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Web Based Decision System For Metal Selection

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Abstract

Material selection is one of the major points that should be taken into account seriously in the engineering design stage. Each material has various properties such as mechanical, thermal, electrical, physical, environmental, optical and biological properties. It is expected that an information source such as the proposed database will provide all the necessary facts and figures to aid both designers and manufacturing engineers. In the scope of this Paper, the aim was to develop a database and a software package for material selection to help the design engineer in his decision making process. The database developed by using Microsoft Visual Studio and also contains different materials standards and can be updated if the user wants. Done the analysis for different components and results should be storage in Database by using visual studio. All features can be used as part of a sequential screening process, guiding the user to an eventual metal shortlist or selection.

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1. Introduction

Selection of a suitable material [1] is paramount in the success of a particular product. If an inappropriate material is manufactured then the result of the product is quite likely to be a failure and, in the most extreme situation, lethal. Even so, there are different levels of significance, for instance the choice of metal for an aeroplane wing far outweighs the importance of selection of a plastic for a pencil case.Deciding upon a material is one of the key selections of an engineering 'entity'. Other entities include manufacturing processes, components and assembled products but all have a large part to play in shaping the options for each other. These are all factors that any manufacturer or designer must take into account and no judgment should be made without reference to all.In the past twenty years, the process of material selection [2] has been developed and has evolved in both access to property data and application techniques. There are currently numerous material and metal databases in existence, ranging from the most basic to the extremely advanced represented in an assortment of media.

The scope of this paper concerns several objectives in addition to the aforementioned creation of an easy-to-use software system. It is important to ascertain the magnitude and aptness of information required by manufacturing industries for the process of selection. In relation to the comprehensiveness of data, the context in which such a database is to be implemented will be clearly defined throughout the paper, and the paper also discusses the intended purpose of the database and the benefits it holds in conjunction with industry.

2. THE ART OF SELECTION

The importance of selecting an appropriate material for a specific purpose is highlighted in the success of the finished product. Different degrees of satisfaction can be achieved depending upon the effort and extent of material research undertaken. The fundamental concept behind a selection of any entity is the prior knowledge of what is actually desired. Obviously, this relates to the schematic of the product [3] as a whole and also deals with more specific requirements.

3. INTERACTION WITH THE DESIGN PROCESS

3.1 Descriptive models

There is no specific step-by-step guide or map of the design process, during the early stages of design, the generation of a solution is formed in order to enable a 'solution-focused' way of thinking. The process can be split into four essential activities to be performed by the designated designer, as described in Fig. 1.If during the evaluation, a fundamental flaw has developed or is discovered then it is common practice to begin the whole cycle again. At the fourth stage, communication with manufacturing begins.

Usually, the four main activities are represented by:

