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A database management system for selection of steel

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ABSTRACT

Selection of an ideal material for a given application will be a relatively simple matter, if perfect or near perfect materials are available. Such a material will have high strength, high toughness, good ductility and good fabricability. These properties would not necessarily be compatible in an existing material. Compromises and trade-offs among various properties become inevitable. On the other hand, infinite number of possible materials in various forms and its usage are so intertwined in all industries that a person can have no real comprehension of the characteristics of all the materials. A computer assistance either in the form of a software or a database is therefore unavoidable. A database is developed to assist in the selection of steels for scientific and engineering applications. A program is written in Foxpro to identify the ideal steel based on its tensile strength, elongation, toughness and hardness. The program can select the suitable steels and can generate the forging temperature, heat treatment procedure, etc. The input data are obtained from various handbooks and textbooks. A Pentium-586 with FOXPRO is used to build the prototype database management system in DOS environment. Human interface with the system is enhanced by the user-friendly menus. The database can be made compatible easily to a wide variety of micro, mini and mainframe computers.

INTRODUCTION

All engineers are involved with materials on daily basis. Knowledge of materials in much needed in design and construction of components. At some stage in the process of converting a design idea into a hardware, decision must be taken on the choice of material and the

manufacturing route. The decision on material should be done as quickly as possible because most of the time material decides the manufacturing route. In the selection of a suitable materials to satisfy a particular design and product development, it is necessary to look at many aspects to ensure that components or assembly can be manufactured with the resources available, that the completed product will function satisfactorily throughout its design life and that all this can be achieved at an acceptable cost [1]. Steel is one of the best material for design and development, obviously because of its low cost, easy availability, wide range of mechanical properties attainable, and high modules of elasticity. The range of mechanical properties attainable in steel is truly remarkable: as-rolled, annealed or heat treated steel plate is manufactured in yield strength levels varying form 25,000 psi to 80,000 psi, and at low cost. C-Mn-B steel is being used in dynamically loaded fasteners at a minimum yield strength of 200,000 psi. This wide variation in engineering characteristics of the steel has major significance for designers to follow [2]. Since steel is available in several grade with wide variation in the properties, selection of steel for a given application would be rather difficult without computer assistance. Computer not only speeds up the selection process but also helps a person with insufficient knowledge about the characteristics of steel.

Data needed for selecting a steel are collected from the various hand books [3,4,5]. These data are stored permanently in a computer as a data base. The software that allows one or many person to use and/ or modify this data is called as data base management system. FOXPRO in DOS environment is made use of to develop this data base management system. A major role of the data base management system is to allow the user to deal with the data in abstract terms, rather than use the computers to merely store the data. In this sense, the data base management system acts as an interpreter for a high level programming language, ideally allowing the user to specify what must be done, with little or no attention on the user's part, to the detailed algorithms or data representation used by the system[6].

MODELLING ENTITIES

An entity is a thing that exists and is distinguishable[7]. For example a colour entity contains the elements red, yellow, green and blue. In this data base management system, a material entity (based on American Iron and Steel Institute), a property entity, and a composition en-

tity are created with several elements as shown from the Table 1.

Table 1: Entities created in the data base management system developed

Material	Properties Entities	Compostion Entities
1006	Tensile strength	Percentage Carbon
1008	Yield strength	Percentage Manganese
1020	Elongation	Percentage Sulphur
1040	Reduction in area	Percentage Phosphorus
1060	Hardness	Combined
	Impact	
	Combined	

MODELLING RELATIONS

The entities in the model must be related with the database created. There is an association between materials and their properties; so, there is relation between the material entity, property entity and composition entity with the data base.

Four types of association exists between the entities : 1. ***One-to-one*** 2. ***One-to-many*** 3. ***Many-to-many*** and 4. ***Many-to-one***. The association between the entities and the database is determined by selecting the elements from composition entity or property entity or material entity to select suitable steel from the database. For example if 1006 is selected from the materials entity, the corresponding composition, properties and the other details are shown in the screen as entered in the database. This type of relation is known as One-to-one type of relation. An example for one-to-one type relation is shown in the Table 4(a) and 4(b). The material entity will not show any other relation except one-to-one type with the database.

