Investigation on PID parameters for Uniform Temperature Distribution in the oven by Forced Convection using Lab VIEW 8.2

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ABSTRACT

In this modern manufacturing era, the complexity of design procedure is exponentially increasing. This will lead to bring the design challenges in moulding. The quality of the castings produced in the foundry depends on the size and strength of core patterns placed inside the mould cavity. For getting uniform quality and repeatability, all the cores should have uniform strength. Temperature is considered as one of the main parameter for the strength of the cores. For getting uniform strength, the temperature distribution should be uniform inside the oven. The distribution can be controlled by making a control over the temperature and air flow. In this paper, the temperature is controlled by means of a virtual PID controller available in the LabVIEW software. The virtual PID controller will give better control and precision over an ON/OFF controller. For various PID values, the temperature distribution is analyzed for uniform temperature distribution inside the oven by using forced convection.

Keywords
PID controller; uniform temperature distribution; labVIEW; forced convection

I. INTRODUCTION

The oven is a heating system which is used to heat the components to the required temperature. In the foundry industry, the cores are extensively used for making parts with holes. The cores will be prepared from core sand by mixing some quantity of water. Then it will be baked in the oven for removing the moisture. The strength of the core depends on the effective heating. In the oven it is found that the cores are heated in a non-uniform manner.i.e temperature distribution is decreased from bottom position to the top position. It results in the rejections of the components. In this discussion importance towards the uniform temperature distribution is attained by using forced convection is explained. In addition to that an attempt is made for setting up of a blower with air flow sensor setup is made for forced convection.

II. LITERATURE REVIEW

The oven is an interesting system to do research. The PID controller is one of the best controllers for controlling the oven temperature. From the literature Collections the following results are concluded.

The temperature is controlled by means of a virtual PID controller available in the Lab VIEW software [2]. Forced convection is usually having uniformity in heating than the natural convection [3]. The PID Controller has to be tuned based on the model/sample inside the oven [15].

The temperature distribution is affected by number of parameters of which coil diameter and coil location is important [13]. In the conventional programmed heating controller, the accuracy and regulation of temperature are <0.50C [12]. In case of PI fuzzy controllers the system gain increases and the offset from the actual value decreases [16].The sample shape has a great influence on heating Rate and temperature distribution within the sample [19].

Temperature distribution is varying by 0.12 to 2.430C in front panel to 0.23-4.460C in the rear panel of the heating zone [16]. The heat transfer functions Vary with the location of the sample, with respect to the Heating coil, if natural convective heat transfer is considered [20]. Real-coded genetic algorithm is used to tune the parameters of the DAC-PID controller such That the temperature can be maintained constant [9]. From the previous Literatures it is concluded that Uniform temperature distribution is affected by the following parameters:

1. Heating time
2. Sample size
3. Heating coil diameter
4. Heating coil position
5. Air flow

The main objective of this project is to maintain uniform temperature distribution in the oven. For various PID values the temperature distribution is going to be analyzed and optimized for uniform temperature distribution in the oven by using forced convection.

III. PROBLEM IDENTIFICATION

The 2-D diagram of the oven is depicted in the following figure.1.The temperature of the object (Core) is decided by capacity of heat source, level of heat source, distance from the heat source, and velocity of air and heat loss to the environment. In case of foundry the cores are placed inside the oven to remove the moisture content. The heating coil is placed at the bottom of the oven. The higher temperature is identified at the bottom cores and lower temperature is felt at the top. Due to the varying temperature distribution, the stability of cores which are away from the heating source is affected. This leads to more rejections in the components to be moulded. The aim of this project is to maintain the uniform temperature distribution inside the oven by forced convection through PID controllers interlinked with Lab VIEW 8.2.

