

USING DATABASES TO DESIGN BEARINGS EMPLOYED IN THE CONSTRUCTION OF MECHANISMS

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Abstract: *Designing the knowledge database of an expert system is a difficult task that requires a close cooperation between a human expert and the knowledge engineer. The result of this cooperation will be the one to determine the accuracy of any solutions obtained by the expert system in question. In this paper, we have designed the rules and the facts database of an expert system used to design bearings for the construction of mechanisms and we have also described the way the said expert system works, based on the computation algorithm.*

Key words: bearing, database, design, rules database, algorithm

1. Introduction

All expert system are based on their knowledge database meant to help them memorise the knowledge existing in their reference field. The quality and usefulness of an expert system depend on the accuracy of the knowledge acquired by the knowledge engineer. This knowledge is both scientific and heuristic and gathering and structuring such knowledge in a way that would make it implementable via a programming language specific to databases, is a very difficult task. [2]

2. Designing the knowledge database

The body of all specialised knowledge obtained from the human expert and from various specialised publications, structured and organised for memorising, interrogation, security and updating purposes, makes up the knowledge database of an expert system.

Following the acquisition of such knowledge, the knowledge engineer reflects this knowledge by designing the knowledge database as a set of data structures.

In case of an expert system using inference mechanisms based on production rules, the knowledge database will be made of rules and facts. In the rules database, one will store the rules that will be usable to solve the initial problem. [2]

The facts database will comprise the problem's initial data, as well as intermediary data obtained while applying the production rules, via the inference mechanism. One fact will be described using three characteristics:

- object - a mechanism component found in a certain state that can be deduced,
- state – the state in which the object is found or the object's relationship with other components of the mechanism,
- quantification – a value indicating the size of the object's state.

The intermediary data represents the rules' snapshots. The use of these snapshots depends on the rules application priority and the conflict resolution system. Thus, the intermediary data is arranged in the facts database according to its priority. [2]

2.1. Requirements for bearings used in the construction of mechanisms

Bearings are widely used in a large variety of constructive assemblies, as well as in a multitude of functioning conditions specific to each implementation domain.

Bearings must have specific properties, depending on their use: enhanced durability at the smallest possible gauge, they must be silent, they must have a good rotation accuracy, insure correct operation at high temperatures, at high and very high speed spinning, they must insure perfect sealing, even under hard working conditions. [3]

Depending on their construction and mounting within an assembly, bearings may take over radial loads, axial loads or any other types of loads placed on any other direction.

The following table describes the correlation between the constructive and the functional features of a bearing, according to INAFAG [3] and the requirements imposed on the bearings used in the construction of mechanisms:

No.	Constructive and functional characteristics	Requirements imposed on the bearings used in the construction of mechanisms
1	Radial loading capacity	Radial strength
2	Axial load	Axial strength
3	Radial gauge	Radial gauge coefficient
4	Axial Gauge	Axial gauge coefficient
5	Insuring the shaft dilation	Shaft dilation
6	Enhanced precision	Precision
7	Sealing on one or on both sides	Sealing
8	Normal operation speed	Working speed
9	Operation at high speed spinning	Limit spinning
10	Silent operation	Noise
11	Operation at high temperatures	Operating temperature
12	High rigidity	Lost motion
13	Losses caused by friction	Moment of friction
14	Type of lubricant	Lubricant viscosity
15	Can they be used as driving bearings?	Mounting requirements
16	They can be used as free bearings	Mounting requirements

Table 1. Correspondence between the bearings' constructive-functional characteristics and their design requirements

2.2. Mounting requirements for bearings used in the construction of mechanisms

One shall set forth the requirements imposed on bearings, depending on the mounting sketch and the axial and radial loads levels:

No.	Mounting characteristics	Requirements imposed on bearings
1	Leading radial bearing box	Must insure the role of leading radial bearing
2	Leading axial bearing box	Must insure the role of leading radial bearing
3	Free bearing box	Must insure the role of free bearing

Table 2. Correspondence between the mounting sketch characteristics and the mounting requirements imposed on bearings

3. Designing the knowledge database

The knowledge database of a rule-based expert system comprises the rules database, the facts database and the bearings database. The knowledge database of the expert system is based on the factual and heuristic knowledge of the human expert, construed as type [1] rules:

IF condition THEN result

The result may be:

- a set of parameters representing a new fact set to be added to the facts database [1]
- the display of a message requiring the introduction of new parameters
- adding a new rule in the rules stack/queue . [2]

The production rules must simulate human reasoning, carrying out the same inferences based on facts.

