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Full Length Research Paper

Prototype expert system for material selection of polymeric composite automotive dashboard

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As a consequence of rapid development in material technology, determination of the right material for a given engineering application was viewed as a crucial decision. Various polymer materials selection methods have been developed to assist designers to determine the right polymer for a given engineering application. This paper presents a new natural fibre composite material selection process for automotive dashboard using expert system. The software tool chosen to assist the development of this expert system is PHPMyAdmin. The software tool was written in Hypertext Preprocessor (PHP) language designed to handle the administration of My Structure Query Language (MySQL) server over the World Wide Web. Various polymer composite properties are considered in order to develop the system. The focused properties of composites in this study are the density, Young's modulus and tensile strength. In order to demonstrate the system implementation, a car dashboard has been selected as a case study. It has been shown that using PHPMyAdmin for polymer composite materials process can assist designers to determine the right polymer composites for a given engineering application.

Key words: Polymer composite materials selection, natural fibre composites, material database.

INTRODUCTION

The use of fibre composite has recently been the subject of intensive research and it is experiencing significant advance development in the world (Zainudin et al., 2002). In recent years, there has been an interest in natural fibre composites as a substitute for glass or carbon fibre composites, motivated by potential advantages of weight saving, corrosion resistance and abundance, low cost and recycabilty (Sapuan and Maleque, 2005; Leman et al., 2008). Nowadays, a wide number of natural fibre composites have been developed and their properties have been improved. These materials are adopted in various applications, such as automotive, building construction, packaging and furniture industries today. As a consequence of this rapid development, there are many materials that can be used for a given engineering application. Hence, material selection becomes an important process which must be done at the early state of the product development. In the 1980's, material selection was studied by various authors (Charles et al., 1997; Cornish, 1987; Farag, 1989), but the one studied by Ashby (2005) has the highly praise applicability. Ashby (2005) promoted a chart which can be used in material selection process for natural fibre composite, namely the material property chart as shown in Figure 1, used to summarize the information of mechanical properties in a compact and easily accessible way. The material selection is an increasingly more sophisticated task. Therefore, computer technology is widely used in material

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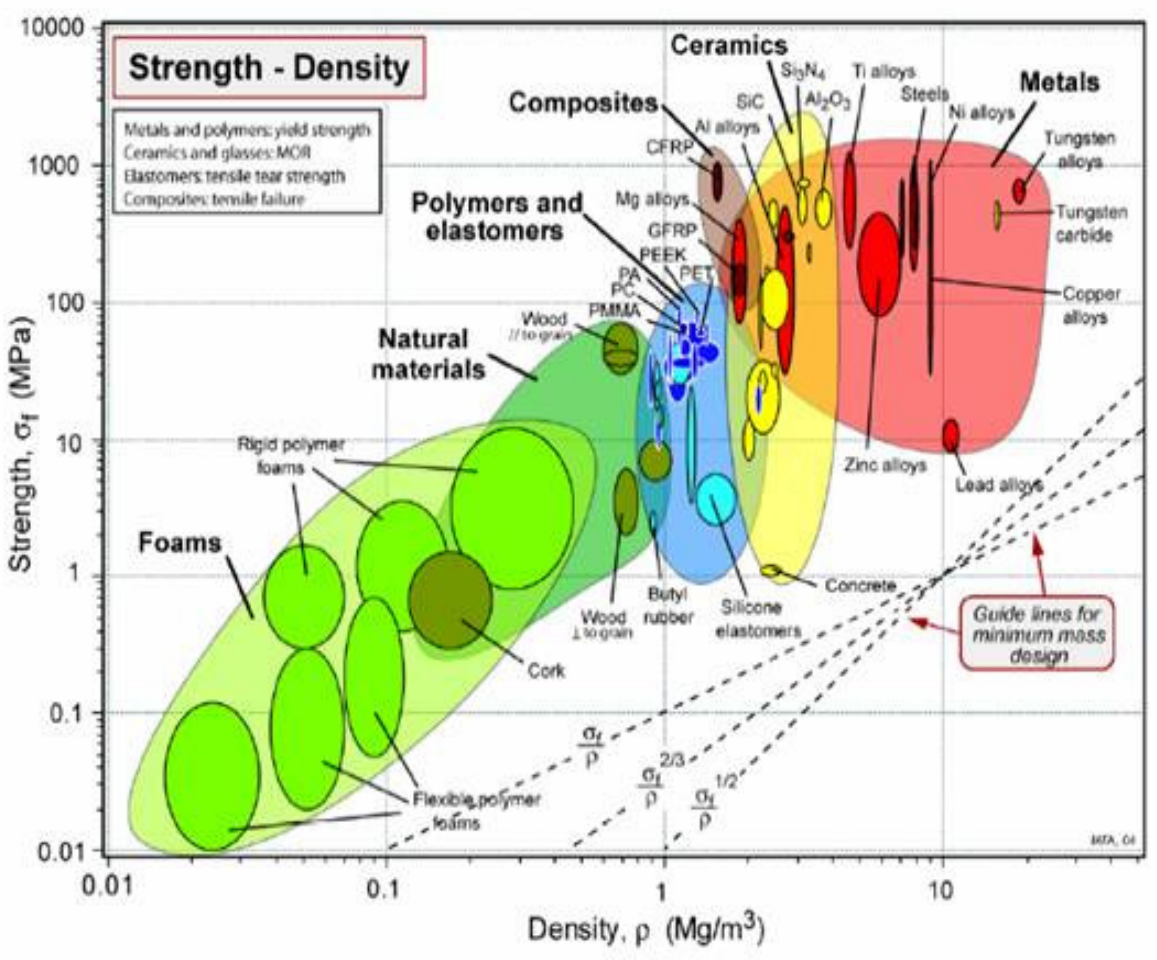