1. Analysis of problem
2. Conceptual design
3. Embodiment of schemes

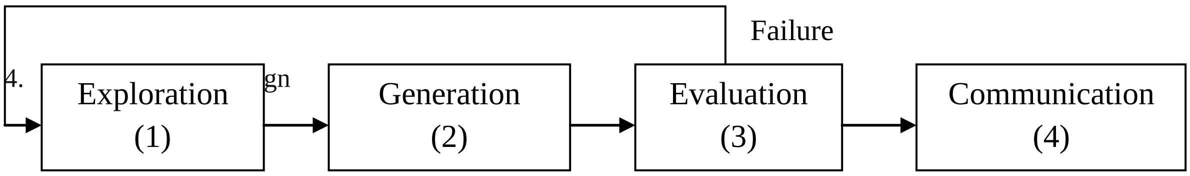

Fig 1: Top-level model of the descriptive design process

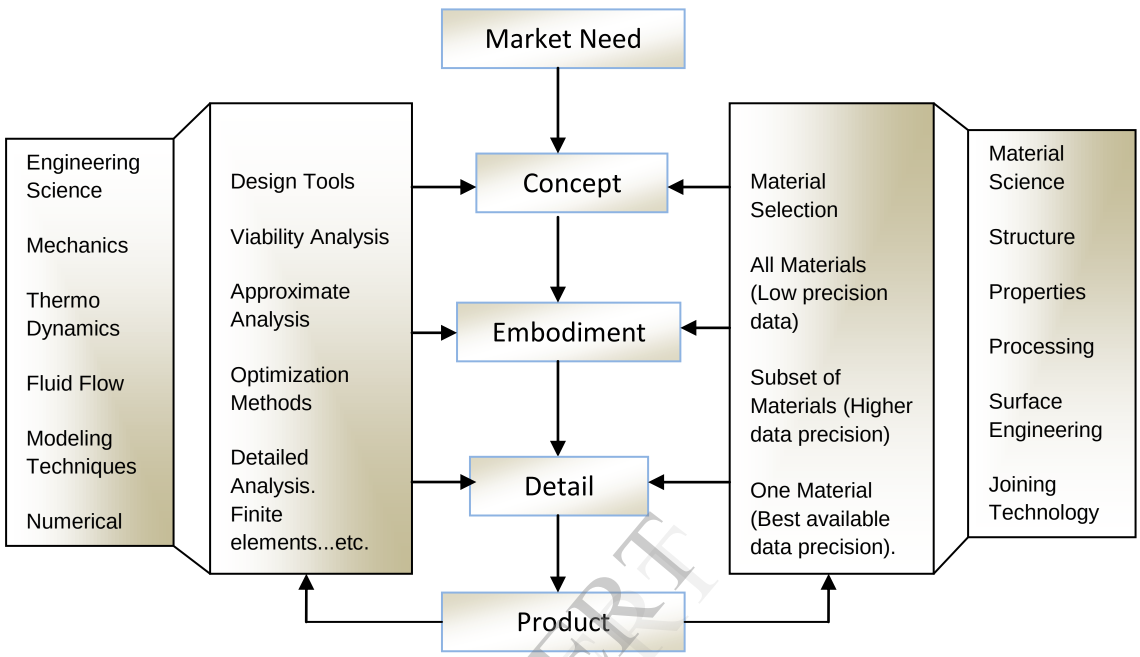

Fig. 2 Material and experimental involvement in the design process (Ashby, M. F. 1992)

3.2 Breadth versus precision

In the current climate where a board variety of materials exist, concept generation can and does dare to reach the extremes. Unfortunately, in some cases, the relevant information on newly developed materials may be difficult to find, poorly published, or not even exist.What is similar to all forms of decision-making is arriving at a compromise: ‘Data breadth versus data precision’ [2]. Designers and manufacturers strive not to over design a product because this has a habit of leading to failure or added complications. Keeping the specification in a purer form is beneficial to both saving time and avoiding unnecessary problems. The conclusion drawn is that in all design or manufacturing situations, this balance needs to be applied sensibly so that the entire criteria are met and there is no compensation made in other areas.

3.3 Areas of computer involvement

There are a large number of databases and metal selecting software currently available on the market and on the internet. The detail and comprehensiveness of each varies considerably, from the basic provision of facts and figures to the intelligent calculations and judgements of an expert system. Each differs depending upon the extent of data needed and guidance involved. Choice in software corresponds to what stage in the design process is being developed and the specifications of the product. Table 1 outlines the level of data actually required by each stage of design and what each software system must entail.

3.4 Database software in current use

Unsurprisingly, a multitude of material selecting software systems exist supplementing commercial, educational and even domestic markets. Evidently, the most advanced are those which are used in industry. These incorporate a number of tools to assist the designer in making a decision, such as filters, plotting selection charts and performing calculations.
The Cambridge Metal/Engineering Selector (CMS), Mat.Db, PERITUS, and CAMPUS are a few selected examples. The packages mainly focus on selection of a material and storage of their properties whereas other databases are more specialised.

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Table1:Material selection involved in the design process outlining breadth and precision of data

	Exploration of market need	Concept	Embodiment	Detail	Final design
Data requirements	Level 1	Level 2	Level 3	Level 4	
	The fundamentals of materials — basic knowledge (i.e. What groups of materials possess hardness properties or can be machined in a certain fashion).	Information encompassing the complete kingdom of mate-rials to compliment greater innovation in ideas gener-ated. Easy access required for greater freedom in considering alternatives.	Further detail on a subset of materials providing sufficient property values and in-depth descriptions. Matching data with calculated values.	Greater detail for one or very few materials. Supplier information needed for design calculations and valid test information.	Revision of final product. Iteration of past methods.
Breadth/ precision	High/Low	High/Low	Mid/Mid	Low/High	High/ High
Information sources	General knowledge/ Common sense	Basic material database/ Handbooks	Handbooks/Expert systems/ Specific material software	Material producers data sheets	All sources

4. Development of a metal selection model

4.1 The nature of material data

When considering the classifications of material properties, it becomes apparent that there are many forms. There is numeric covering all the properties measured by numbers displayed as a single value or a range. Counter to this representation is the non-numeric form which translates as a text-based portrayal of properties.

