IN THE NAME OF GOD

COMPUTER SIMULATION OF CONTINUOUS FURNACES BY MEANS OF ZONE METHOD

BY

MOHAMMAD RAHIMI NASR

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EVALUATED AND APPROVED BY THE THESIS COMMITTEE
AS: **EXCELLENT**

....M. MATIN , Ph.D., ASSISTANT PROF.
OF MECHANICAL ENGINEERING.
(CHAIRMAN)

....M. RASHIDI , Ph.D., ASSOCIATE PROF.
OF MECHANICAL ENGINEERING

....A. A. GOLNESHAN , Ph.D., ASSISTANT PROF.
OF MECHANICAL ENGINEERING

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Dedicated To

My Dear Family For Their Kindness

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ABSTRACT

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Heating of metals for further forming processes is usually done in furnaces which are commonly known as batch or continuous depending on the nature of the proposed forming process. Nevertheless each material needs to be processed within a specific temperature range which transfers it into a status of best plasticity. Therefore, the ideal heating temperature and soaking time must be set to the furnace based on the heating curve of the material which is subsequently being formed.

However, the aforementioned goal is only achieved by a proper control of the furnace which in turn calls for an accurate mathematical modeling of the heat transfer within the furnace chamber.

This research work was devoted to present the general mathematical model that describes the steady-state behaviour of continuous furnaces. The proposed three dimensional radiation model is based on the zone method where the mathematical formulation allows the prediction of gas temperature, by applying energy balance to each gas zone, as well as the temperature distribution along the walls of any furnace enclosure of specified shape and size. Based on the aforesaid theoretical base, implementation of its application regarding a walking-beam, a pusher type and a rotary-hearth furnaces are illustrated and computational results are in close agreement with the relevant experimental data found from industrial records.

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CHAPTER ONE
INTRODUCTION

The term 'reheating furnaces ' applies to those furnaces in which heat is imparted for the purpose of rising metal temperature in such to be suitable for further forming processes, while no chemical changes, or change of state e.g. melting and/or vaporization takes place. However depending on the nature of the proposed forming operation, either batch type furnaces or continuous ones are used. The furnace-temperature is practically uniform, but time dependent, throughout the interior of the batch type furnaces, whereas in continuous ones the charged material or stock moves along the furnace while is being heated in different heating zones. The latter method of heating prevents the tendency of the heat sensitive materials to form cracks. Generally speaking, each metallic material needs to be formed within a specific temperature range having the lower and upper limits. The lower boundary must be at least as high as the recrystallization temperature, but somewhat higher in order to compensate phase transformation. The upper temperature limit is determined by excess oxidation, coarse grain formation, or phase transformation.

The heating of a metal workpiece reduces the flow stress and thus leads to a corresponding decrease in the force and energy required for deformation. However, the flow stress may vary considerably within the forming temperature range. In order to keep the stresses and forces as low as possible, hot forming is usually started at the highest permissible temperature since cooling due to the temperature difference between workpiece and tool is unavoidable. However, care must be taken that the temperature is as even as possible over the entire cross section of the billet (slug). This becomes increasingly difficult with large cross sections and where the thermal conductivity is poor. For example chrome, nickel and manganese steels exhibit poor thermal conductivity accompanied by high creep resistance. Therefore, in order to avoid damages to any of such materials, through heating should be carried out according to its accurate heating curve. This in turn minimizes the induced thermal stresses but the heating process may last several days.

Now a days it is practically established that, each material has to be heated according to its specific heating curve, which dictates the heating speed as well as the temperature range for the operating furnace. In another words in any hot forming process the temperature limits together with the soaking time are set to the preheating furnace according to the ideal heating profile of the processed material. Therefore, heating of a metallic workpiece in any industrial furnace, followed by subsequent forming operation, is a precise task that can only be fulfilled by an appropriate control of the furnace.

In this research work, the Hottel's zone method [1] was adopted to present the general mathematical model that describes the steady-state behavior of continuous furnaces, and then comparison of the