Figure 1. Material property chart of strength density (Ashby, 2005).

selection process. Attention is being made to the use of computer systems to store and process data (Sapuan et al., 2006) regarding the properties of the materials. It enables the designers to achieve large capacity and rapid retrieval from a computer database to provide easy access to the materials data. Many selection systems are available to help design engineers to choose the most appropriate materials (Sapuan et al., 2002; Jahan Hambali et al., 2010). The expert systems, also called knowledge-based system (KBS) which can be applied in material selection, such as Plastics Computer Aided Materials Selector (Plascams), PERITUS, Cambridge Materials Selector (CMS) , Microsoft Excel and Microsoft Access. Plascams is an expert system for plastic material selection. With this, user is able to search quality material from hundreds of materials which works using two search routines (Maier, 1993). PERITUS contains expert system to perform manipulations of data to assist with the preliminary selection of materials for the selection of polymer, metal and ceramic materials as well as processes for design (Dodd and Fairfull, 1989). The CMS (Ashby, 1993) is an expert system which works using materials selection charts. The selection process depends on implementing performance indices, a combination of material properties, which if maximized, optimizes performance. With this, the charts are developed to present the results so that the most suitable selection of materials and shape can be carried out. The use of expert system gives greater flexibility and rapid accessibility to the potential of selection. The aim of this paper is to describe the computerized material selection tools for selecting natural fibre composites.

Natural fibre composites database

The practical starting point of material selection is to gather the information regarding to selection component of the material from the database. A source of reliable and consistency on material properties data is one of the important basic of a successful material selection and process selection. The material properties of natural fibre composites considered in the material selection criteria are predetermined as density, Young's modulus and