In many situations, the more information, the better. A superior design can be the result of the designer asking more questions and gaining more knowledge. It is for this reason that an advantage to the designer is achievable with the availability of the following:

- Supplier information – FE modules
- Standards and codes (ISO 14000)
- Sector-specific approval (FDA, MilSpec)

There is also the consideration of whether the data is 'structured' or 'unstructured'. One simple version of 'structured' data can be seen on Matweb — an impressive database of materials on the internet.

4.2 Computer package appraisal

Reviewing literature on previous and current software systems, it was decided that the most effective system would be a database. The features prevalent to most database packages provide some, if not all of the functions required when making a selection. With regard to this, it was decided to use VB .net as it is a well-known application and therefore a more familiar set-up for future users and developers. Microsoft Excel XP proved not to have sufficient data-handling features, a must-have for active selection.

4.3 Identify end-user requirements

It was difficult to create a completely original solution due to the number of databases already in circulation. There-fore, the culmination of the best features within each system would offer the most superior solution. The new systems have the possibility to identify a set of the following end-user requirements:

- Store adequate resources of metal data in a convenient and available manner
- Allow smooth retrieval of desired information in table, record or report format
- Provide an interface that is user-friendly and easy to understand
- Reduce the amount of time to sift through endless data leading to a selection
- Enable filter options by mechanical and physical properties
- Browse by UNS number or usual trade name
- Print a hard copy of retrieved information as forms or reports
- Divide and display metals into subcategories
- Link common manufacturing properties with the appropriate metals

4.4 Key inputs and outputs

The variables and dynamics that contribute to database

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design [9] ensure the appropriateness of the outcome. Without suitable input, the end result may never be achieved. Figure 3 highlights the key inputs and shows how they are manipulated in order to produce the outputs.
Several key stages of system development were identified before the design commenced. These included:

- Object identification
- Choice of metals and properties
- Inclusion of manufacturing information – Validation of data
- Selecting tools – Testing

4.5 Storage and manipulation of information

A database has many methods of storing data, including tables, forms and reports. Common practice is to create base-tables called Total metal of all fundamental and useful data which can then be used to develop these forms, reports and also queries [10].

4.5.1 Entity relationships

In modern database design, much emphasis is placed upon entity-relationship models. Entities describe an

properties. Firstly, suitable 'field names', 'data types' and 'field sizes' had to be decided. Selection of an inappropriate name or type would lead to poor usability and difficulties where data manipulation is necessary. All quantity property fields must be of data type 'number' so that search operations can be performed. Table 2 displays a selection of fields and their types present in the table, Total metal. The metal selector achieved validity of data by incorporating a series of range checks in data entry. With respect to certain entity attributes, a class of metals has a unique identifying range. For example, nickel alloys have their own exclusive set of Young's Modulus values.

Errors in data are most likely to stem from incorrect or incomplete data. Range checks detect where discrepancies lie and reject invalid input. Initially, range checks were employed when separate tables were used for individual metal groups. This validated the data entry before the information was transferred to the complete table.