One-to-one type of relation will not exist if a single element from property entity is selected, because steels are not classified based on their properties. Since the steels show wide variation in the properties, a few grades of steel can qualify if selection criteria is based on one element of the property entity. For example if tensile strength is selected

Table 2(a) : Input entry form

Select the required steel : 1006

***Tabel 2(b)** : Selected steel for input data given in Table 2(a)*

DESIGNATION CODE

AISI No. : 1006 ASTM No. : 0000 SAE No.: 1006 DIN No.:___

STEEL COMPOSITION (%)

%C	Min. 0.00	Max. 0.08	%Si	Min. 0.00	Max. 0.00
%Mn	Min. 0.25	Max. 0.40	%Ni	Min. 0.00	Max. 0.00
%P	Min. 0.00	Max. 0.04	%Cr	Min. 0.00	Max. 0.00
%S	Min. 0.00	Max. 0.00	%Mo	Min. 0.00	Max. 0.00

TREATMENT TEMPERATURE (F)

Annealing	950-1200	Normalizing	1650-1750
Quenching	1650-1700	Forging	0.0

CRITICAL POINTS (F)

Ac1	1350	Ar1	1255
Ac3	1605	Ar3	1570

MECHANICAL PROPERTIES

Tensile Strength	(M psi)	→	Min. :	58.00	Max :	58.00
Yield Stength	(M Psi)	→	Min. :	0.00	Max :	0.00
Elongation (2 in.)	(%)	→	Min. :	30.00	Max :	30.00
Yield Point	(M Psi)	→	Min. :	45.00	Max :	45.00
Redn. in area	(%)	→	Min. :	66.00	Max :	60.00
Hardness :	Brinlel	→	Min. :	121	Max :	121
	Rockwell	→	Min. :	0	Max :	0
	Vickers	→	Min. :	0	Max :	0
Izod	(Ft. Lbs.)	→	Min. :	0	Max :	0

Comment : Aver. prop. in. rd. bars; annealed and cold drawn.

as the selection criteria from the property entity, the corresponding steel, whose tensile strength are matching with input data, from the database are selected. This type of relation between entities is called as one-to-many type of relation. An example to one-to-many relation is shown in Table 5(a) and 5(b).

On the other hand, if combination of more than one element is selected as a selection criteria from the property entity, the corresponding material or materials from database is selected. If one steel is selected from the databse, the type of relation is known as ***many-to-one*** type, otherwise, if more than one steel is selected, the relation is called as ***many-to-many*** type of relation. Table 6 and Table 7(a) - 7(d) show many-to-one and many-to-many relation between the entities and the database.

The selected steel from the property entity or composition entity displays the heat treatment temperature ranges, critical points, forging temperature in addition to the properties listed in the property entity.

Tabel 3(a) : Input data entry form

Query on Mechanical Properties
Tensile Strength (M psi) : 64.00

***Tabel 3(b)** : Selected Steel for Input data given in Table 3(a)*

DESIGNATION CODE			
AISI No. : 1008	ASTM No. : 0000	SAE No.: 1008	DIN No.___

STEEL COMPOSITION (%)					
%C	Min. 0.00	Max. 0.10	%Si	Min. 0.00	Max. 0.00
%MN	Min. 0.25	Max. 0.50	%Ni	Min. 0.00	Max. 0.00
%P	Min. 0.00	Max. 0.04	%Cr	Min. 0.00	Max. 0.00
%S	Min. 0.00	Max. 0.00	%Mo	Min. 0.00	Max. 0.00

TREATMENT TEMPERATURE (F)			
MAnnealing:	1000-1350	Normalizing :	1650-1750
Quenching :	1650-1700	Forging :	0-0

CRITICAL POINTS (F)

Acl	: 1350	Arl	: 1255
Ac3	: 1605	Ar3	: 1570

MECHANICAL PROPERTIES

Tensile Strength	(M psi)	→	Min. : 50.00	Max. : 65.00
Yield Stength	(M Psi)	→	Min. : 40.00	Max. : 55.00
Elongation (2 in.)	(%)	→	Min. : 20.00	Max. : 30.00
Yield Point	(M Psi)	→	Min. : 0.00	Max. : 0.00
Redn. in area	(%)	→	Min. : 50.00	Max. : 60.00
Hardness :	Brinlel	→	Min. : 95	Max : 121
	Rockwell	→	Min. : 0	Max : 0
	Vickers	→	Min. : 0	Max. : 0
Izod	(Ft. Lbs.)	→	Min. : 0	Max. : 0

Comment : Cold rolled bar 1/4 - 3 in diameter

***Tabel 3(c)** : Selected Steel for Input data given in Table 3(a)*

DESIGNATION CODE

AISI No. : 1010	ASTM No. : 0000	SAE No.: 1010	DIN No.