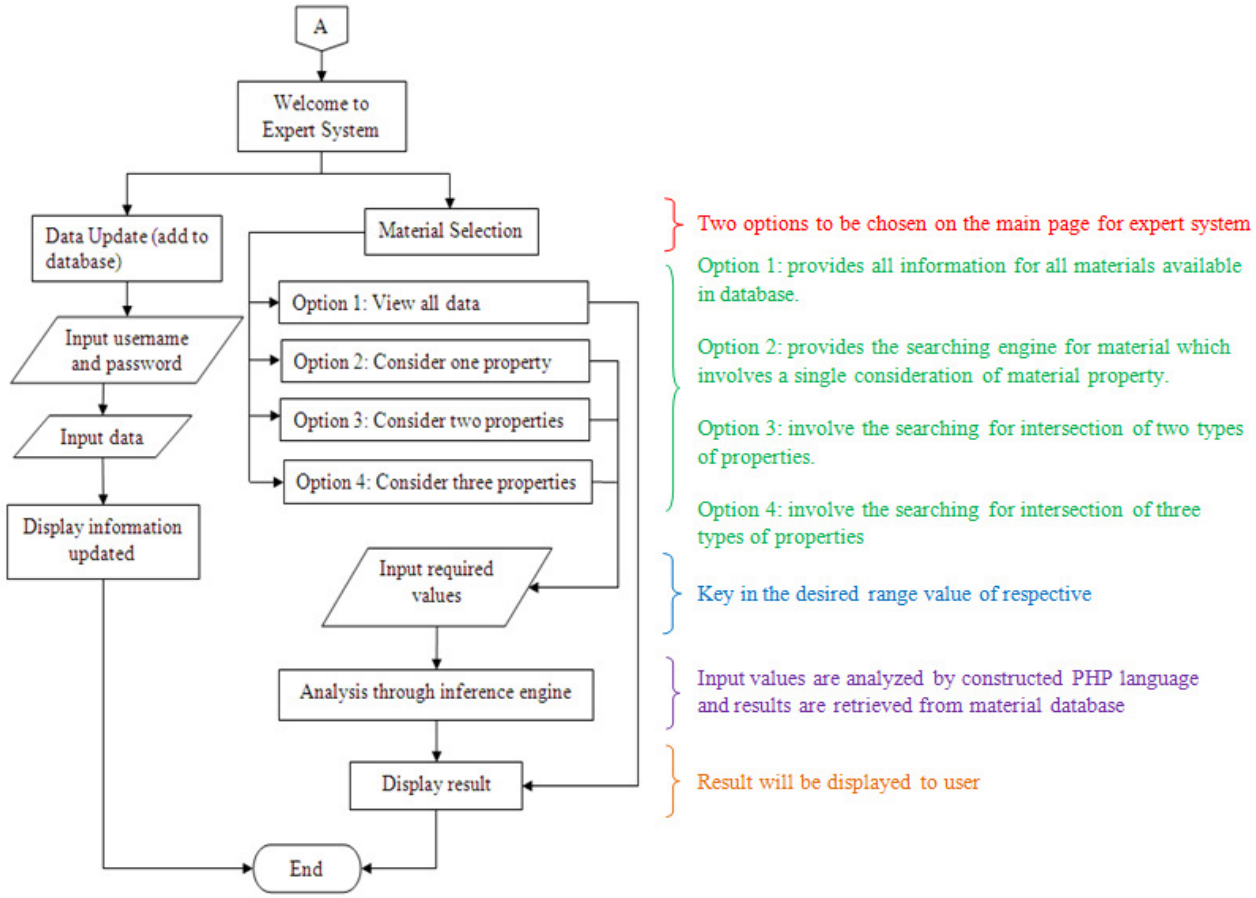

Figure 2. Flows of material selection process.

tensile strength. These material properties are very important in defining the general application of the natural fibre composites.

There are many sources of information that can be accessed to gather the relevant properties, such as reference books, journals, articles, engineering societies, research institutes, material producers and online material databank available from online sources. In addition, there are many helpful digital tools that can be found for material selection in product design. Detail descriptions of natural fibre composites are being recorded which include information like fibre factors, fibre orientation and form of fibre in matrix composite, process of manufacturing and reference of data. By doing this, users are not only able to fulfill the properties requirement but also, may have deep understanding on the selected materials which will become more convenient in their manufacturing process consideration. We need to take note that all natural fibre composites in database are standardized in mass fraction to ensure every material is comparable when making a selection.

In expert system, a database system is an important element. All the data can be stored in MySQL database, which is a fast, robust and scalable relational database management system (Welling and Thomson, 2005). In this study, a software tool has been chosen to develop the expert system, namely PHPMyAdmin. This is a free software tool written in PHP language designed to handle the administration of MySQL server over the World Wide Web (PHPMyAdmin, 2008). The storage of material data can be executed in this application.

Development of expert system (PHPMyAdmin)

The use of computers in engineering design has become an acceptable route in most of the engineering projects. Expert systems are particularly suitable for the processing of complex problems like the selection of materials for design with novel materials. In all the systems, data of the materials and their properties were processed and stored in database systems. Logical user interfaces between expert systems and database were developed. Then, the design and selection of the optimal materials were solved through experience and expert knowledge. The expert system developed could offer companies sufficient research potential to solve their practical problems. Figure 2 shows the proposed flows of material selection process.

