EXPERT SYSTEM APPLICATION
FOR IMPROVING THE MANUFACTURING PROCESS
FOR RECREATIONAL WATERCRAFTS
MODELLING YACHT PROPULSION

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Abstract

This article deals with the problems of design improvement and the process of production preparation for recreational watercrafts. An original expert system was created to facilitate the design of mechanical equipment systems and to support the production of pleasure boats. This expert system contains information about issues related to the selection of appropriate mechanical equipment used in modern yachts. An expert system is a computer program, which contains information about a specific and usually narrow field of expertise. With the help of this kind of program, it is possible to solve problems on the same level as a human expert. Like most expert systems, this program is built in such a way that the knowledge base is separated from the rest of the system. It contains two main modules: the knowledge base and the inference mechanism. This system provides conclusions in a descriptive form and in the form of numbers, and presents explanations, diagrams, drawings, photos and videos. What is unique about this expert system is that a user with specialist knowledge in the field of yacht engineering can easily modify the knowledge base. With the development of technology, it is easy to feed new information into the system. This system can become a major tool in design offices and plants producing yachts, because it can be easily expanded and adapted to individual needs.

Keywords: expert systems, yacht propulsion, manufacturing of yachts, knowledge engineering

1. Introduction

Managing information and knowledge becomes vital for a company's competitive ability, notably when it comes to expert knowledge.

Up to now, in scientific literature, there has been little discussion about the challenges of special machinery and practical solutions regarding an implementation of technical intelligence in a special boat production environment. Therefore, the goal of this article is to give an example of how an expert system can be applied to special boat production surroundings and thus, increases productivity [12].

An examination displayed how the complexity of special machines leads to iterative processes for diagnosing and problem solving and thereby, increases lead times significantly. Hence, an intelligent management of information and knowledge becomes vital for a company's competitive ability, notably when it comes to expert knowledge. "Intelligence" is the capacity to learn, the capacity to acquire adapt, modify and extend knowledge in order to solve problems. Thus, when building intelligent entities, problems cannot only be solved by human experts but also by artificial intelligence. One very successful application of artificial intelligence technology is expert systems [1, 3, 4, 8, 11, 13].

Expert systems use artificial intelligence concepts to enable computers to function in decision – support roles as advisors, personifying human expert decision-making capabilities. Hence, expert systems cannot replace human specialists, but they can serve as highly efficient support – tools in

the decision – making process. In general, expert systems can be used for analysing, diagnosing, monitoring, forecasting, planning, and designing and have been successfully implemented in various fields; predominantly in medical, manufacturing and business fields [6].

When it comes to the design of knowledge – based methods for reasoning and decision – making, uncertainty plays a significant role [12].

Therefore, the aim of this article is to give an example of an interactive expert system and its implementation in production of yachts.

A key factor for the effectiveness of an expert system is the quality of the knowledge base. Expert systems can provide fast and reliable answers and quality of decisions improves when human decisions are being supported by recommendations from an expert system [1, 2, 9, 11].

In yacht building, the time required for the production of an individual boat is often less important than a focus on extremely high quality, providing exceptional comfort and luxury to the owner and his or her guests with state of the art furnishings and equipment. This equipment will include electronic and hydraulic systems providing the ability to control and manoeuvre the vessel in adverse conditions with a little or no stress and with a very small crew [5].

Very often, the reputation of the boat building company is the determining factor in setting the boat's final price and producing the order to proceed with design completion and construction.

A common practice of boat manufacturers is to select individual items of equipment from recommendations in catalogues, which may well be weighted to specify all items to be "safe" in terms of strength and power output, but which may also be unnecessarily heavy and expensive. This has the potential for increasing the final cost of the vessel, and in some cases such as diesel engines for bringing about premature failure as a result of excessive low power and low temperature operation [5].

Conversely, selecting under-sized or underpowered components will lead to frequent breakdowns, early replacements, and in extreme situations, may endanger the lives and safety of the people on the vessel.