A deductive expert systems, will start from the initial data (facts), then the rules in the knowledge database will applied one by one in order to determine a result.

An inductive expert system will start from the result (purpose) and it will look for rules that can be applied in order to demonstrate the proposed result [2].

The conceptual model of a rules database comprises the following tables: Bearings – Related Rules, Conditions, message, having the following structure:

Bearings –Related Rules	Conditions	Message
Rule code	Condition code	Message code
Priority	Rule code	Message
Result code	Attribute code	
Result	Value	

Table 3. Structure of the tables comprised in the rules database

The conceptual model of a bearings database comprises the following tables: Bearing, Attribute, Mounting, Bearing-Mounting, having the structures described in the following table:

Bearing	Attribute	Mounting	Bearing- Mounting
Bearing Code	Attribute code	Mounting Code	Bearing Code
Name	Attribute name	Name	Mounting Code
			Leading radial bearing box
			Leading axial bearing box
			Free bearing box

Table 4. Bearings database tables and their structure

The content of the attribute table corresponds to Table 1.

The conceptual model of a facts database comprises the following tables: Initial Conditions, Rules to be applied, Bearings Solutions, having the following structure:

Initial Conditions	Rules to be applied	Bearings Solutions
Condition code	Rule code	Bearing code
Attribute code	Priority	Code of the applied rule
Value	Result code	
	Result	

Table 5. Structure of the tables comprised in a facts database

3.1. Stages of interrogating a knowledge database

Firstly, the database must be filled in with the bearings' attributes, their names, symbols, and the types of mountings they can be used in, as well as the rules that can be applied.

The user shall input the initial data comprising the attributes and their values according to the requirements. This data shall be stored in the Initial Conditions table. One shall search the rules database for all the rules that may be applied according to the initial conditions and the rules thus found shall be stored in the Rules to be applied table. These rules shall be ordered according to their priority.

The first rule in the table shall be applied, the one with the highest priority. For each rule, the result code may have three values [2]:

- 1- if a bearing was found. In this case, the bearing code will be displayed in the Result field and stored in the Solutions table.
- 2- if a message has to be displayed. This message may be used to inform the user that additional pieces of information are needed or that the search for a solution has been completed.
- 3- if another rule must be applied. In this situation, the code of the rule to be applied shall be displayed in the Result field and it shall be added to the "Rules to be applied" table, along with all the information related to the new rule to be applied.

If there are bearings meeting the requirements stated, the user shall be guided to the second stage, e.g., introducing the mounting requirements.

If there are no bearings meeting the stated requirements, the user shall be asked if he/she wants to restart the first stage of the search, where the requirements stated correspond to the bearings existing in the database.

The second stage, designed to choose the bearings mounting, shall be initiated taking into account the results of the first stage and the verifications already made. If there are any bearings that meet the requirements stated, then the final stage of the process is initiated: displaying the results. If there are no bearings meeting the stated restrictions, the user shall be asked if he/she wants to restart the first stage of the search, where the requirements stated correspond to the bearings existing in the database

The third stage shall display the type of bearings meeting the constructive requirements a then, the types of bearings meeting the mounting requirements and then, the types of bearings meeting both the constructive and the mounting requirements.

The programme has been written in C++ and it is using multiple structures corresponding to each table in the database, as well as several auxiliary structures.

We coded the attribute values corresponding to the entry data value range. For instance, for the radial strength in the Attributes table, the code of attribute 1 shall be memorised, as well as the attribute's value – a number between 1 and 10, depending on the radial strength required by the user:

Attribute value	Range[N]	Attribute Value	Range[N]
1	0...300	6	1501-1800
2	301-600	7	1801-2100
3	601-900	8	2101-2400
4	901-1200	9	2401-2700
5	1201-1500	10	2701-5000

Table 6. Correspondence memorised values – value ranges

The programme's algorithm is described in figure1.