Figure 3. Interface of the main page for expert system.

METHODOLOGY

How to select material in PHPMyAdmin program

The selection process was carried out using rule-based system. Expert knowledge is presented in simple IF-THEN relations, which is the language of expert system. After user inputs, material selection process can be started. This is done by initiating the inference mechanism in the expert system which provides a tool to store and process expert knowledge. Programming languages are needed to give commands for various wanted selection. It is an excellent tool to process expert knowledge. The expert system of the material selection for natural fibre composites is developed by using PHP language. Interactivity between user and server is a critical element of web functionality. It can interact with a large number of databases, such as MySQL. In these concerns, PHP language could become a suitable candidate in developing the expert system. PHP is a scripting language that provides great web functionality on Web application (Boudreaux, 2005). It is usually used to create dynamic web pages, which is acting as interface for expert system. After having intense study of the available application in the market, a suitable software tool has been chosen to assist in the development of the expert system, namely PHPMyAdmin. This is a free software tool written in PHP language designed to handle the administration of MySQL server over the World Wide Web (Anon, 2008). This software application can synchronize with Microsoft Internet Explorer, in which all the interface will be displayed on it. In other words, PHP can be interpreted and executed on the web server. The written PHP programming would have direct effect on the interface displayed in Internet Explorer browser. This feature is greatly improving the feasibility in developing a desire expert system.

The developed expert system is used to provide a user-friendly interface for material data updating and material selection purposes. The material selection in this expert system acts as a search engine used to figure out the right natural fibre composites under a certain material properties requirement. The focused material properties involved in the selection process are density, Young's modulus and tensile strength. The detail description of each material also is displayed to user for the selected material as additional information to make the material selection more reliable and useful in real application.

Generally, the whole structure of the expert system can be divided into two parts, which are "Data Update" and "Material Selection". The structure of the expert system is being developed in such a way that it will be better interactive to user. Data update function acts as an additional useful feature by updating materials that are stored in database, meanwhile material selection is the main core function of this expert system because it serves as material search engine. However, adoption of data update feature would make the expert system to become more reliable and sustainable as it is important that the designer stays updated to the rapid development of materials.

Since natural fibre composites are recently in the track of expending and new kind of natural fibre composites would emerge very fast in the market, therefore data update function would be vital to keep the material database up to date. It is not limited by current use only, but for future practice. Figure 3 introduces the main page of expert system, "material selection for natural fibre composites". The whole structure of this expert system is developed under PHP platform. Throughout the implementation of expert system, clear and comprehensive instructions are provided to improve its interactive quality. The interface of the expert system is very user friendly to expert and non-expert personnel.