STEEL COMPOSITION (%)

%C	: Min. 0.08	Max: 0.13	%Si : Min. 0.00	Max. 0.00
%MN	: Min. 0.30	Max. 0.60	%Ni : Min. 0.00	Max. 0.00
%P	: Min. 0.00	Max. 0.04	%Cr : Min. 0.00	Max. 0.00
%S	: Min. 0.00	Max. 0.00	%Mo : Min. 0.00	Max. 0.00

TREATMENT TEMPERATURE (F)

Annealing	: 1000-1350	Normalizing	: 1650-1750
Quenching	: 1650-1700	Forging	: 0-0

CRITICAL POINTS (F)

Acl	: 1350	Arl	: 1255
Ac3	: 1605	Ar3	: 1570

MECHANICAL PROPERTIES

Tensile Strength	(M psi)	→ Min. : 64.00	Max. : 64.00
Yield Stength	(M Psi)	→ Min. : 0.00	Max. : 0.00
Elongation (2 in.)	(%)	→ Min. : 28.00	Max. : 28.00
Yield Point	(M Psi)	→ Min. : 48.00	Max. : 48.00
Redn. in area	(%)	→ Min. : 65.00	Max. : 65.00
Hardness :	Brinel	→ Min. : 131	Max. : 131
	Rockwell	→ Min. : 0	Max. : 0
	Vickers	→ Min. : 0	Max. : 0
Izod	(Ft. Lbs.)	→ Min. : 0	Max. : 0

Comment : Aver. prop. in. rd. bars; cold drawn 1/16 in draft : Annealed cold drawn.

Table 3(d) *Selected Steel for Input data given in Table 3(a)*

DESIGNATION CODE

AISI No. : 1012 ASTM No. : 0000 SAE No.: 1012 DIN No.___

STEEL COMPOSITION (%)

%C	: Min. 0.10	Max. 0.15	%Si	: Min. 0.00	Max. 0.00
%MN	: Min. 0.10	Max. 0.60	%Ni	: Min. 0.00	Max. 0.00
%P	: Min. 0.00	Max. 0.04	%Cr	: Min. 0.00	Max. 0.00
%S	: Min. 0.00	Max. 0.00	%Mo	: Min. 0.00	Max. 0.00

TREATMENT TEMPERATURE (F)

Annealing	: 1000-1350	Normalizing	: 1650-1750
Quenching	: 1650-1700	Forging	: 0-0

CRITICAL POINTS (F)

Acl	: 1350	Arl	: 1255
Ac3	: 1605	Ar3	: 1570

MECHANICAL PROPERTIES

Tensile Strength	(M psi)	→	Min.	:	64.00	Max.	: 64.00
Yield Stength	(M Psi)	→	Min.	:	0.00	Max.	: 0.00
Elongation (2 in.)	(%)	→	Min.	:	28.00	Max.	: 28.00
Yield Point	(M Psi)	→	Min.	:	48.00	Max.	: 48.00
Redn. in area	(%)	→	Min.	:	65.00	Max.	: 65.00
Hardness :	Brinlel	→	Min.	:	131	Max.	: 131
	Rockwell	→	Min.	:	0	Max.	: 0
	Vickers	→	Min.	:	0	Max.	: 0
Izod	(Ft. Lbs.)	→	Min.	:	0	Max.	: 0

Comment : Aver. prop.. 1. in. rd. bars; cold drawn 1/16 in draft : Annealed cold drawn.

