

Research Programs

CHT-*q/t* - Computer-aided Heat Treatment Planning System for Quenching & Tempering

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Introduction

Optimization of the heat treatment process is of great significance in the industry due to the ever increasing energy costs and competition. During past years we have visited many member companies of CHTE and investigated the application of the heat treating technology in United States. During the investigation we acquired a lot of information about continuous and batch furnaces and a tool for part load design and temperature control in batch and continuous has been developed and put into application in various member companies. In order to complete the whole heat treating cycle i.e. to include the Quenching and Tempering operations we proposed to develop "Computerized Heat Treating and Planning System for Quenching and Tempering, CHT-*q/t*". The aim of the development is to model a complete heat treatment cycle comprising of heating, soaking, quenching and tempering which can be used for the optimization of load pattern and furnace control.

Objectives

The goal of this project is to develop an analytical tool to predict the temperature profile of load in batch as well as continuous furnace during heating, quenching and tempering of steel, then to estimate the mechanical properties as Quenched & Tempered through analyzing the microstructure evolution during the thermal process, and finally to optimize the heat treatment process design with the aim to save energy and reduce cost.

In general, the research objectives are set as follows

- To simulate the thermal process in a complete heat-treating cycle with various heat terms and temperature profile as its output.
- To predict the mechanical properties of the heat-treatable steels as quenched and tempered using TTT diagrams and equations for microstructure evolution.
- Applicable for heating in batch as well as continuous furnaces for gas fired cooling chamber and quench tank.
- To help implement quality control and part load optimization in the heat-treating industry.

Methodology

CHT-bf and CHT-cf have been developed in previous research. Therefore the objectives of this project will be achieved through enhancing CHT-bf and CHT-cf by including the quenching and tempering so that to analyze an entire heat treatment cycle. A software tool - Computerized Heat Treatment Planning System

for Quenching and Tempering (CHT-q/t) is under development. The strategy is to integrate the thermal analysis, material micro-structure evolution analysis, and mechanical property analysis. In modeling the heating and cooling processes, the basic models developed in CHT-bf and CHT-cf are utilized while the expansion is necessary with more detailed enmeshment. Particularly in modeling the cooling and quenching processes, the previous work at WPI on the heat transfer coefficient and quench factor are utilized, i.e., integrating the database, Quench-Pad into CHT-q/t. The tempering processes are modeled with a knowledge/data base approach. Without considering the phase transformation induced heat generation term in the microstructure evolution analysis model and with limited data available in the quenching study, the CHT-q/t will be limited to a certain number of materials and workpiece types (shapes and orientations).

Salient Results and Related Publications

1. System design

CHT-q/t integrates all of the heat treatment process i.e., heating, quenching and tempering. CHT-q/t is built with six major modules and every module is supported with several comprehensive databases. The major modules are Workpiece enmeshment module, Heating module, Quenching module, Microstructure and Phase transformation module, Tempering module and Mechanical properties module.



Figure 1. CHT-q/t user interfaces

The powerful CHT-q/t modules are presented to the user with an elegant user friendly interface. The interfaces include beautiful graphics and powerful tools to visualize the simulated thermal results and material properties. The software is built with simple interfaces and is catered to the users in a heat treatment shop. Anyone in the shop floor with knowledge on heat treatment should be able to use the software right away with minimal training.

2. System validation case studies at beta test sites

All the software that we develop at CHTE undergoes a thorough beta testing at several of our member facilities. We evaluate the system accuracy and validate the different modules during this phase. The current version of CHT-q/t is available for the CHTE member companies and already several experiments were conducted in Vacuum furnaces to verify the thermal modules. Further several experiments are planned to validate the accuracy of the individual modules in different furnaces and process parameters.

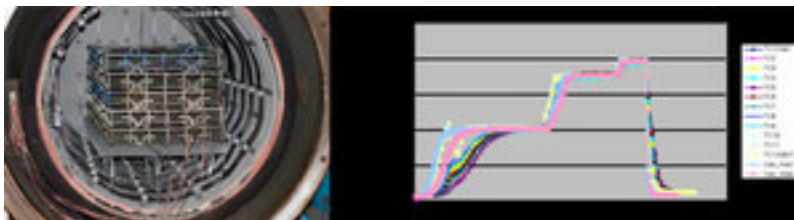


Figure 2. Experiment at American Heat Treating Corporation, Monore, CT to validate the CHT-q/t Quench model in vacuum furnace

Publications

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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
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