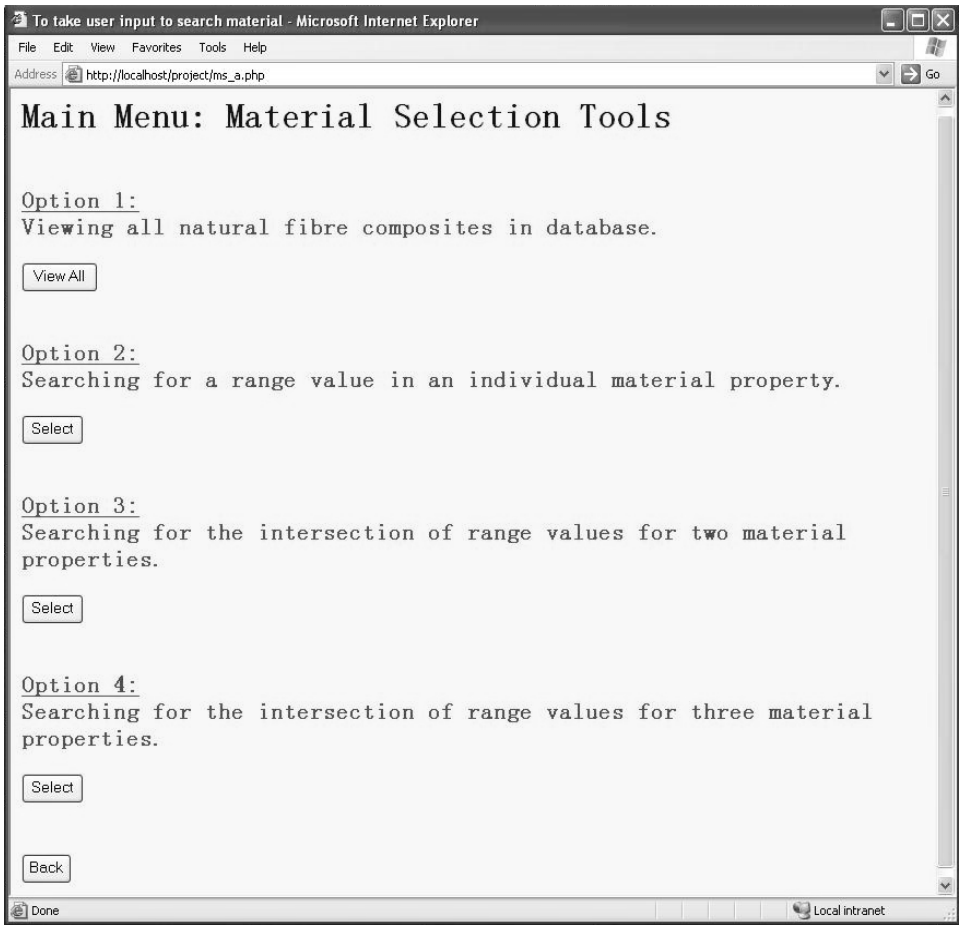

Figure 4. Main menu of material selection.

The first option in the main page of expert system is data update. This update feature is designed especially for authorized person only. It brings the meaning that not every person can make changes to the material database. The security consideration is important in this context because inaccuracy of data modification to the database may significantly affect the correctness of the displayed result to user. This feature requests for the username, and password is displayed in order to verify the authority of certain individual who attempts to execute update for material database.

This expert system is a material selection tool for natural fibre composites. From the main page of expert system, “material selection” can be executed after preparing and updating all the data of natural fibre composites in the database. This section is the main core of expert system. User can click the “material selection” button to get into the world of material selection for natural fibre composites. This system can provide better flexibility for the material selection. Finally, the results of the material selected are displayed to the user in a systematic, clear and friendly user interface. The development of an expert system is a highly iterative process. The system developed needed to be tested repeatedly to figure out the possible defect and verify its availability.

Figure 4 shows the main menu of material selection. It contains four types of selection processes and it provides a better material selection platform to user base on user requirement. Option 1 provides the information for all natural fibre composites that are available in material database. User can check on all the existing natural fibre composites and have a general view of them in alphabetical order. Option 2 provides the search engine for material which involves a single consideration of material property. Selection is done in carrying out a certain range of one type of property, either by density, Young’s modulus or tensile strength only. Option 3 involves the search for intersection of two types of properties; meanwhile, Option 4 is used for finding intersection of all the three types of properties. These are developed under set basic in which result only displays materials that are able satisfy all the wanted criteria.

A demonstration of using this expert system is executed in Option 4 from material selection main menu which is acting as search engine considering all the three material properties. Figure 5 shows the interface of this searching process. The advance search of this expert system figures out a solution for finding natural fibre composites that satisfies the entire properties requirement. User needs to have all relevant information about a particular design before starting the searching process. It may aid user to determine the optimum material by using this material selection function.

RESULTS AND DISCUSSION

The previous material selection is done on the virtual product by presetting its material properties. User may suspect its real application. Therefore, it is very important to perform a material selection by using expert system under real engineering applications.