Table 4(a) : Input data entry form

Query on Mechanical Properties

Tensile Strength (M psi)	: 72.00	Reduction in Area (%)	: 62.00
Yield strength (M psi)	: 0.00	Hardness (BHN)	: 146
Elongation (2 in.)(%)	: 22.00	Izod Impact (Ft. Lbs.)	: 0.00
Yield Point (M psi)	: 60.00		

***Table 4(b)** :Selected steel for input data given in Table 4(a)*

DESIGNATION CODE

AISI No. : 1016 ASTM No. : 0000 SAE No.: 1016 DIN No.___

STEEL COMPOSITION (%)

%C	: Min. 0.13	Max. 0:18	%Si	: Min. 0.00	Max. 0.00
%MN	: Min. 0.60	Max. 0.90	%Ni	: Min. 0.00	Max. 0.00
%P	: Min. 0.00	Max. 0.04	%Cr	: Min. 0.00	Max. 0.00
%S	:. Min. 0.00	Max. 0.00	%Mo	: Min. 0.00	Max. 0.00

TREATMENT TEMPERATURE (F)

Annealing	: 1575-1650	Normalizing	: 1650-1750
Quenching	: 1600-1650	Forging	: 2050-2350

CRITICAL POINTS (F)

Acl	: 1350	Arl	: 1260
Ac3	: 1560	Ar3	: 1520

MECHANICAL PROPERTIES

Tensile Strength	(M psi)	→	Min. : 72.00	Max	:	72.00
Yield Stength	(M Psi)	→	Min. : 0.00	Max	:	0.00
Elongation (2 in.)	(%)	→	Min. : 22.00	Max	:	22.00
Yield Point	(M Psi)	→	Min. : 60.00	Max	:	60.00
Redn. in area	(%)	→	Min. : 62.00	Max	:	62.00
Hardness :	Brinel	→	Min. : 146	Max.	:	146
	Rockwell	→	Min. : 0	Max.	:	0
	Vickers	→	Min. : 0	Max	:	0
Izod	(Ft. Lbs.)	→	Min. : 0	Max.	:	0

Comment : Aver. prop. in. bars cold drawn 1/16 in draft : annealed cold drawn.

Table 5(a) : Input data entry form
Query on Mechanical Properties

Tensile strength (M psi)	: 100.00	Reduction in area (%)	: 0.00
Yield strength (M psi)	: 0.00	Hardness (BHN)	: 200
Elongation (2 in.)(%)	: 18.00	Izod Impact (Ft.Lbs.)	: 0.00
Yield point (M psi)	: 0.00		

***Table 5(b)** : Selected Steel for Input data given in Table 5(a)*

DESIGNATION CODE

AISI No. : B1111 ASTM No. : 0000 SAE No.: 1111 DIN No.__

STEEL COMPOSITION (%)

%C	: Min. 0.00	Max. 0.13	%Si	: Min. 0.00	Max	0.00
%MN	: Min. 0.60	Max. 0.90	%Ni	: Min. 0.00	Max	0.00
%P	: Min. 0.07	Max. 0.12	%Cr	: Min. 0.00	Max	0.00
%S	: Min. 0.08	Max. 0.00	%Mo	: Min. 0.00	Max	0.00

TREATMENT TEMPERATURE (F)

Annealing	: 0-0	Normalizing	: 0-0
Quenching	: 0-0	Forging	: 0-0

CRITICAL POINTS (F)

Acl	: 0	Arl	: 0
Ac3	: 0	Ar3	: 0

MECHANICAL PROPERTIES

TensilE Strength	(M psi)	→	Min.	:	75.00	Max	: 100.00
Yield Stength	(M Psi)	→	Min.	:	0.00	Max	: 0.00
Elongation (2 in.)	(%)	→	Min.	:	10.00	Max	: 20.00
Yield Point	(M Psi)	→	Min.	:	70.00	Max	: 95.00
Redn. in area	(%)	→	Min.	:	35.00	Max	: 50.00
Hardness :	Brinnel	→	Min.	:	179	Max	: 229
	Rockwell	→	Min.	:	0	Max	: 0
	Vickers	→	Min.	:	0	Max	: 0
Izod	(Ft. Lbs.)	→	Min.	:	0	Max	: 0

Comment : Bar 1 in. section; As drawn

***Table 5(c)** : Selected Steel for Input data given in Table 5(a)*

DESIGNATION CODE

AISI No. : B1112	ASTM No. : 0000	SAE No.: 1112	DIN No.

