Development of Materials Database System for CAE System of Heat Treatment Based on Data Mining Technology

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Abstract

Computer simulation for materials processing needs a huge database containing a great deal of various physical properties of materials. In order to employ the accumulated large data on materials heat treatment in the past years, it is significant to develop an intelligent database system. In this paper, based on data mining technology on data analysis, an intelligent database web tool system of computer simulation for heat treatment process named as IndBASEweb-HT is built up. The architecture and the arithmetic of this system as well as its application are introduced.

1. Introduction of system

Numerical simulation on materials processing, such as heat treatment, casting and so on, is an important method to evaluate complex physical behavior with coupled fields of temperature, microstructure and stress/strain. However, this simulation needs a lot of data containing the parameters of the mechanical and thermal properties as well as the diagram related to phase transformation. On the other hands, parameters of inelastic constitute equation and kinetics model of phase transformation can not be directly obtained from experiment. Therefore, it is significant to develop an intelligent system based on data mining.

In this paper, the research strategies for supporting computer simulation of heat treatment process are to construct the database based on following points:

1) Web-based system for easy remote access and administration.
2) Knowledge-based database to analyze the functional relationship and to discover the potential rule of the data by its intelligence.
3) Interfaces to allow experts to inspect and modify the algorism of the core modular.

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According to above strategies, following technique were employed to construct the frame of the database.

a) Browse/Server mode to work on networks and transform platform. b) Component design for extensibility. c) Security and authorization. d) Date mining technique.

Based on these requirements, we developed the intelligent database system, which is shown in Fig.1. This system includes following kinds of functions, data search; data statistics; data mining; data conversion and data export. The function map is shown in Fig.2.

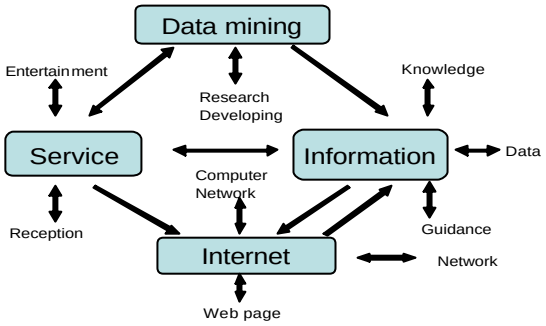

Fig. 1 Architecture of this system

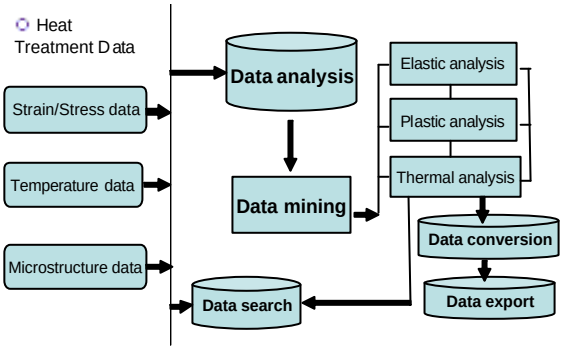

Fig. 2 Function map of the modulus

2. Build of the scientific database

2.1 Data source and classification The original data are obtained in various ways such as from experimental results and technical references. The data are classified by steel grade concerning alloy and carbon content; by technical test and by materials property. The expansibility is enhanced by the adoption of

component design. The system can get external data and export data sheet by ODBC. We design and implement the XML-style presentation of model and integrate the database system with data mining technique.

2.2 Data search Three types of engines are built by steel name, chemical compositions and examining test. User can select the combined search mode and output statistical information about the data. As an example, the searched page of steel SCr420 is shown in Fig. 3. And the detailed result enclosed the original data and corresponding graphs is shown in Fig. 4.

2.3 Data analysis This system can generate the function curve and output the equation. Functional modulus with regression and clustering algorisms has been built. The interfaces allow experts to select and inspect the algorism and scope for data mining.

2.4 Data conversion This system can converse the mining results into special data format for commercial simulation software; user can also choose the conversion mode.