Yacht manufacturing costs are also greatly affected by excessive expenditures for labour to install over-sized equipment, well intended to ensure the safety of the yacht and ensure the comfort of its use. A fully developed Expert System will optimally choose, customize and calculate the required materials and equipment for safety, comfort and cost control. In other words, the information provided by such an expert system will significantly affect all costs, causing the final price of the to be much lower while maintaining the desired comfort and capabilities required in the completed yacht. In addition, the use of this Expert System will mean that production will be smooth and efficient [5].

2. About Expert Systems

An Expert System is a computer program, which contains knowledge about a specific and usually narrow field. The system has a capability to solve problems comparable with that of a human expert in the same filed of knowledge – it is computer software designed to solve problems that require specialized knowledge [7]. Expert Systems belong to the field of artificial intelligence, which is the study of issues including fuzzy logic, evolutionary computation, neural networks, artificial life and robotics. Artificial intelligence is a branch of computer science, the object of which is to study the rules of human behaviour and intelligence, to create formal models of that behaviour and human thought processes and, as a result, to create computer programs that simulate the behaviour and intellect of humans [6].

The starting point to development of the Expert System is analysis of the process of preparation of production [6].

The main idea is to create programs, which, when knowledge and reasoning techniques are introduced, can generate answers similar to those that would be provided by a highly experienced human being. In effect, you will use the system to access the human expert's knowledge and

experience through the user interface of the computer or other device running the program. The user of this service asks questions and receives answers and explanations presented in various forms, such as: text, video, sound, photo, figure, scheme [6].

Advantages of Expert Systems
– reduces the time taken to solve the problem
– includes the knowledge of many experts, its more accurate than a single expert
– improves customer/patient services and the standing of the expert
– can predict future problems and solve current ones
– saves the company money due to faster service time
– in some areas such as car fault diagnosis, it can mean that less skilled work force is required.... lower wage bill

3. Expert Systems in Manufacturing

Expert Systems have been used in manufacturing for a wide variety of applications. Expert Systems have been used in manufacturing automation for a number of years. The initial systems developed by the research community or by early adopters of the technology provided some significant paybacks and created an initial enthusiasm for the technology. Expert Systems have a great deal of opportunities for implementation into manufacturing, such as scheduling and forecasting, simulation, process modelling, and resource allocation, diagnostics, process control and planning, quality and safety, pricing, packaging, and customizing. These areas can all be divided up again so there are hundreds of possibilities out there for any type of manufacturing [5, 14].

4. Description and structure of the presented expert system, which can improve of yacht manufacturing processes and modelling yacht propulsion

Recreational craft, to which Expert System can be applied, include sailing yachts, displacement-hull powerboats and planning powerboats.

The inspiration to create such a system is the fact that the Polish market does not contain detailed literature describing problems in design of yachts, engineering production of yachts. There is no software supporting the yacht design and manufacturing process. There is a strong demand for materials presenting practical knowledge in field of yacht design and manufacturing but so far, no Expert System has been developed in Poland, and perhaps the world, to assist in that design and production process – no yacht designer or manufacturer in Poland uses such software [6].

The described Expert System has been built as an application of the PC-Shell computer tool, an independent tool for construction of Expert Systems. It combines various methods of solving problems and knowledge representation. It can be used in any field; hence, the range of its applications is very wide. The PC-Shell is mainly predisposed to solve the problems of the diagnostic and classification and interpretation of data.

In industrial practice, the watercraft production preparation is most often focused on the work related to the preparation of technical documentation, whose share in the overall production preparation structure of work is the largest.

Preparing the production of a new yacht model is an extremely complex, complicated and time-consuming process. This process requires solving many tasks from very different and distant fields. It is obvious that when designing a watercraft, we focus on its external shape, aesthetics and nautical values, (which is obvious). Also at this stage, the drive system should be well planned. In the case of a yacht with a shaft drive, is responsible for the proper functioning of the yacht, it depends on the system whether we will enjoy the pleasure of using the yacht.

