IPRO 330
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Operator Information Tool to Manage Heat Treat Furnace Parts for A. Finkl & Sons

ILLINOIS INSTITUTE OF TECHNOLOGY

Project Background

A. Finkl and Sons is the leading supplier of forging die steels, die casting tool steels, and custom open die forgings. The engineers operating the heat treatment facility need to optimize the furnace load configurations in order to minimize the number of pieces which turn out to be inadequately tempered. The engineers would like to have a simple way to visualize and manipulate the loading configuration of pieces of steel inside a furnace.

Project Objectives

- Survey the temperature distribution within both an unloaded and loaded tempering furnace
- To determine a method of stacking that provides the most uniform temperature distribution.
- To create an efficient and intuitive tracking system that allows the exact location of each part in the furnace to be recorded and catalogued for future reference.
- To put this knowledge together to create a software package that can be used to quickly and easily generate a stacking sequence that will result in a proper heat treatment for each piece in the furnace each time.

Current Solutions

There are existing software packages available that enable the loading of various types of containers.

CargoWiz by softtruck
FurnXpert by CompAS Controls, Inc.
VMS Solver by Logen Solutions
MaxLoad Pro by Tops Engineering
Cargo Optimizer by Dreamsofts Optimizer

- Most are geared toward the shipping industry and not suitable for this application
- FurnXpert by CompAS Controls Inc. is intended for furnace simulation, but contains extraneous features
- It is not intended as a production managing tool, and cannot efficiently be used to keep track of stacking configurations
- No existing software met the needs for a user-friendly commercial grade application
- It was determined that a completely new application was necessary

Software: AutoStack

- A 3-D visualization software used to simulate the loading of steel parts into a heat treatment furnace
- Can detect collisions between pieces
- Allows a furnace operator to quickly and easily place a three dimensional geometry representing an actual piece in a simulated furnace.
- When there is a failure, the operator can know not only what furnace the part was treated in, but where in that furnace the part was located
- A 3-D visualization software used to simulate the loading of steel parts into a heat treatment furnace
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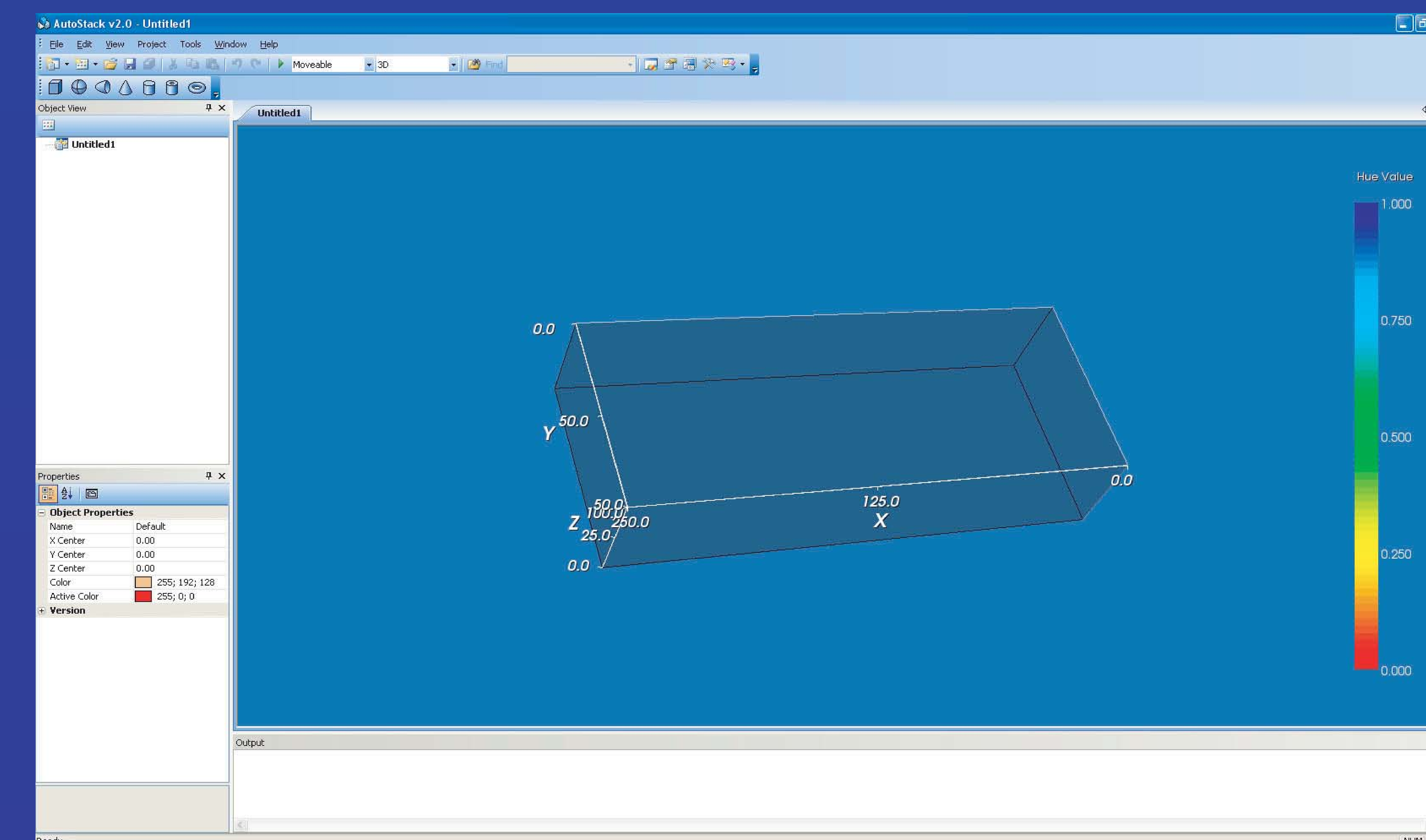