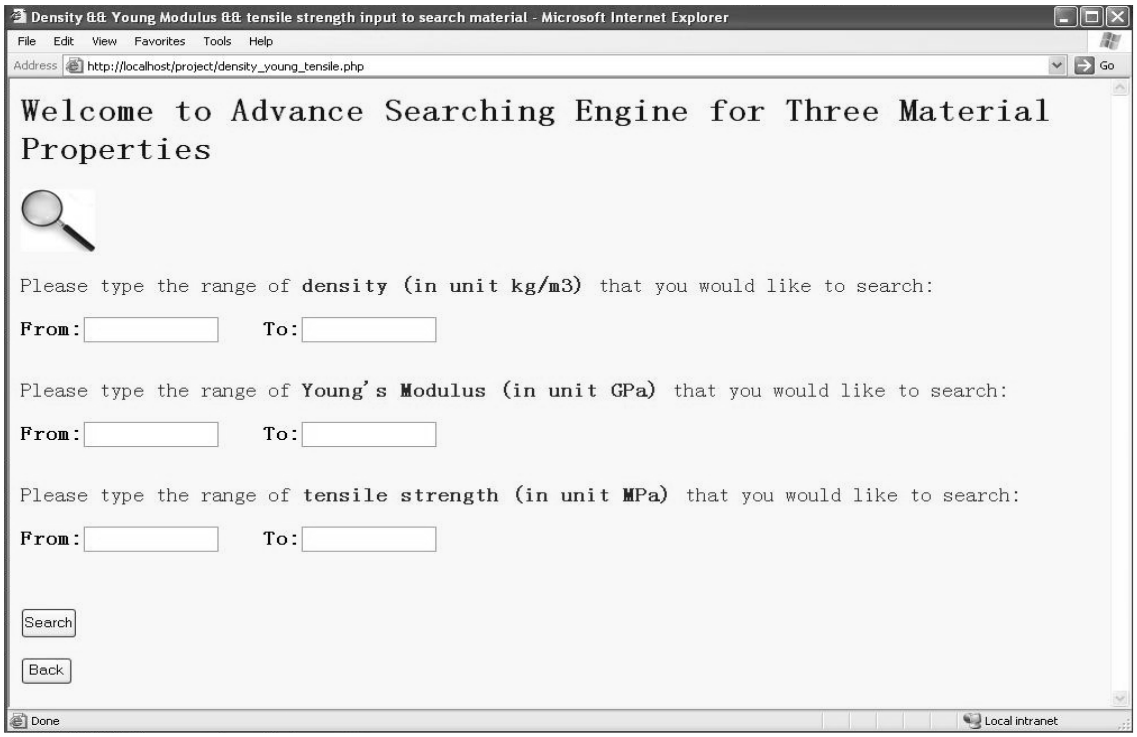

Figure 5. Fourth option from the main menu of material selection (Advance Search).

Table 1. General mechanical properties of automotive dashboard (Borealis Group, 2008).

Material properties	Range of value
Density (kg/m^3)	980 - 1100
Young's modulus (GPa)	2 - 6
Tensile strength (MPa)	20 - 30

In this context, the expert system is conducted under a real case study to figure out the appropriate natural fibre composites for fabricating automotive dashboard in order to further convince its usefulness. Before starting the selection process, the user has to determine material properties of car dashboard. The general mechanical properties of automotive dashboard are stated in Table 1. The expert system is executed in selecting suitable natural fibre composites for car dashboard according to the indicated product requirement. The search results of automotive dashboard are shown in Figure 6.

From the results obtained, two natural fibre composites match the entire requirements of a car dashboard. They are kenaf 30% + polypropylene (PP) and jute 40% + PP. They are the optimum natural fibre composites suggested to user. As shown in the figure, all the input values are displayed together with the search results for user convenience and to minimize possible error of inserting values. Search engine also computes the total number of natural fibre composites selected under these requirements. This return result is very helpful for the user to know the number of materials that can be applied to the design. In real automotive industrial, kenaf and jute are among the popular natural fibres being used in fabricating interior parts of car. Therefore, the result of this material selection is reliable and applicable in actual material selection scenario.

The materials selection process using CMS is done in a way by which the results are presented in a chart with the desired properties as the axes, and all materials contained in the database with applicable data entries are plotted on the graph, whereas for PERITUS software, the materials selection is worked with two search routines. The first is based on an elimination procedure while the second search routine is based on the optimization that can rank the potential material by entering weighting values to the bias. Note that the materials selection process using PHPMyAdmin is much easier and user-friendly as compared to the mentioned programs earlier. User may not need to interpret the sophisticated chart as in CMS where the PHPMyAdmin program allow user to obtain the result directly from the output as shown previously. Furthermore, user may not need to obtain the weighting values of the desired properties as in PERITUS.