4. Results obtained

One example of rule to be used to obtain a bearing is:

IF (('Radial strength' == 5) && ('Axial strength' == 2) && ('Radial gauge' == 3) && ('Axial gauge' == 1) && ('Limit spinning' == 7) && ('Working spinning' == 7) && ('Lubricant viscosity' == 3) && ('Precision' == 2) && ('Noise' == 3) && ('Friction moment' == 1) && ('Limit temperature' == 3) && ('Shaft dilation' == 3) && ('Lost motion' == 2)) THEN 'result-code'=1, 'result'=101
where 101= „Radial ball bearing”.

An example of production rule used to choose the leading bearing in a mounting is:

IF ('Bearing type' == „Ball bearing” && „Leading radial bearing box' == 9 && „Leading axial bearing box' == 6 && „Free radial bearing box' == 0) THEN Result=102
Where 102= „Axial radial with two rows of balls ”.

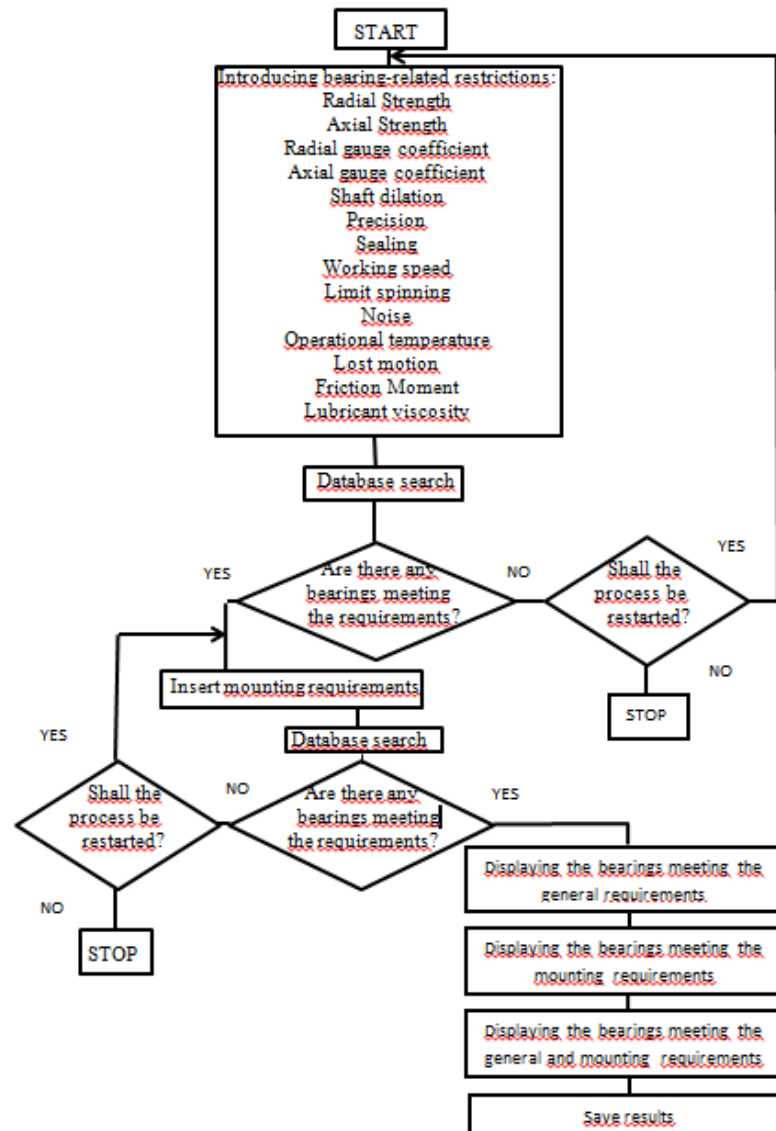


Fig. 1. Computation programme algorithm

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