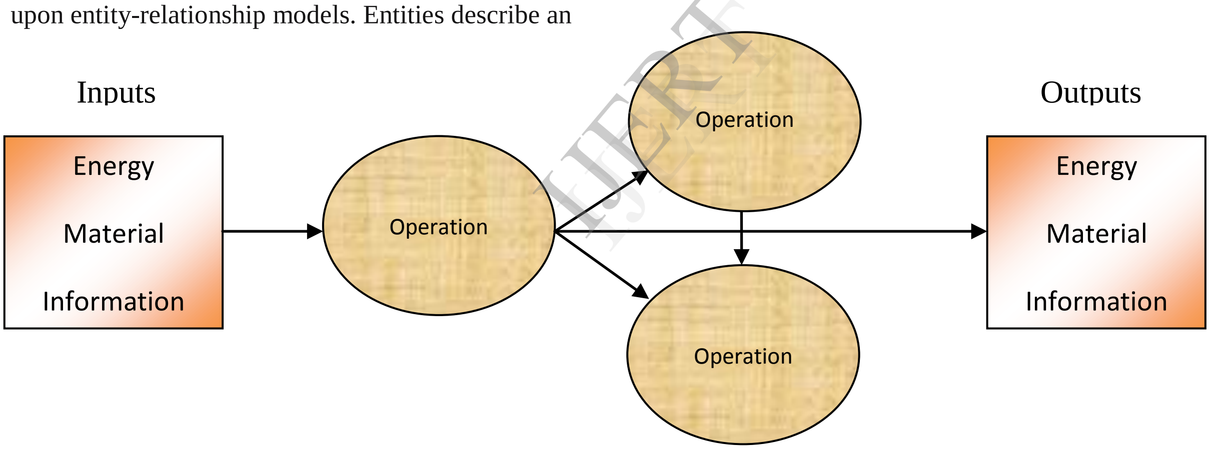

Fig.3 Overview of database development

object, for example a metal is an entity and there are often many in a database interacting mutually. Relationships can be defined as one-to-one, one-to-many and many-to-many depending on the resources shared between entities. It became apparent that for this project, entity-relationships were not wholly required as only one table of entities was to be implemented. The only relationship in existence is the one-to-many interaction in operation between the Total metal and Category tables (Fig. 4).

4.5.2 Table of metal properties

The construction of the primary table involved data entry of all selected metal members and their

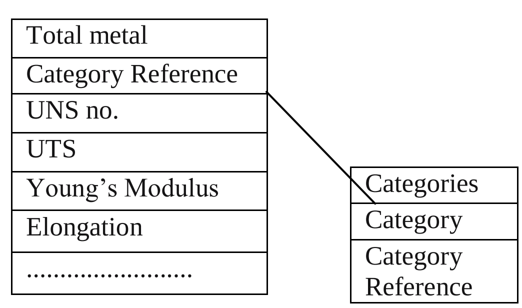

Fig 4: Actual Entity Relationships

4.5.3 Null values

A major disruption to the development of the database was the unavoidable inclusion of null values. These represented fields for which data could not be found in handbooks or elsewhere. In many cases, information was not available because it was not relevant to a certain metal and the level of completeness was jeopardised as a result. One proposal was to assign a 'non-applicable' value to the field, ultimately assisting in search operations. It transpired that because many of the attribute fields were of type 'number' then this solution was not possible since 'n/a' is of type 'text'. This added an element of awkwardness when generating the query designs.

4.5.4 Query designs

The effectiveness of a database relies heavily on the quality of queries employed in retrieving the necessary information. It is this factor which defines the database as a selecting tool and not just a source of information. It is essential that these queries deliver satisfactory information to the end-user. With regard to existing systems and common features, the concept was to make available:

- A browsing feature enabling the user to access information on a particular metal group or member.
- A search engine enabling the user to enter criteria and locate matching records.
- As a result of the number of permutations of both search values and field entries, the database is extremely intricate. It was for this reason that the decision was made to split the search feature into three or four main groupings reducing the likelihood errors:
- UNS Number and Trade Name – Density, Strength and Toughness

These four groups were chosen because of the actual type of property (e.g. mechanical, electrical, thermal etc) and their mutual compatibility.

4.6 Search operations

4.6.1 Range searches

The uncompromising nature of the data within the database suggested that if a user were to enter a single value for a property then there would be a low probability of retrieving adequate data if any at all. In certain records, the properties are stored as ranges or are very similar to each other, leaving 'gaps' between metal groups. To react to these concerns and provide the user with a worthwhile subset of data, range searches were adopted, although singular values can also be entered.

Designers and manufacturers require flexibility when selecting the most appropriate metal. It is not always the case that a fixed value is essential to the success of a product, so a compromise between properties is common. The utilisation of range searches enables a more compre-hensive collection of data to be retrieved, offering greater freedom in selection. Essentially, having a good under-standing of what is available and suitable is the first-step to optimising a selection.

