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COMPUTER ASSISTED SYNTHESIS OF HEAT TREATMENT TECHNOLOGY FOR HIGH SPEED STEELS

Summary The paper presents the technological database system aimed at the heat treatment technology development and cutting tools design with particular emphasis laid on the concept of the database design. Several aspects of the data base concept are presented beginning with the initial relation scheme of the attributes constituting the high speed steel definition data. General considerations of the ways in which the system may be used are discussed. One exemplary form of the system output is enclosed.

1.Introduction

The significant variety of the high speed steels makes the problem of their proper usage very important. The scope of their makes is widening as new markets open and the links among manufacturers get closer making proper choice even more difficult. To this end we have decided to develop a system to assist the synthesis of proper technology of high speed steels [1]. The first step to reach the final solution was development of a database system which would gather all significant data about the high speed steels themselves as well as about the machined materials. Next important decisions had to be made in respect to the user interface and the form and volume of the information supplied on request [2].

The system in question should offer assistance for numerous classes of users to name only a few:

- manufacturing engineers - designing new technological processes,
- tool designers - employing new materials, choosing the most adequate one from the variety offered,
- science workers and students - studying the general properties of numerous kinds of steels, etc.

Every one from the above classes of users has its own unique needs in respect to the query method to be implemented in the system. The basic decision was made to develop the system using the relational database model being the one most widespread on the market and offering many off-the-shelf software tools to start with.

2. The model of the database system

The database in question has had to be a flexible one - that means that it should be able to maintain not only the high speed steels' data, it should be also possible to store the machined materials' data in it. More - its scheme should be general enough to deal with other alloys as well. This design principle has lead us to division of the database system to two subsystems:

- root one - able to maintain information about any type of alloys,
- dedicated one - designed specially for the high speed steels.

Many dedicated subsystems may be created and implemented along with the root system, this paper covers only the high speed steels subsystem. The basic relation scheme describing any high speed steel has been defined as follows:

HSS (SYMBOL,NOTES,STANDARD,(STANDARD_SYMBOL,TITLE,VALID_SINCE,COUNTRY(NAME,CURRENCY,EXCHANGE_RATE)),STEEL_TYPE(TYPE_SYMBOL,STEEL_GROUP(GROUP_SYMBOL)),CHEMICAL_COMPOSITION(COMPONENT(CHEMICAL_SYMBOL,COMPONENT_NAME),LOWER_LIMIT_OF_MASS_CONC,UPPER_LIMIT_OF_MASS_CONC)...),APPLICATION(TYPE_SYMBOL,LOAD, TOOL(NAME,TECHNOLOGY)...),MANUFACTURER(NAME,COUNTRY,ADDRESS,PRICE),PROPERTIES(HRC,RG,K,ANNEALING_TEMPERATURE(LOWER_LIMIT,UPPER_LIMIT),HEATING_SPEED,NO_OF_HEATING_STEPS,AUSTENITIZING_TEMPERATURE,AUSTENITIZING_TEMPERATURE_TOLERANCE, AUSTENITIZING_ TIME (TOOL,CRITICAL_DIMENSION),COOLING_SPEED, TEMPERING_TEMPERATURE (LOWER_LIMIT, UPPER_LIMIT),TEMPERING_TIME, NO_OF_CYCLES_OF_TEMPERING,... etc)

The above form had to be transformed to the 1NF first and then decomposed to the Boyce-Codd and 3NF forms [3,4]. To do this we had to take into consideration many functional dependencies like for instance

SYMBOL -> NOTES
SYMBOL -> STANDARD_SYMBOL
SYMBOL -> TYPE_SYMBOL -> GROUP_SYMBOL

After all the necessary transformations we have created the relations shown in fig. 1 + 3.

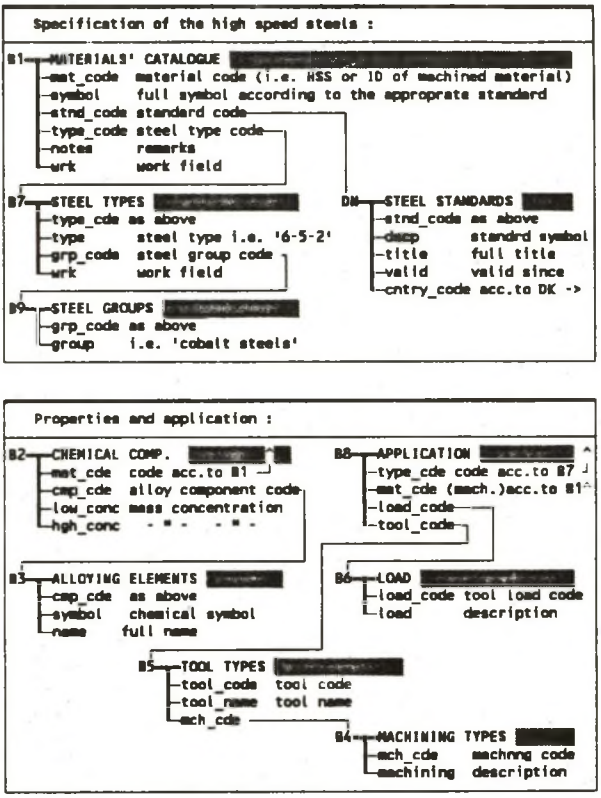

Fig 1 Some database structures defining the specification of the high speed steels