When designing a yacht with motor drive (combustion, electric or other ...), special attention should be paid to the power unit to its layout and all elements that work with it.

Each drive system contains many components that cooperate with each other. If one of the elements or devices is technically isolated from the rest, it may affect its proper functioning.

The propulsion system is one of the most important boat systems. Well calculated, manufactured and installed not only increases comfort while sailing, but also significantly improves the reliability of the vessel, increases the safety of the crew and boats and the joy of using the yacht.

Using Expert Systems boils down to the supply of facts or other information to the Expert System where, on this basis, the expert answer is presented [6].

Expert System = Knowledge base + Skeleton of the Expert System.
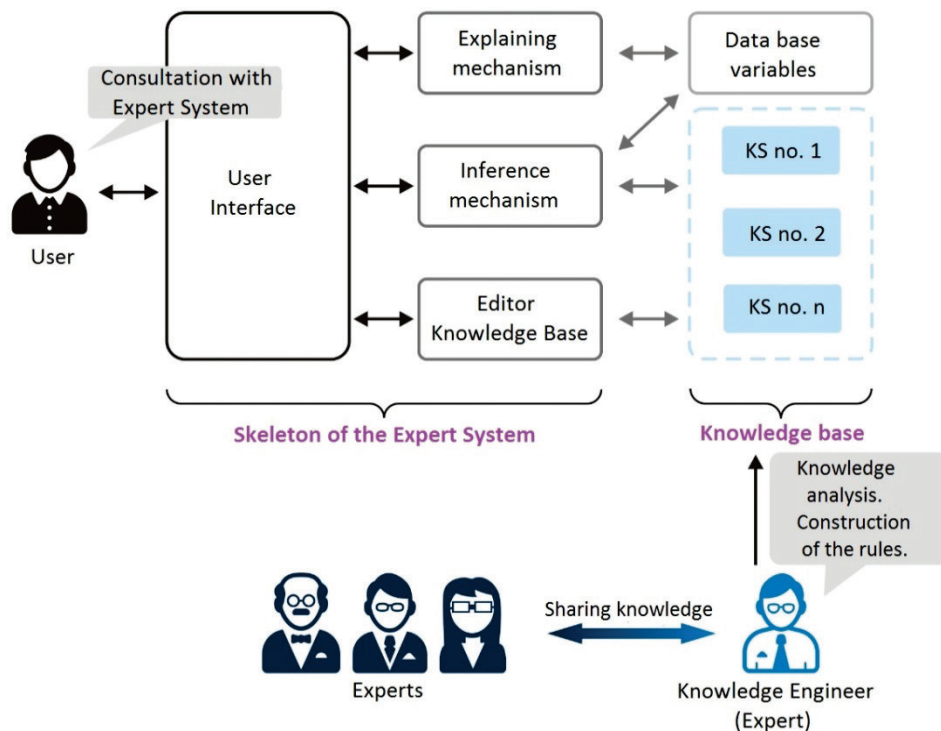
Fig. 1. Schematic diagram of the presented Expert System

4.1. Knowledge base

A knowledge base contains facts and rules which are necessary to solve the problem in a specific field. The facts are sentences that mean for example: sailing vessel has a length of 15 meters. This fact can be represented as a relationship between certain objects and characterized with different features. Besides, it in the knowledge base can be other objects such as displacement for motor boats or planning-hull powerboats.

An important feature of the system is the possible of parameterization of the knowledge bases. With this solution the dynamic changes of selected values (parameters) in the knowledge base, take place without any changes in the source code of the base [9]. A good example of the application of parameterization mechanism can be a knowledge base in which we test some values of some indicators such as how to choose the correct bow and stern thruster for the vessel depending on the length of the hull at the water line. At the same time, some threshold values can be variable, depending on the case. For example, you can evaluate several different indicators of a boat depending on its destination [9].