4.6.2 The search interface

The structure of the search engine has been considered at the back-end of the database, and the logistics defined. As important, if not more so, is how this will interact with a user of the metal selector. Forms are methods of displaying unbound information, data in tables or the results of queries. They can be designed to have direct relations with the source data and can control the entry of several key parameters.By using previous knowledge and experience of search engines, a simple but effective front-end design was produced. This incorporated the range search technique as well as a simple entry method

4.6.3 Retrieval of matching records

The output of a search is of equal importance to the input. Metal members matching the criteria must be displayed with all relevant information and provide opportunity to produce a hard copy. In order for the data to be retrieved, the search forms, queries and result pages must be linked. This is achieved via the use of 'Macros' and 'Command Buttons' and a chain is formed until a conclusion is reached.

4.6.4 Process design

Macros act as the connection between stages in the selection process. It is for this reason that they almost outnumber the total amount of forms, reports and queries put together. The transition to the relevant action is vital to the efficient running of the system. A command is entered at the design stage of the macro which informs the database of what operation to carry out once the macro has been activated.

4.6.5 Display of matching records

In the Metal Selector System, results are shown in two media: forms and reports.Where the two are distinctly different is in the amount of data that they show. A form displays one record for one metal member whereas a report contains many. The form is ideal for viewing an ongoing practice through the development of a metal selection system was the testing features on completion. The continuous checking involved the examination of macros, queries and usability. These tests were hugely important in recognising problems and thus prompting trouble-shooting. As more tests were implemented, the database's shape changed and developed. shows the principal of macro and interface tests. The table listed 5 tests and the recommended actions are taken.

The screen shots of the package developed are depicted in the last page of the work published.

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Table 2 Definition of fields and respective attributes

Field name	Data type	Other information
ID	Auto number	Primary key
AISI type/trade name	Text	Field size 20
Category reference	Text	Field size 20
UNS number	Text	Field size 20
Density	Number	Double
Young's modulus	Number	Double
0.2% yield strength	Number	Double
Ultimate tensile strength	Number	Double
Brinell hardness	Number	Double
Thermal conductivity	Number	Double

Table 3 Selection of range check criteria

Metal	E (GPa)	σy (MPa)	σuts (MPa)	Elongation in 50 mm (%)
Al alloys	69–79	35–550	90–600	45–4
Cu alloys	105–150	76–1,100	140–1,310	65–3
Steels	190–200	205–1,725	415–1,750	65–2

Table 4 Truth table assistance in queries

Count	Yield strength	U.T. strength	Brinell hardness	Density
1	0	0	0	0
2	0	0	0	1
3	0	0	1	0
4	0	0	1	1
5	0	1	0	0
6	0	1	0	1
7	0	1	1	0
8	0	1	1	1
9	1	0	0	0
10	1	0	0	1

5. Conclusions

The metal selector is an innovative and useful tool in the field of metal selection. It conforms to the typical structure of existing systems and provides numerous features that assist both manufacturers and designers. There is provision of sufficient data and supporting information in the system to enable a comprehensive screening process to be carried out.The system possesses two main functions depending upon the requirements of the user. Focus was placed upon both the concept and embodiment stages of the design process and these correspond to the browsing and search functions respectively.The browsing feature operates in a hierarchical fashion with selection of metal groups and alloy subsets. This allows the user quick and easy navigation between the different pages within the database. Freedom of choice is the key motive for this feature which allows the designer greater originality in his ideals.

In comparison, the search feature offers the option of multi-constraint selection. Using three separate search engines, the user can locate matching records of metal members depending on the criteria they enter. The alternative searches are grouped into metal characteristics: mechanical, thermal/electrical and UNS number/ Trade name for similarity.Design of such systems has required a great deal of research into the field of material selection and the development of a database system. It has been both challenging and rewarding in creating a metal selecting software system that is simple but extremely effective