Conclusions

PHPMyAdmin can be used to develop material selection

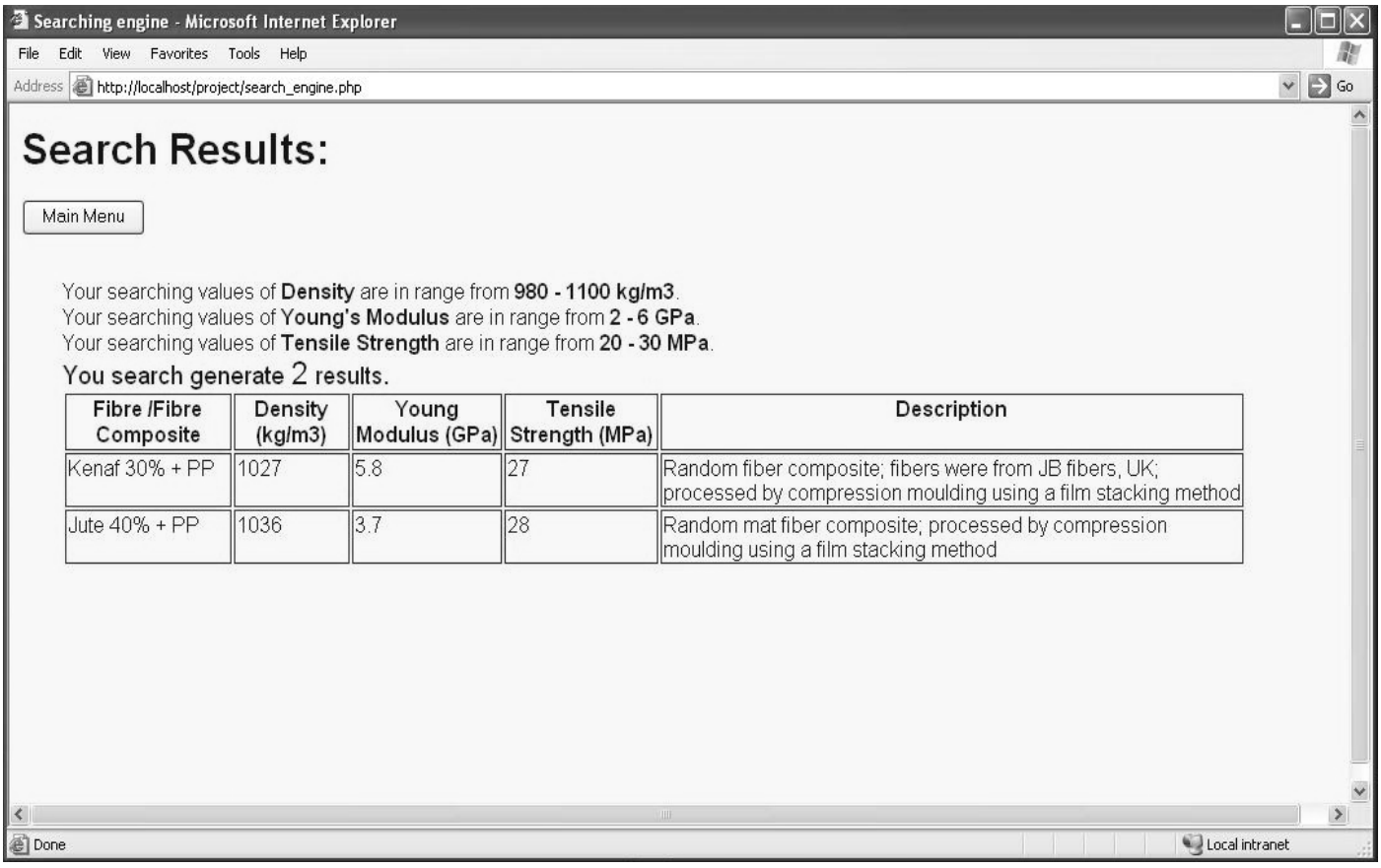

Figure 6. Search results for automotive dashboard.

tools for natural fibre composites. Database of natural fibre composites has been constructed in order to make the whole selection process more functional and reliable. Data can be retrieved and displayed to user in short time after user inputs desired requirement. The advanced material selection tool has greatly refined the output of candidate materials. It has proved to be faster, more interactive and effective in material selection process while providing accurate and reliable results.

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