Figure 1: AutoStack - Empty furnace

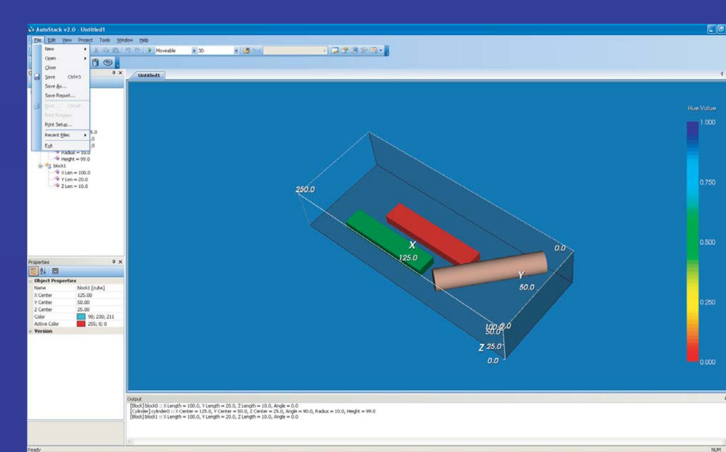

Figure 2: AutoStack - Multiple pieces

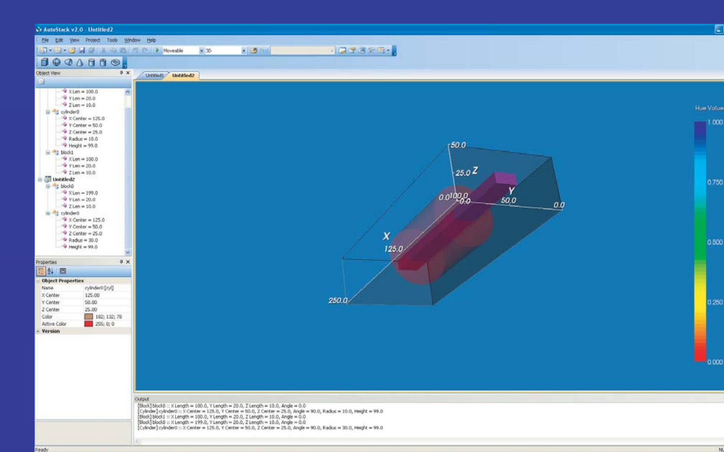

Figure 3: AutoStack - Complex geometry

- 8000 lines written in C++ using Visual Toolkit (VTK) which is based on OpenGL
- GUI front-end created with Xtreme Toolkit by Codejack which extends MFC (Microsoft F C)
- Fast scene rendering with per pixel lighting, normal mapping, spectacular highlighting
- HTML rendering engine