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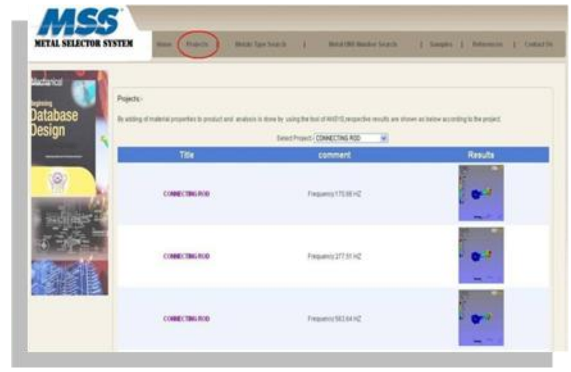
METAL SELECTOR SYSTEM
Database
Design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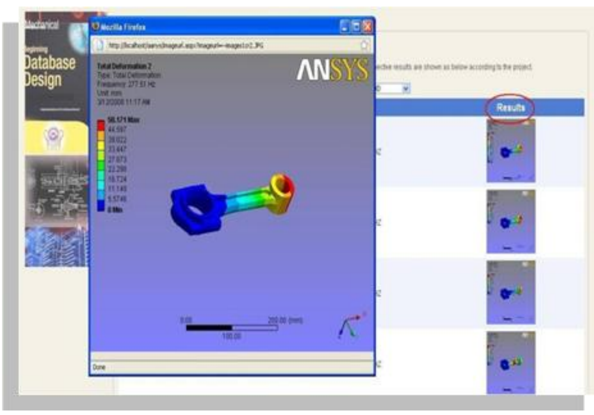
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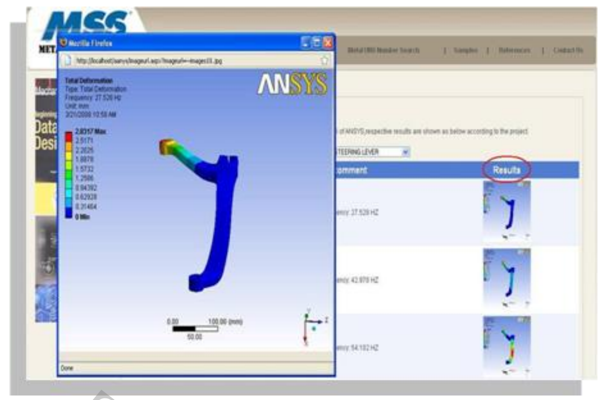
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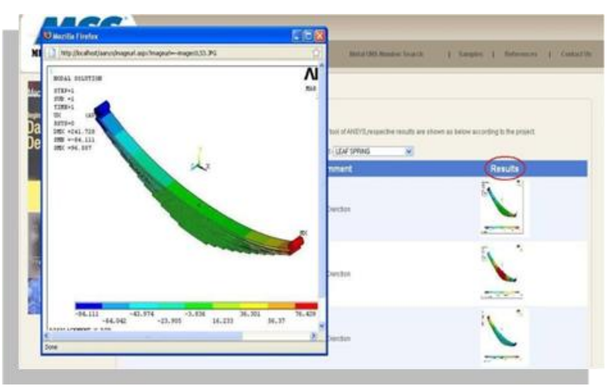
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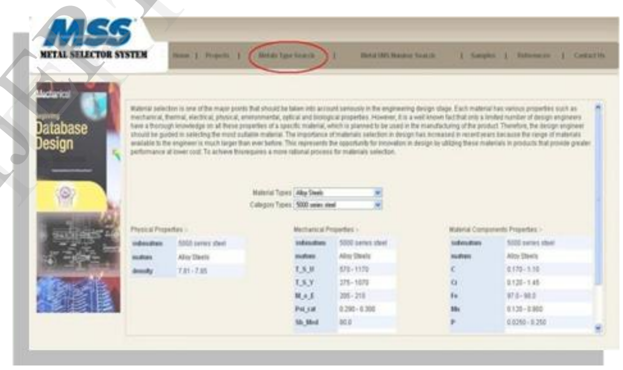
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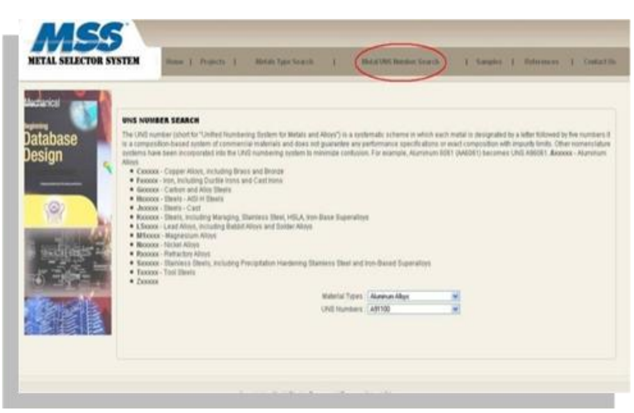
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