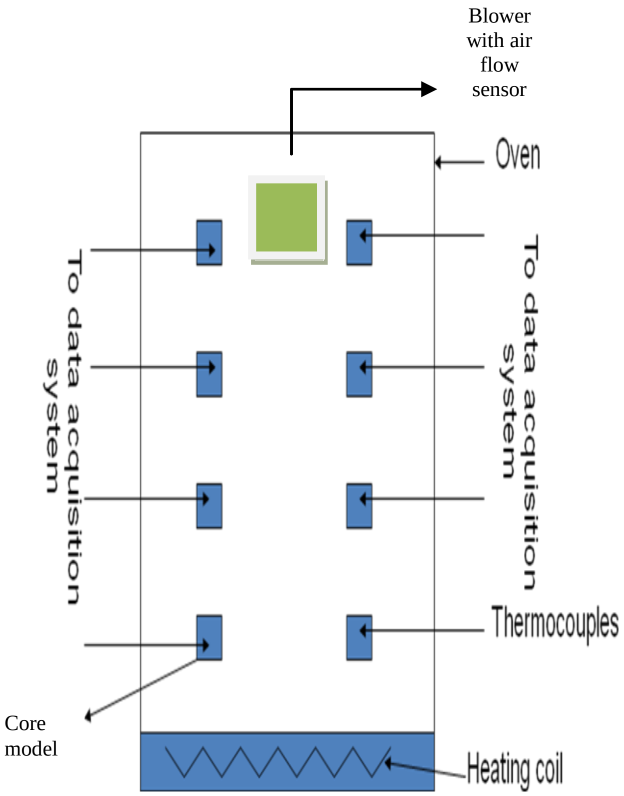

Figure.1: The schematic view of the electric oven

IV. FORCED CONVECTION

In forced heat convection, transfer of heat is due to movement in the body which results from many other forces, such as a fan, blower, and pump.
The general equation for convection is,

$$q_c = h_c A\ \Delta T \qquad (1)$$

Typically the convective Heat Transfer coefficient is greater with forced convection than with natural convection, which results in improved heating of the product.

In this paper, fan with blower setup is used for forced convection. Blower along with air flow sensor is added inside the oven, air flow sensor is used to find out the flow velocity inside the oven. With forced convection, the most important variable is the velocity V and,

$$v = -\frac{k}{\eta f_L}\nabla(P + \rho_L g) \qquad (2)$$

Where v is the flow velocity, k is the permeability which depends on distance between dendritic arms and volume fraction, η here is the kinematic viscosity, P is pressure, ρL is the liquid density and g is the acceleration due to gravity.

The relevant dimensionless groups are the Nusselt and Prandtl Numbers and the Reynolds number (Re). In using the Nusselt number to calculate the heat transfer coefficient c h the characteristic length L is replaced by the hydraulic diameter H D equation. If Re > 2000 the flow is turbulent.

V. PROGRAMMING PID ALGORITHM IN LABVIEW 8.2

LabVIEW VIs contain three main components

- Font Panel
- Block Diagram
- Icon/Connector Pane

(1) Virtual Instrumentation is a user interface. It can build the front panel with controls (inputs) and indicators (outputs)
(2) Block diagram contains the graphical source code. Front panel object appears as terminals on the block diagram.
(3) Icon/Connector pane

- Icon: graphical representation of a VI
- Connector Pane: map of the inputs and outputs of a VI
- Icons and connector panes are necessary to use a VI as sub VI
  1. A sub VI that is inside of another VI
  2. Similar to a function in a text-based programming language

The PID controller VI consists of four Sub VIs: Proportional, integral, derivative and Sub VIs. The mathematical algorithm of PID controller is as follows:

$V_{OUT}(t) = Kp\ e(t) + KI \int e(t)\,dt + Kd[de(t)/dt]$

Where e (t) is the error. Kp, ki, kd are coefficients of proportional, integral and derivative actions respectively.

VI. SOLUTION METHODOLOGY

The PID controller in the LabVIEW software is going to be used for controlling the heating coil and blower set up. The block diagram of this controller is shown in figure.2.