Knowledge base description of the presented Expert System reference to modelling yacht propulsion

The presented Expert System displays knowledge about the yacht's propulsion system from the following areas:

I. Engine and around the engine:
   – the engine power calculator for displacement boats,
   – the engine power calculator for planning boats,
   – engine assembly – Movie;
II. Stern gear systems:
   – selection of the numbers of bearings supporting the drive shaft,
   – selection of the diameter of the drive shaft,
   – selection of the type of coupling,
   – construction of the drive line;
III. Transmissions.

4.2. Skeleton of the Expert System

The skeleton of the expert system contains basic modules that control the work of the entire expert system, such as:
– data base (knowledge sources),
– editor knowledge base,
– explaining mechanism,
– inference mechanism
– data base variables,
– user interface.

An Expert System is designed in such a way that it is easy to enter a new source of knowledge into the system, that is for example, together with the development of technology, the knowledgeable engineer can enter new information into the system [6].

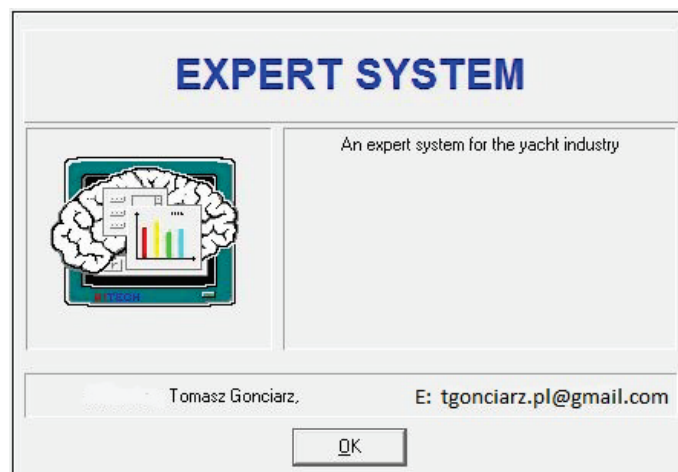## 5. An Expert System presentation

Fig. 2. The Expert System welcome screen

In Fig. 3, a view of the function, which enables the calculation of the required engine power for the boat, is shown. The user selects from the Main Menu functions „Engine power calculator" and enters values such as the length and width of the hull at the water line, draft and number of engines. After clicking the Calculate button, the required engine power for the boat N_e is returned.
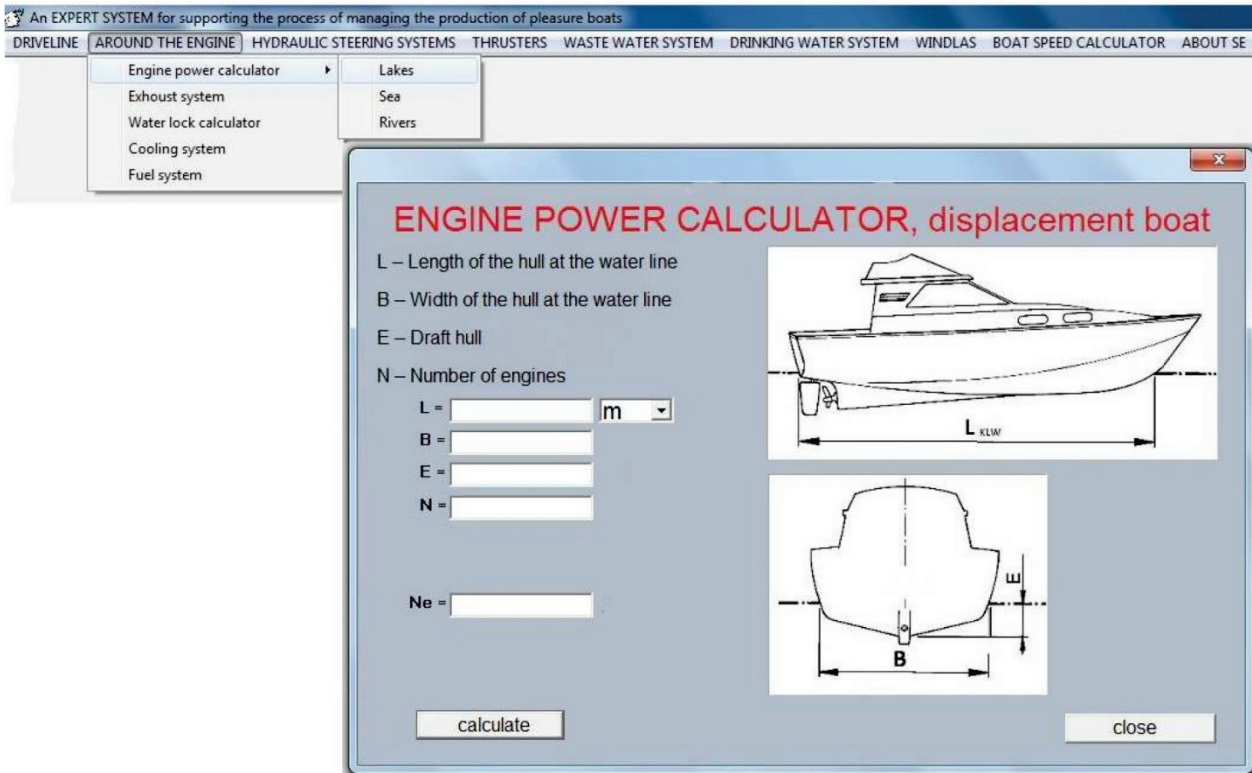
Fig. 3. Main Menu and the Engine Power Calculator dialog box

