

IN THE NAME OF GOD

**COMPUTER SIMULATION OF CONTINUOUS FURNACES
BY MEANS OF ZONE METHOD**

BY
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THESIS

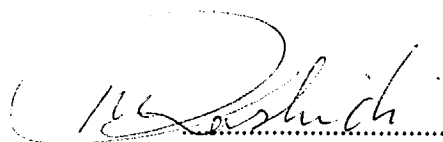
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Dedicated To

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.

TABLE OF CONTENTS

CONTENT	PAGE
LIST OF TABLES	X
LIST OF FIGURES	XI
CHAPTER ONE : INTRODUCTION	1
CHAPTER TWO : METAL WORKING FURNACES	4
2.1. Introduction	4
2.2. Rotary hearth type	7
2.3. Pusher-type	10
2.4. Walking-beam furnace	15
CHAPTER THREE : MODELING OF PREHEATING FURNACES	20
3.1. Review of the previous works	20
3.2. Heat transfer model of furnace chamber	26
3.2.1. Introduction	26
3.2.2. The zone energy balance equation	28
3.2.2.1. Introduction	28
3.2.2.2. Total energy balance for combustion products	29
3.2.2.3. Wall heat loss	31
3.2.2.4. Load heat transfer	32
3.2.2.5. Calculation of directed flux areas	33

CONTENT	PAGE
3.2.2.6. Calculation of the direct and total exchange areas	34
3.2.2.7. Energy balance equations	35
3.2.2.8. Solution of equations	35
CHAPTER FOUR : FORMULATION	37
4.1. Introduction	37
4.2. Emission from a black body	37
4.3. Emission and absorption by non-black surfaces	40
4.4. Interchange of radiation between surfaces	42
4.5. Emission and absorption by gases	45
4.5.1. Scattering by particles	47
4.5.2. The emissivity and absorptivity of combustion products	48
4.5.3. The mixed gray gas model for emissivity and absorptivity	51
4.6. Zonal analysis	54
4.6.1. Direct exchange areas	55
4.6.1.1. Surface-Surface exchange area	55
4.6.1.2. Volume-Surface exchange area	56
4.6.1.3. Volume-Volume exchange area	57
4.6.2. Total exchange areas	58

CONTENT	PAGE
4.6.3. Summation rules for total and direct exchange areas	64
4.6.4. Directed flux areas	65
4.6.5. The radiant energy balance	67
CHAPTER FIVE : COMPUTER PROGRAM	70
5.1. Introduction	70
5.2. Variables	70
5.3. External files	71
5.4. Arrays	71
5.5. Subroutines	73
5.5.1. Subroutine 'INPD'	74
5.5.2. Subroutine 'INPS'	74
5.5.3. Subroutine 'SSS'	74
5.5.4. Subroutine 'GSL'	74
5.5.5. Subroutine 'GSS'	74
5.5.6. Subroutine 'GGG'	74
5.5.7. Subroutine 'GGS'	75
5.5.8. Subroutine 'VARO'	75
5.5.9. Subroutine 'SGS'	75
5.5.10. Subroutine 'TOFA'	75
5.5.11. Subroutine 'F'	75
5.5.12. Subroutine 'NEWT'	75

CONTENT	PAGE
CHAPTER SIX : RESULTS , DISCUSSIONS & CONCLUSIONS	76
6.1. Introduction	76
6.2. Example I	77
6.2.1. Results	78
6.3. Example II	83
6.3.1. Results	84
6.4. Burners layout	91
6.5. Example III	92
6.5.1. Results	92
6.6. Heating Program	94
6.7. Conclusions	96
APPENDIX : STEEL USED FOR FORGED PARTS	97
REFERENCES	100
ABSTRACT AND TITLE PAGE IN PERSIAN	

LIST OF TABLES

TABLE		PAGE
3.1	Ratio of useful heat (Q_{eff}) to supplied heat (Q_s) for different types of furnaces	23
4.1	Gray gas parameters used in mixed gray gas correlations $\frac{P_{\text{H}_2\text{O}}}{P_{\text{CO}_2}}$	53
6.1	Heating program of 15 tons/hr rotary hearth furnace	91
6.2	Heating program of 6 tons/hr walking beam furnace	94

LIST OF FIGURES

FIGURE		PAGE
2.1	Batch-type or "in-and-out" type of furnace	5
2.2	Continuous furnace with end discharge	6
2.3	Continuous furnace with rotating hearth	6
2.4	Temperature mode in heating furnaces	7
2.5	A rotary-hearth furnace	9
2.6	Temperature conditions and temperature profiles in pusher-type continuous furnaces	13
2.7	A pusher-type furnace	14
2.8	A walking-beam furnace	16
2.9	Walking-beam transfer system	18
2.10	Position of burners in a traveling-hearth furnace	19
3.1	Section through a typical continuous reheating furnace	22
4.1	Radiation density of a black body	38
4.2	Energy transfer in a given direction (η , θ) from a differential area on a plane black surface	39
4.3	The radiant interchange between two differential plane gray surfaces	43
4.4	The interchange of radiation within an enclosure containing gray surfaces	44

FIGURE		PAGE
4.5	The emissivities of combustion products containing carbon dioxide and water in the ratio 2:1	50
4.6	The emissivities of combustion products containing carbon dioxide and water in the ratio 1:1	50
4.7	Direct exchanges between differential surface and volume elements in a radiating enclosure	58
4.8	The incident and leaving fluxes at a surface element	60
6.1	Heating curve for stock : 200×200×4000×1216 kg in pusher type furnace	79
6.2	Experimental and Numerically predicted results versus time in pusher-type furnace	80
6.3	Experimental and Numerically predicted results versus length in pusher-type furnace	81
6.4	Heat absorbed by load in pusher-type furnace	82
6.5	Heating curves for three types of stock in rotary-hearth furnace	85
6.6	Experimental and Numerically predicted results for stock : D700×2735mm×8000kg in rotary-hearth furnace	86
6.7	Experimental and Numerically predicted results for stock : D450×3600mm×4352kg in rotary-hearth furnace	87
6.8	Experimental and Numerically predicted results for stock : D300×3600mm×1934kg in rotary-hearth furnace	88

FIGURE		PAGE
6.9	Heat absorbed by three types of stock in rotary-hearth furnace	89
6.10	Actual heat for stock : D700×2735mm×8000kg in rotary- hearth furnace	90
6.11	Experimental and Numerically predicted temperature in walking-beam furnace	93
6.12	Heat absorbed by stock in walking-beam furnace	95

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