STEEL COMPOSITION (%)

%C	: Min. 0.00	Max. 0.13	%Si	: Min. 0.00	Max. 0.00
%MN	: Min. 0.70	Max. 0.90	%Ni	: Min. 0.00	Max. 0.00
%P	: Min. 0.07	Max. 0.12	%Cr	: Min. 0.00	Max. 0.00
%S	: Min. 0.16	Max. 0.00	%Mo	: Min. 0.00	Max. 0.00

TREATMENT TEMPERATURE (F)

Annealing	: 0-0	Normalizing	: 0-0
Quenching	: 0-0	Forging	: 0-0

CRITICAL POINTS (F)

Acl	: 0	Arl	: 0
Ac3	: 0	Ar3	: 0

MECHANICAL PROPERTIES

Tensile Strength	(M psi)	→	Min. : 75.00	Max :100.00
Yield Stength	(M Psi)	→	Min. : 0.00	Max. : 0.00
Elongation (2 in.)	(%)	→	Min. : 10.00	Max. : 20.00
Yield Point	(M Psi)	→	Min. : 70.00	Max. : 95.00
Redn. in area	(%)	→	Min. : 35.00	Max. : 50.00
Hardness :	Brinnel	→	Min. : 179	Max. : 229
	Rockwell	→	Min. : 0	Max. : 0
	Vickers	→	Min. : 0	Max : 0
Izod	(Ft. Lbs.)	→	Min. : 0	Max. : 0

Comment : Bar; As drawn

***Table 5(d)** : Selected Steel for Input data given in Table 5(a)*

DESIGNATION CODE

AISI No. : C1151 ASTM No. : 0000 SAE No.: 1151 DIN No.___

STEEL COMPOSITION (%)

%C	: Min. 0.48	Max. 0.55	%Si	: Min. 0.00	Max. 0.00
%MN	: Min. 0.70	Max. 1.00	%Ni	: Min. 0.00	Max. 0.00
%P	: Min. 0.00	Max. 0.04	%Cr	: Min. 0.00	Max. 0.00
%S	: Min. 0.08	Max. 0.00	%Mo	: Min. 0.00	Max. 0.00

TREATMENT TEMPERATURE (F)

Annealing	: 0-0	Normalizing	: 0-0
Quenching	: 0-0	Forging	: 0-0

CRITICAL POINTS (F)

Acl	: 0	Arl	: 0
Ac3	: 0	Ar3	: 0

MECHANICAL PROPERTIES

Tensile Strength	(M psi)	→	Min. :	90.00	Max :	110.00
Yield Stength	(M Psi)	→	Min. :	75.00	Max. :	95.00
Elongation (2 in.)	(%)	→	Min. :	12.00	Max :	22.00
Yield Point	(M Psi)	→	Min. :	0.00	Max. :	0.00
Redn. in area	(%)	→	Min. :	38.00	Max. :	58.00
Hardness :	Brinnel	→	Min. :	183	Max. :	183
	Rockwell	→	Min. :	0	Max. :	0
	Vickers	→	Min. :	0	Max :	0
Izod	(Ft. Lbs.)	→	Min. :	0	Max. :	0

Comment : Annealed - cold drawn > 9/16 in. - 1.5 in. incl.

CONCLUSION

Information provided by the steel database is essential for engineering applications ranging from product design, manufacturing engineering and for computer simulation of manufacturing process. Moreover, this database facilitates the modification or addition of data. However, the material entity ends not only with steels but can include nonferrous alloys. Also the selection criteria may include many other properties besides the properties listed in the property entity. The database can be updated and modified by increasing the elements in both material and property entities.

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REFERENCE

[1] V.B. John., "Introduction to Engineering materials", *ELBS,* 1992, pp492-493.
[2] Roy, F. Kern, "Steel Selection", *Wiley Inter Science,* 1985, pp1-2.
[3] Taylor Lymar, *"ASM Metals Handbook",* 8th Edition, Vol. 1, 1973.
[4] Taylor Lymar, *"ASM Metals Handbook",* 8th Edition, Vol. 2, 1973.
[5] Samuel L. Hoyt, *"ASME Metals Properties",* McGraw Hill, 1954.
[6] Jeffrey D. Ullman, "Principles of database system", Galgotia, 1990, pp1-12.
[7] Mahmoud Y. Demeri, "A relational database management system for engineering materials", *Proc. of Intl. symp. "on Materials Processing in the Computer Age",* Louisiana, USA, Feb. 17-21, 1991, Ed. by V.R. Voller *et.al.,* 1991, p.61-75.