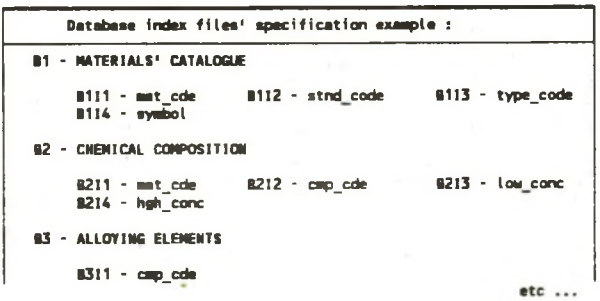

Fig 2 Data base index files' example

```
D1.DBF  - 1 High Speed Steels

mat_cde     - material code according to B1
HRC_1       - HRC hardness change :          range    0 - 300 °C
HRC_2       - HRC hardness change :          range  200 - 500 °C
HRC_3       - HRC hardness change :          range  400 - 700 °C

RG_1        -  as above for Rg                       0 - 300 °C
RG_2        -  as above for Rg                     200 - 500 °C
RG_3        -  as above for Rg                     400 - 700 °C

K_1         -  as above for K                        0 - 300 °C
K_2         -  as above for K                      200 - 500 °C
K_3         -  as above for K                      400 - 700 °C

W_Z_D       - lower limit of soft annealing temperature      °C
W_Z_G       - upper limit of soft annealing temperatur       °C
W_Z_SZ_CH   - cooling speed of softening                   °C/h
W_Z_T_CH    - lower limit of the cooling temperature         °C
                                                        etc ...
```

Fig 3 Excerpt from the high speed steels' properties database

3. Forms and sources of data

All data to be stored in the database is gathered from the standards, manufacturers' data and partially from our own research work. This is inevitable where the available data is inconsistent or incomplete. We have to maintain the properties' data as functions of tempering temperature - not only as fixed values. To this end we have approximated the characteristic curves with several formas of functions to mention only some of them - fig.4. Our staff has to fill in the forms similar to the one shown in fig.5. This method simplifies data input and minimizes the number of errors. Special validation procedures are employed to ensure data integrity and make easier the task of verification of data being stored in the database.

1. $f(x) = A \cdot x^7 + B \cdot x^6 + C \cdot x^5 + D \cdot x^4 + E \cdot x^3 + F \cdot x^2 + G \cdot x + H$
2. $f(x) = A \cdot (B \cdot x^2 + C \cdot x + D) \frac{E}{F} + G$
3. $f(x) = A \cdot (B \cdot x + C)^{\frac{D}{E}} + F$
4. $f(x) = (\frac{A}{B} + C) \cdot (D \cdot x^3 + E \cdot x^2 + F \cdot x + G) + H$

Fig 4 Some functions utilized to approximate the steel properties values

All constants - in this case A through F - are the field type variables with values stored for every temperature range of particular property for all steels. The function forms themselves are kept in a separate database being identified and retrieved using their unique key function codes. An example of an evaluation of a property function value is shown in fig 5 - this example is implemented in Clipper 5.0. We have exploited

```
RECORD 3, FIELD FN, CS0  -> "A*(B*X+C)^(D/E)+F"

code block definition :  -> cb := { |x| &fn }
function value :         ->  y  = EVAL(cb,x)
```

Fig 5 Example of the evaluation of the code 3 (fig.4) function for a given x value

