comes closer and thus tension is created in the wire rope. Due to this mechanism of turnbuckle, load is applied on the test material. The other end of turnbuckle is connected to load cell via spring. Load cell is a sensor which converts a load or force into electrical signals with the help of strain gauges which are basic elements of load cell. When a force is applied strain gauge gets compressed, its length gets reduced which depends on the magnitude of force applied. The amount of load applied or removed is displayed on digital indicator. After applying load to the specimen, the desired temperature which needs to be achieved for the test is set using temperature controller. Now desired load is acting on the specimen, under the effect of desired temperature. Thus because of this two parameters, elongation in the specimen will take place. But one thing should be noted that creep is a time dependent phenomenon, hence it will take time. Because of the elongation of the specimen, the pointer which is attached to the hot pull rod will get displaced. The amount of displacement should be noted along with the time taken for displacement.
Due to this elongation tension in the wire rope is reduced, thus in order to compensate this tension, spring is connected to the turnbuckle. Earlier the spring was in tension because of the applied load but as the elongation takes place, the tension in the wire rope reduces result of which spring contracts and proper tension is maintained in the wire rope

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