Furnace Survey

- Furnace surveys were performed to determine the temperature distributions in the tempering furnaces
- Performed both in an unloaded and loaded furnace
- Approximately 20 thermocouples were used for each survey

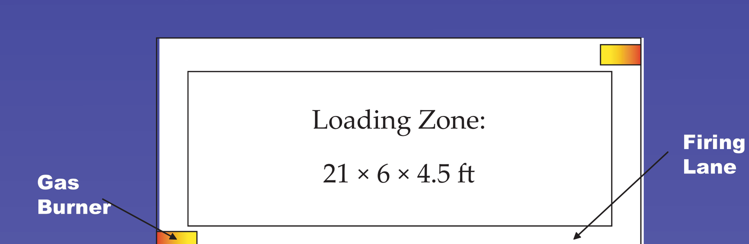

Figure 4: Furnace Schematic

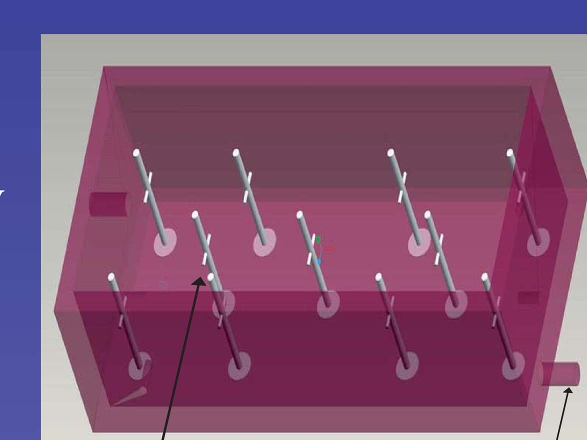

Figure 5: Furnace Model

Thermocouple Stands

Gas Burner

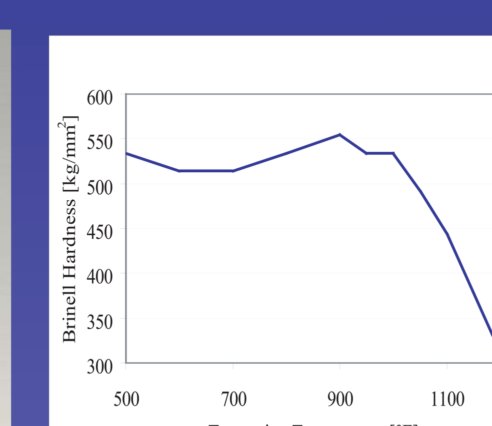

Figure 6: Shelldie® Tempering Curve

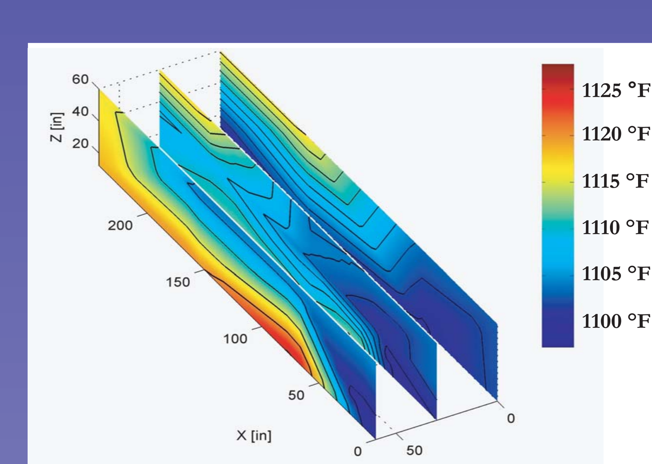

Figure 7: Unloaded furnace at 1100°F.
For unloaded furnaces, thermocouples were placed on stands arranged in the loading zone.

