Design Development and Fabrication of Preheating Chamber for Upset Forging

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***Abstract* - Forging is the process of forming the metal piece into the desired shape. This process is widely used in the industries for obtaining the desired shape of the metal. From developing simple shapes in earlier centuries with the simple hammers and anvil to developing complex shapes in the current times, there is a vast advancement in the forging process. Many types of forging processes are used in the industries such as impression die forging, cold forging, open die forging, etc. Most of the processes are carried out at 2300°F and more. A heating furnace is required for heating the metal piece to achieve the required temperature. For heating the metal pieces, we have designed and developed the direct resistance heating chamber.**

Keywords - Resistance heating, heating coil, helical coil, insulation.

1. INTRODUCTION

Forging is the process of forming the metal piece into the desired shape. This process is widely used in the industries for obtaining the desired shape of the metal. The properties generated in the product by the process, such as acceptable dimensional accuracy, higher strength to weight ratio, superior microstructure, etc., make the forging process attractive. Other attributes such as faster processing and low material wastage, push down the cost of production of complex-shaped parts.

Upset forging is used to increase the thickness or the bar’s diameter and hence reduce its length. This type of method is only used in some of the cases such as in forming the bolt head, etc.

In this process, the area which is to be upset is heated locally and the rest of the area is quenched in water so that the other area does not get affected by the process. This type of process is done very carefully and it is kept in mind that the other part of the material does not get bent or deformed.

For heating, the metal rods induction machines are used in the industries. The setup of these machines is complex to understand, initial as well as the maintenance cost is also high and the power consumed is also higher. This setup will overcome these drawbacks of the induction machines. This paper proposes the setup of the resistance heating chamber which has simple operating conditions, lower and affordable rates with less power consumption.

2. LITERATURE REVIEW

In recent times, as we know that electricity is one of the major sources of available energy. So, electric-based process heating systems are producing methods that use electricity as its input source to produce or transform the product through the heat produced by this process. [1]
An electric-based heating system is used in industry as they are controllable, clean, and efficient. In some cases, this system is selected for their unique technical capabilities while for some electricity or other fuel price is the deciding factor. So, now new systems and equipment must be made based on this system. [1]

A. Resistance Heating:

Resistance heating process is one of the simplest electric-based methods for heating of metals and non-metals. This process gives efficiency close to 100% and the operating temperature can exceed 3600°F. There are two basic types of this process;

a) Direct Resistance Heating
b) Indirect Resistance Heating

Many different applications are there where resistance heating is used. These same operations can also be carried out by a variety of fuel-based processes as well as a steam-based process. Since resistance heating is simple yet efficient so it is used over other processes.

B. Heating Coil

Materials to be used for heating by electric means depends upon the resistance to the flow of electricity to generate heat. The alloy should resist the flow of electricity to perform as the electric heating element.

The resistance heating alloys are divided into two main groups;

a) NiCr based alloys i.e. austenitic alloys – These are the alloys which contain high nickel content and are operated in the temperature range of 1150°C to 1250°C with resistivity ranging from 1.09 Ωmm2/m to 1.18 Ωmm2/m. [2]
b) FeCrAl based alloys i.e. ferritic alloys These alloys have a balanced proportion of all the elements. They can be operated at a maximum temperature from 1300°C to 1425°C and has the resistivity of 1.39 Ωmm2/m to 1.45 Ωmm2/m. [2]

Designing of the heating element is the most important part when designing an electric heater. Following are some of the parameters in designing a coil;

a) Type of coil - Many different types can be used for the heating element. So, depending upon the type of application helical coil is selected. This coil can be operated at a higher temperature without any stress-induced and it also provides compactness and increased heat transfer. [3]
b) The material of the coil - Depending upon the required operating temperature, the material for the heating element is selected. There are several other parameters as well which contributes to the selection of material. [3]
c) Design of coil - Many parameters are considered while designing a coil such as design, the current supplied, length of wire required, no. of turns in a coil, length of wire in one turn of the coil, etc. [4]

C. Insulation Material

One of the most important factors that determine thermal performance is the heat in the workspace. Insulation of a heating furnace is another most important element in designing furnace. Thermal insulation provides a region in which thermal conduction is reduced or thermal radiation is reflected rather than absorbed by the lower-temperature body. [5]

Different varieties of insulation are available which are used depending upon the various parameter such as its generic form, structure, overall shape, application, operating temperature, and most important is its thermal properties. [5]

Heat transfers through insulation material occur through conduction while heat loss to or heat gain from the atmosphere occurs through convection or radiation. So, by adding more insulation to furnace it will decrease the heat transfer rate. [5]

3. EXPERIMENTAL SETUP

The schematic of the experimental set is shown in figure 1. This experimental setup consists of the following components:

a) Heating Coil
b) Casing
c) Insulation material
d) Table Stand
e) Digital Temperature Indicator
f) Electric Switch

Heating Coil: The coil is placed inside the casing for heating the rods. This coil is made of kanthal APM material and is in a helical shape. Kanthal APM material is used for the wire because it can be operated till 1425°C and has a high melting point at 1500°C. Kanthal APM wire when heated to high temperature prevents oxidation. Helical shape is used as it permits operation at high temperature without any stress-induced. It also provides compactness and increased heat transfer.