User can get additional explanations from the expert system, which may help him/her even at the stage of the application process. That function is called „WHAT IS IT ?".
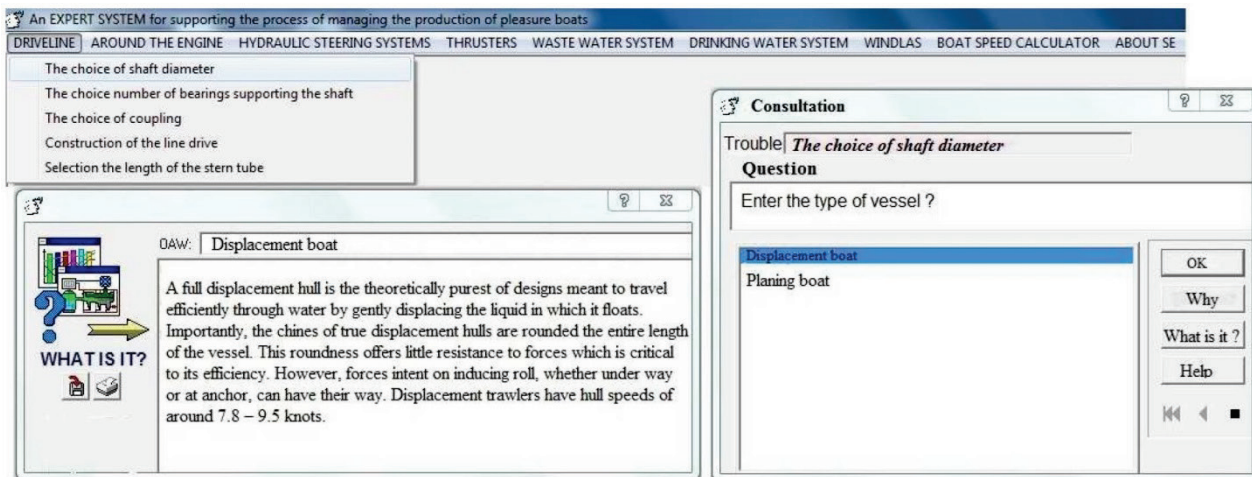

Fig. 4. Menu and additional explanation window „WHAT IS IT?"

In Fig. 5 and Fig. 6 is a view of another example of human consultation with an expert system. the Problem is as follows: Selection of the number of bearings as it should support the drive shaft.