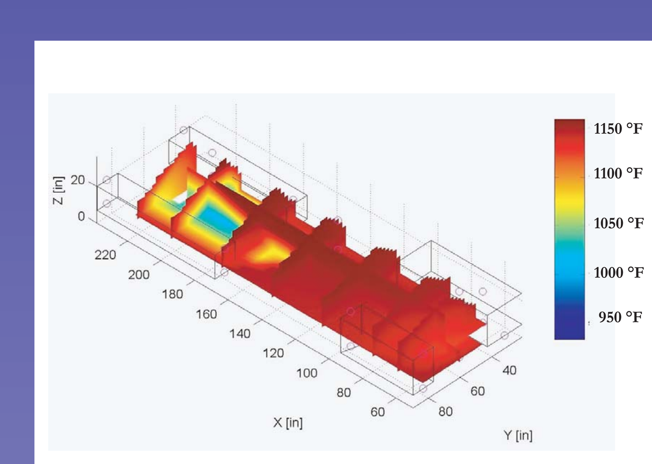

Figure 8: Loaded furnace at 1150°F.
For loaded furnaces, thermocouples were welded directly to parts that were being tempered.

Survey Results

- Temperature distributions in both loaded and unloaded furnaces are acceptable
- Air temperatures near the floor are cooler in a loaded furnace, however part temperatures are still relatively even
- The firing lanes are typically hotter than the loading zone volume
- Parts must be loaded completely within the loading zone

Conclusions

Furnace Survey

- Furnace #30 was running up to specifications
- Only tested 1 of several furnaces
- Only tested 1 stacking set-up

Software benefits and limitations

- Represents actual stacking in 3-D
- Replaces old hand-written files
- Currently, only able to create simple shapes

Groundwork for final solution has been laid

Future Projects

- Develop a portable handset display for the operators
- Enhance the shape database in the software
- Survey more furnaces and furnace conditions
- Perform statistical analysis of temperature ranges
- Develop a system to track pieces quickly and easily

Ipro 330 Team

Team members from the left to right:

Prof. S. Mostovoy, Pat O'Leary, Leland Barnard, Eddie Schwalbach, Zheyan Chen, (front) Bill Cappello, (Back) Joseph Velton, Colleen Roberts, Syed Ijaz, Ivan Tovalin, Minaz Virani

References

Dowling, Norman E. Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue. Upper Saddle River, New Jersey.: Prentice Hall, 1999
Hertzberg, Richard W. Deformation and Fracture Mechanics of Engineering Materials. New York, New York.: John Wiley & Sons, Inc, 1996.
Kalpakjian, Serope and Steven R. Schmid. Manufacturing Processes for Engineering Materials. Upper Saddle River, New Jersey.: Prentice Hall, 2003.
Reed-Hill, Robert E. and Reza Abbaschian. Physical Metallurgy Principles. Boston, Massachusetts.: International Thomson Publishing, 1994.
Shackelford, James F. Introduction to Materials Science for Engineers. Upper Saddle River, New Jersey.: Prentice Hall, 2000.
Aerospace Material Specification 2750 Revision C. Warrendale, Pennsylvania. Society of Automotive Engineers, Inc., 1990.
Hot Work Die Steel Data Sheet: Shelldie. Chicago, IL. A. Finkl Sons & Co.
Hot Work Die Steel Data Sheet: ShelleX. Chicago, IL. A. Finkl Sons & Co.
Premium H13. Florence, Kentucky. International Mold Steel, Inc, 2000.
Basics of Design Engineering - Engineering Materials
< http://www.machinedesign.com/BDE/materials/bdemat6/bdemat6_6.html > April 13, 2006.
eFunda: General Information on Tool Steels
< http://www.efunda.com/Materials/alloys/tool_steels/tool.cfm > April 13, 2006.
All Metals & Forge
< http://www.steelforge.com/infoservices/matoverview/mo_tool_steel.asp > April 13, 2006.
AnCAD Matfor GUI System <http://www.ancad.com/overview.html#overviewmenu.> February 23, 2006.
OpenInventor < http://oss.sgi.com/projects/inventor/ >. February 23, 2006.
FurnXpert by CompAS Controls, Inc.< http://www.furnxpert.com/ > March 01, 2006.
CargoWiz by softtruck
< http://www.softtruck.com/?OVRAW=truck%20loading%20software&OVKEY=truck %20loading%20software&OVMTC=standard > March 01, 2006.
VMS Solver by Logen Solutions
< http://www.logensolutions.com/index.asp?from=Solver > March 01, 2006.
MaxLoad Pro by Tops Engineering
< http://www.topseng .com/MaxLoadFeatures.html > March 01, 2006.
Cargo Optimizer by Dreamsofts Optimization
< http://www.cargooptimizer.com/OSC/index.php?currency=USD&language=en > March 01, 2006.

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