Insulation Material: Here two types of insulation are used, they are cementite and Glass wool. It is used so that the heat loss occurring is minimum.

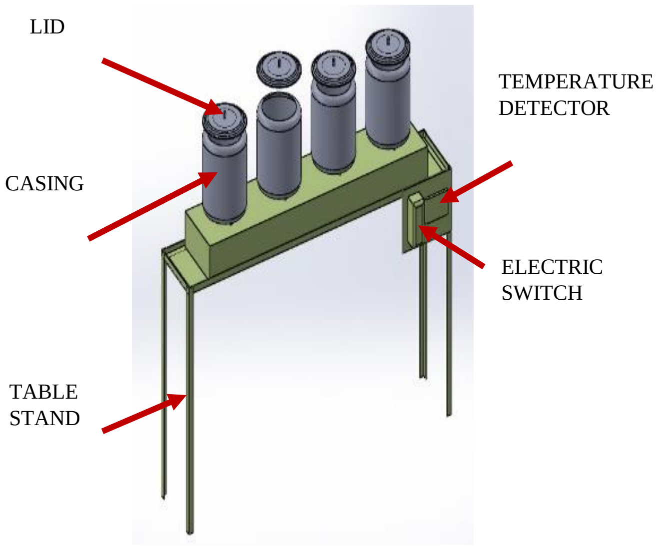

FIG 1: DESIGN OF EXPERIMENTAL SETUP

Construction: In this setup, there are in all 4-heating coil of Kanthal APM material. We have used this material for coil because this material can be operated till the temperature of 1425°C. These coils are placed inside the cementite muffle to avoid heat loss. This cementite covered coils are placed inside the stainless-steel casing, between the casing and the coil there is a thick layer (5mm) of glass wool placed to prevent the transfer of heat to the casing from the coil. The component to be heated is placed inside the coil. These heating chambers (casing with coil and insulation) are then attached to the table stand with the help of nuts and bolts. The temperature sensor used in the setup can detect temperature up to 1500 °C. A standard electric switch is used for ON-OFF of the system.

Working: As soon as the switch is ON the circuit is closed and the current starts passing through the coil. When the current is passing through the coil, the coil starts heating and the sensor shows the reading of the temperature attained by the coil. After the coil reaches the temperature (1000°C) the component to be heated is placed in the heating chamber. When the temperature reaches 1100°C the heated component is removed and placed in the forging machine for further processing.

4. DESIGN PROCEDURE OH HEATING COIL

Current and Resistance is calculated using Ohm's Law;

$$P = V \times I \text{ and } V = I \times R$$

Length of wire required in m/kg is calculated using;

$$L = I^2 \times Ct$$

The actual length required for the coil in m is calculated using,

$$L = R / (Ct \times Rt)$$

Closed length of the coil is given as,

$$Lc = L\ (feet) / 2.34$$

Free length of the coil,

$$Lf = 2 \times Lc$$

Length of wire in one turn

$$Lt = \pi (D - d)$$

5. FINAL SETUP

FIG 2: FINAL MANUFACTURED SETUP

6. RESULTS AND DECISION

1. While testing this setup, we have a heated metal rod of different diameters and obtained the readings of how much time does the rod takes to get heated. The readings of the timing required which are obtained are acceptable.
2. Depending on the time required for heating the rod we will calculate the number of rods that can be heating during the working shift of the industry, that is, the work output of the heating chamber.
3. The number of components heated per working shift helps the industry to achieve its daily target to maximum possible extend.
4. Following where the reading obtained after testing:

Sr. no.	Size of component (diameter in mm)	The average time required for heating	The time required for forging
1.	Φ 12	150 sec	10 sec
2.	Φ 16	160 sec	10 sec
3.	Φ 20	192 sec	10 sec
4.	Φ 24	210 sec	10 sec
5.	Φ 27	228 sec	10 sec
6.	Φ 30	240 sec	10 sec

7. CONCLUSION

In this project, the setup manufactured of the preheating chamber helps the industry to overcome the drawbacks of the induction mechanism to a possible extension. It also helps the industry to overcome the losses that occur due to the breakdown of the initial induction mechanism. This setup can be used as an alternative device in the industry as this mechanism can heat the component at an accurate temperature which will be required for a particular material for upset forging.

8. REFERENCE

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9. NOMENCLATURE

ALPHABETS

V	Voltage (in volts)
P	Power (in watts)
D	Outside diameter of the coil
I	Current (in amps)
R	Resistance of coil (in Ω)
Ct	Temperature factor
L	Length of coil
d	Wire diameter
Rt	Resistance of wire (per meter coil)
Lc	Closed length of the coil
Lf	Free length of the coil
Lt	Length of wire in one turn of the coil

GREEK SYMBOL

Ω	Ohm