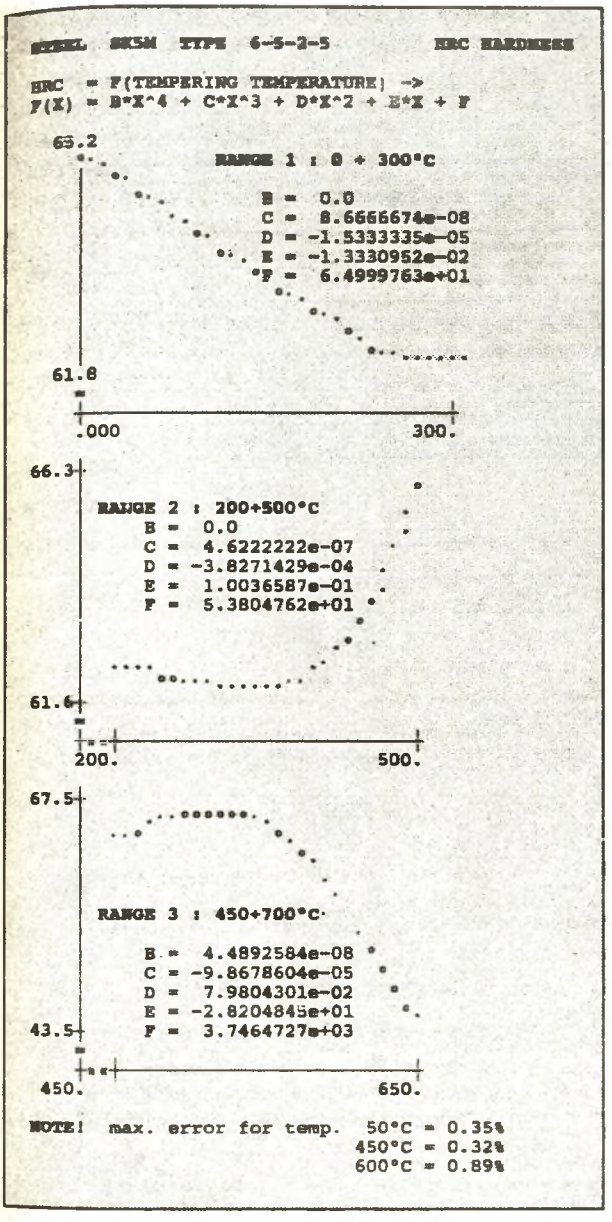

Fig 6 Approximation of the HRC hardness as a function of the tempering temperature

a new Code Block feature of this version. Code blocks are compiled at compile-time along with the rest of the program so they are more efficient than macros which are compiled at run-time. An approximation data with exemplary HRC hardness data is shown in fig 6. Collection of numerical data like this is a very time consuming task being carried on now for all available HSS data. This task is being done using Borland Eureka™ but a shift to Jandel Scientific Table Curve™ is planned due to its significantly greater versatility especially for the approximation tasks within the numerical data management option.

4. System output

One of the aims to be achieved by implementing the system was to enable a user to obtain useful information about the chemical composition and for instance applicability of any high speed steel which data is stored in the database. Exemplary system output is shown in table 1. This information can be viewed on screen - scrolled up and down, and upon request the system may produce it as a listing on a printer or dump it to an ASCII text file that can be easily imported to most word processors.

Table 1 Exemplary system output - requested application sheet for a steel

SK5M acc. to PN-86/H-85022 (Poland)
cobalt steel, type 6-5-2-5

mass conc. %	C	Si	Mn	Cr	W	Mo	V	Co	-	-
	0.88+ 0.96	maks. 0.50	maks. 0.40	3.80+ 4.80	6.00+ 6.70	4.20+ 5.20	1.70+ 2.10	4.50+ 5.50	- -	- -

MACHINING

tools for gears' machining	load			
machined material	high	medium	low	undefined
nonferrous metals				
steel				
cast steel				
cast iron				

milling cutter	load			
machined material	high	medium	low	undefined
nonferrous metals				
steel				
cast steel				
cast iron				

screw - tap	load			
machined material	high	medium	low	undefined
nonferrous metals				
steel				
cast steel				
cast iron				

threading die	load			
machined material	high	medium	low	undefined
nonferrous metals				
steel				
cast steel				
cast iron				

form tool	load			
machined material	high	medium	low	undefined
plastic				
cast iron				

parting-off tool	load			
machined material	high	medium	low	undefined
plastic				
cast iron				

twist drill	load			
machined material	high	medium	low	undefined
nonferrous metals				
steel				
cast steel				
cast iron				

etc...

System may present in similar form informations about:
- HSS standards from the whole world,
- steels appropriate for a given tool,
- actual steel prices,
- list steel manufacturers,
- list steels of similar chemical composition and/or properties,
- HSS properties including heat treatment technology.

5.Conclusions

Actually the system is being under development as new data is constantly added and new output forms are being designed and implemented. Next step is planned in which graphic capabilities will be included. Future plans include utilisation of this database in an expert system. This task would need enriching present data with a knowledge base within a proper shell. This paper documents the present state of the system development.

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KOMPUTERUNTERSTüTZTE WAHL DER TECHNOLOGIE DER WÄRME-BEHANDLUNG VON SCHNELLARBEITSSTAHL (SCHNELLSCHNITTSTAHL)

Zusammenfassung

In der Arbeit werden die technologischen Datenbasen, die die Technologiebearbeitung der Wärmebehandlung sowie die Gestaltung von Werkzeugen unterstützen, dargestellt. Ferner sind die Probleme der entsprechenden Struktur von Basen sowie auch die Bildung von Datenbasen diskutiert. Es wurden die Hinweise für die Benutzung des Systems angegeben. Im folgenden wird auch ein Beispiel von Druckausgabe dargestellt.

KOMPUTEROWO WSPOMAGANY DOBÓR TECHNOLOGII OBRÓBKI CIEPLNEJ DLA STALI SZYBKOTNĄCYCH

Streszczenie

Referat przedstawia bazy danych technologicznych ukierunkowane na wspomaganie opracowywania technologii obróbki cieplnej i konstruowania narzędzi, przy czym szczególny

nacisk położono na zagadnienie właściwej struktury baz. Przedstawiono kilka problemów budowy baz danych poczynając od pierwotnego schematu relacji atrybutów stanowiących dane opisujące stale szybkotnące. Podano ogólne uwagi o sposobach korzystania z systemu. Zamieszczono przykładowy wydruk informacji z systemu.

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