3. Data mining system

Data mining (sometimes called knowledge discovery or data exploration) is an analytical tool of finding correlations or patterns among dozens of fields in large relational database. It allows users to analyze data from different aspects, categorize, summarize and identify the unknown relationship. In this system, following data mining technique were employed.

a) Sequence model. Use regression method to find the potential rule in the data.

b) Classification. Classify the data to suitable data scope.

4. Application of the Database

As an example, the accumulated data were analyzed by the data mining technique integrated in this system to determine the potential functional elastic coefficient and the strain/stress relationship for heat treatment simulation. The measured materials properties by tensile test are recorded as numerical value in series of information and data sheets. The information sheet describes the detailed testing conditions and specimen. The data sheet concerns the original experimental results shown in Table 1 as part of active webpage. The original data are first analyzed by clustering and classification tools to release the noise and determine an optimized scope. The regression is used to get the functional relationship of the elastic coefficient with temperature by multinomial regression as shown as Fig.5. In summery, this system provides an effective and efficient database tool for the materials simulation researchers.

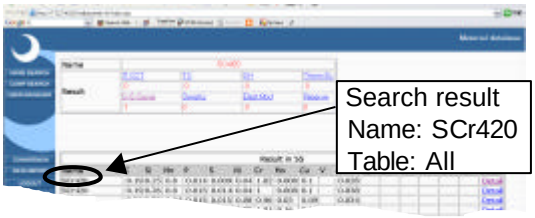

Fig.3 Result of the search function

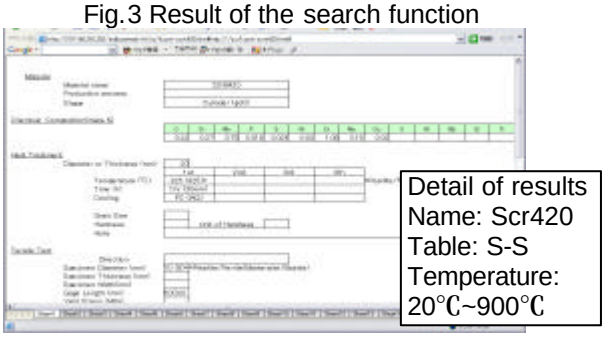

Fig.4 Detail of the database

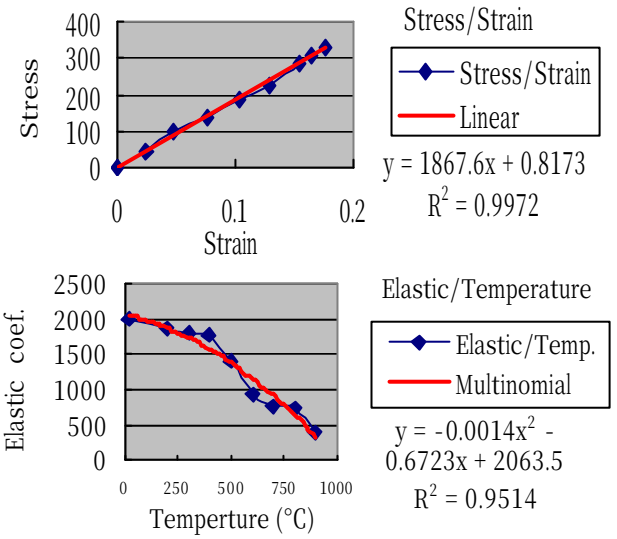

Fig. 5 Results of data mining generated

Acknowledgements

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References

[1] T. Inoue, K. Okamura and D.Y. Ju, *Material Database for Simulation of Metallo-Thermo-Mechanical Field*, Proc. 20th ASM Heat Treating Conf. on Quenching and Distortion Control, ASM Inter., pp.753-760, 2002

[2] G.E Totten, M. Gergely and S. Szilvia, *Software tool for Heat Treaters and Material Engineers: EQUIST2000, the Database of Standard Steels*, Proc. 4th Inter. Conf. Quenching and Control of Distortion, pp.193-200, 2003

[3] N. Chen and D. Zhu, *Intelligent Materials Processing by Hyperspace Data Mining*, Engineering Applications of Artificial Intelligence, Vol.13, pp.527-532, 2000