After the user has indicated the range of 1500-2000 mm, the expert system gives the answer presented in Fig. 6.

6. Conclusions

This program, that is part of artificial intelligence, is the first expert system of its type in Poland and probably in the world. The collected information is a compendium of knowledge,

which cannot be found in currently available publications. It includes practical knowledge obtained through empirical methods.

Using the presented Expert system reduces the time during the design and preparation process of yacht production and protects against making mistakes.
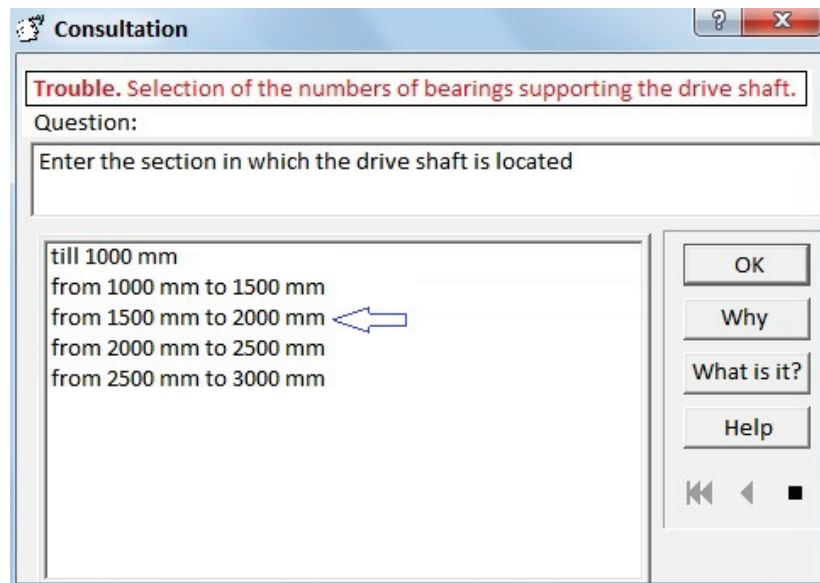

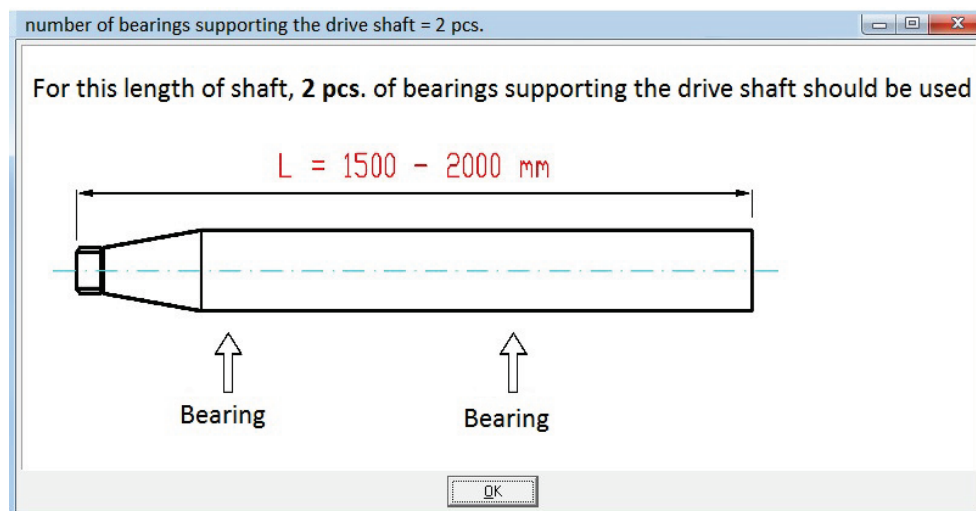*Fig. 5. An expert system ask a question: „Enter the section in which the drive shaft is located"*

Fig. 6. Problem solving presented by the Expert System in a graphical and textual manner

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