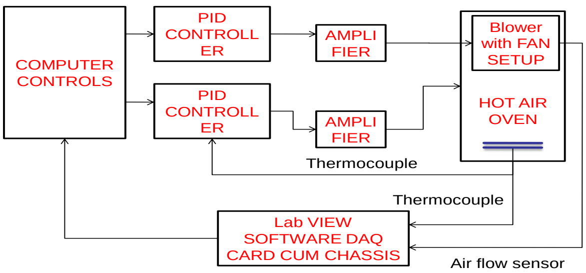

Figure.2: Block diagram of the experimental setup

1. The ampere rating of the coil, air flow rate of the blower are taken as parameters which control the uniform temperature distribution. The cores are prepared and placed in trays inside the oven from the bottom to top whose temperatures are monitored using the thermocouples placed nearer to them. Blower along with air flow sensor is added inside the oven. The temperature distribution will be analyzed by observing the temperatures of the cores placed inside.
2. The temperature terminals and the air flow equipments of the oven considered will be interfaced with the Lab VIEW 8.2 and system model is generated in the software to monitor the experimental setup (temperature, air flow rate).
3. A TRIAC controller is used to control the ampere rating of the heating coil, fan with blower setup. It controls the ampere rating by controlling the phase angle of the input pulse. The control over the phase angle will change the voltage input and accordingly the ampere rating will vary.
4. The PID controller in RS Logic PLC software is used for controlling the TRIAC controller. Whenever the temperature at the bottom portion increases, the current input to the coil is reduced. Since the heat transfer is through forced convection, higher heat energy distributes to the middle and top trays at that time the bottom tray will also reach the same temperature.
5. Whenever the temperature reaches below the set value, the current input is increased accordingly. In the similar fashion, the uniformity will be maintained throughout the oven space.

VII. CONCLUSION

Experiments are conducted by placing eight samples inside the oven to ensure the non uniform temperature distribution. The following graphs showed the top plate and bottom plate having very noticeable temperature difference. By the above investigation it is found that there is some contradiction arises between LabVIEW and PID controller while working. In order to overcome these limitations it is preferred to use LabVIEW alone for the above investigation.

BR – Bottom Right core
MR – Middle Right Core
BL - Bottom left core
ML – Middle Left core
TR – Top right core
M2R – Second Middle Right Core
TL – Top left core
M2L – Second Middle Left Core

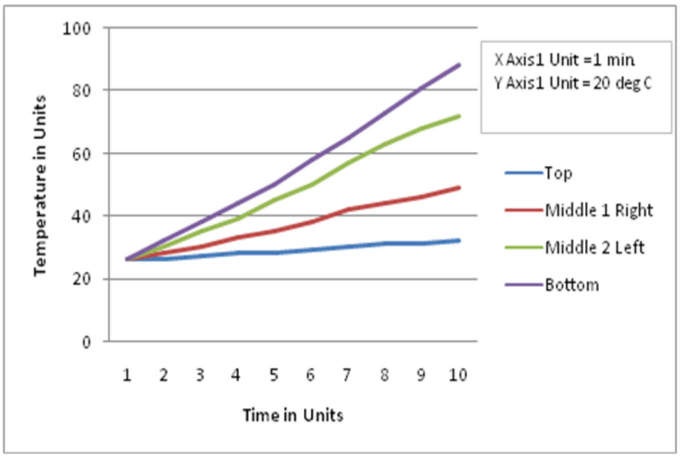

Figure.3: Temperature analysis with 8 cores after 10 minutes

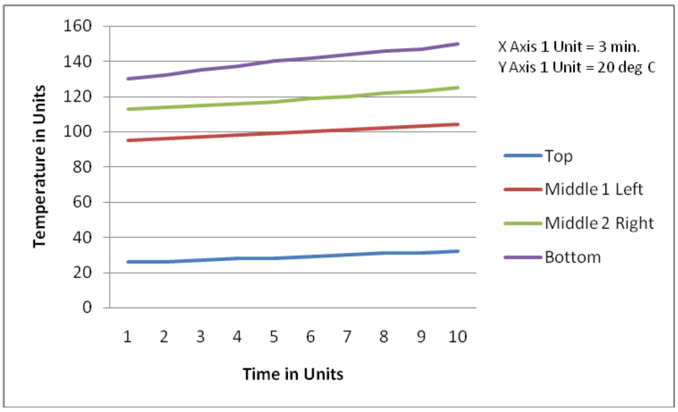

Figure.3: Temperature analysis with 8 cores after 30 minutes

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