Research Programs

CHT-*cf* - Development of an Analytical Tool for Part Load Design and Temperature Control in Continuous Furnaces

January 2003 - June 2004

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Introduction

Heat treatment is a manufacturing process to control the mechanical properties of metallic components. The thermal history of each part and the temperature distribution in the whole load directly determined the final quality of parts. The thermal exposure a component undergoes depends on the design of the furnace load, location of the component within the load, furnace configuration, thermal schedule, and control strategy. As the part and furnace are given, part loading and thermal schedule are the main factors for temperature control the heat treatment process. In the heat treatment furnace heat transfer involves furnace control, combustion, convection, radiation and conduction.

Objectives

The objectives of the proposed project was to develop a computer tool to model and simulate the heat transfer in continuous furnace for guiding the part load design, decide on load moving speed and temperature control, to optimize the heat transfer in continuous furnaces, and finally to save energy and reduce cost.

The main functions of CHT-cf were designed for this project and all of them have been achieved:

- Accurately predict temperature profile in furnace with different parts and part load.
- Simulate various load patterns (arranged or random) with or without fixtures
- Model different furnaces with continuous and step part feeding (Conveyor, Pusher, Rotary Hearth, Shaker and Mesh Belt)
- Simulate the effects by varying the load pattern and furnace zone temperature control
- Determine the slowest and the fastest heating parts for a given load pattern
- Calculate the heat input required for the load under different conditions
- Predict fuel flow rate and determine the fuel required as a function of time, for better control of furnace performance.
- Establish a comprehensive database and database management functions.

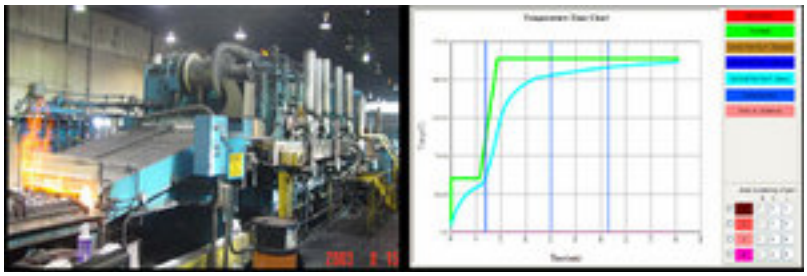
Methodology

Continuous furnaces are widely used for the heat treatment of mass production parts. So to optimize the heat treating process in continuous furnace is of great significance. A tool for part load design and temperature control in batch furnaces had been developed and put into application from the previous project funded by Center for Heat Treating Excellence. In this project, the furnace model was expanded to continuous furnace.

- The research followed the procedure: task investigation, definition of the application scope and calculation domain, establishment of mathematical models, program design and development, validation and case studies.
- For industrial application, the models should be efficient. Therefore, hybrid model of numerical method and analytical method are applied.

Salient Results and Related Publications

A software tool -- Computerized Heat Treatment Planning System for Continuous Furnaces (CHT-cf) was developed. When the part loading is specified as weight per unit time and the moving speed, as well as the zone temperature is determined, the temperature distribution in the load and inside parts can be calculated and predicted. Therefore, the part loading and temperature control can be optimized through several iterations of heat transfer analysis. The system can be used for modeling different types of furnaces, such as mesh belt furnaces, cast belt furnaces, conveyor belt furnaces; pusher furnaces, shaker furnaces, walking beam furnaces, and screw hearth furnace. The system was evaluated by several case studies with production data at CHTE focus group member companies.



Publications

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2. J. Kang, Y. Rong, W. Wang, "Numerical simulation of heat transfer in loaded heat treatment furnaces", Journal of Physics, Vol. 4, France, No. 120, 2004, pp. 545-553.
3. J. Kang, T. Huang, R. Purushothaman, W. Wang, Y. Rong, "Modeling and simulation of heat transfer in loaded continuous heat treatment furnace", Transactions of Materials and Heat Treatment, Vol. 25, No. 5, 2004, pp. 764-768
4. Q. Lu, R. Vader, J. Kang and Y. Rong, M. Hoetzl, "Development of A Computer-Aided Heat Treatment Planning System", Heat Treatment of Metals, March 2002, pp. 65-70
5. R. Purushothaman, J. Kang, L. Zhang, and Y. Rong, "Application of CHT-bf and CHT-cf in Heat Treatment Process Operation Design", ASM Materials Science and Technology Conference and Exhibition, Sep. 25-28, 2005, Pittsburgh, PA
6. J. Kang, T. Huang, Y. Rong, "Modeling and Simulation of Heat Transfer in Loaded Heat Treatment furnace", The Third Sino-Korean Conference on Advanced Manufacturing Technology, Xi'an, China, June 10~13, 2004

7. J. Kang, R. Purushothaman, Y. Rong, "Industrial Applications of CHT-bf and CHT-cf", the 23rd ASM Heat Treating Society Conference and Exposition, September 26-28, 2005 in Pittsburgh, PA.
8. J. Kang, T. Huang, R. Purushothaman, W. Wang, and Y. Rong, "Modeling and Simulation of Heat Transfer in Loaded Continuous Heat Treatment Furnace", 14th International Federation for Heat Treatment and Surface Engineering Congress, Shanghai, China, Oct. 26-28, 2004.
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10. J. Kang, Y. Rong and W. Wang, "Numerical Simulation of Heat Transfer In Loaded Heat Treatment Furnaces", 2nd International Conference on Thermal Process Modeling and Computer Simulation, (ICTPMCS), March 31 - April 2, 2003, Nancy, France, pp. 545-553
11. J. Kang and Y. Rong, "Modeling And Simulation of Heat Transfer In Loaded Heat Treatment Furnaces", The 13th International Federation for Heat Treatment and Surface Engineering Congress, Columbus, OH October 7-10, 2002