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EXPERT SYSTEM FOR CHOICE OF MATERIALS

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Abstract: *To choose a material have much knowledge about the properties and qualities of materials and need for specialized books, which involves a lot of time. To assist engineers who need to choose a material with certain characteristics, properties that meet certain conditions author proposes an expert system for selection of materials. Expert system using two types of information: data and knowledge. Expert system uses rules based on qualitative information and knowledge processing involves combining adequate solutions and their synthetic versions. The application is developed in the programming language specialized expert system, CLIPS..*
Keywords: *chose material, expert system, CLIPS.*

1. INTRODUCTION

Choice of materials is very important in the design process of gears. In the design process of gears choice of materials are performed based on initial operating conditions presented in detail in the paper. Frequently, the choice of materials is not a simple step, requiring consultation literature in terms of their characteristics, data, usually as table or chart form [8, 9] .
For this reason it is useful to create a program of expert system type for choosing material.
This paper presents an expert system developed in CLIPS programming language.

1.1. Expert System

In the last period, based on achievements in the field of artificial intelligence (AI), computer aided engineering developed based on knowledge underpinning of modern computer-aided design. Using artificial intelligence tools in the processes of design may develop intelligent systems for analysis and synthesis products. [1, 2, 3, 4, 5, 6, 7, 10]
Expert systems, like applications of artificial intelligence, working with specialized knowledge and reasoning to solve real problems that normally require human experts. Building an expert system involves extracting relevant knowledge domain (knowledge acquisition) in a suitable form to be introduced in the knowledge base of expert system. This activity constitutes preoccupation the knowledge engineer [1, 2, 3, 4, 5, 6, 7, 10] .
Expert systems are used to solve large problems in medicine, mathematics, engineering, geology, business, education, etc. Solved problems may involve activities prediction, diagnosis, design, monitoring, interpretation, etc. In the field of mechanical engineering expert systems were created for: product design, design for automatic assembly, diagnosis, etc. The most used programming languages specialized on expert systems are: Clips, Jess, Prolog, SWI-Prolog's [11].

1.2. Programming language CLIPS

CLIPS (C Language Integrated Production System) is probably the most used medium for expert systems because it is fast, efficient and free. Although now part of the public domain is still updated and supported by the original manufacturer, Gary Riley [11, 12].
CLIPS programming language is object-oriented, called COOL (CLIPS Object-Oriented Language), is a combination of features found in other object-oriented languages such as CLOS (Common Lisp Object System) and SmalTalk which have brought new ideas [11, 12].

Procedural part of CLIPS is similar to programming languages: C, Ada, and Pascal and syntactically very close to LISP [11, 12].
CLIPS have following three basic components [11, 12]:

- List of facts – contains data that will interact with the program.
- Knowledge base – contains all rules.
- Inference engine – controlling successive selection rules of the program.

CLIPS are intended to help software development to model near human knowledge and expertise. There are three ways to represent knowledge in CLIPS [11, 12]:

- Rule – representing heuristic knowledge based on experience.
- Functions – representing procedural knowledge.
- Object-oriented programming – also the procedural knowledge required.

In Figure 1 is presented CLIPS program that contains four frames:

- Bottom left – application made in CLIPS programming language.
- Bottom right – agenda that must be to follow application.
- Top right – list of facts.
- Top left – Dialog windows where the user give commands and answer to questions.

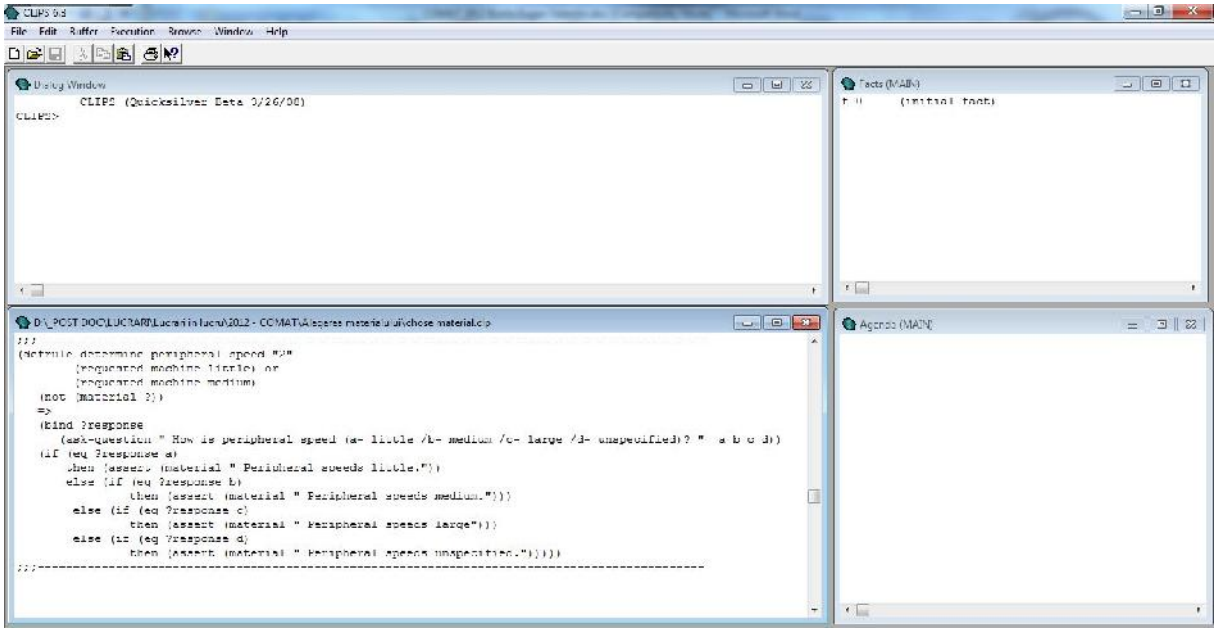

Figure 1: CLIPS programming language

1.3. Purpose of article

To choose a material have much knowledge about the properties and qualities of materials and need for specialized books, which involves a lot of work and time.
To assist engineers who need to choose a material with certain characteristics, properties that meet certain conditions author proposes an expert system for selection of materials.
Analyzing programming languages author believes that CLIPS programming language is most suitable for this application is a free and fast specialized expert systems which is suitable for the current problem.

2. METHODS

It was important to achieve the application choice of materials to be studied all materials to be included in the application database. The twenty-five materials which have been inserted in the database are presented in Table 1. The order in which have been introduced in the table has no importance, were introduced in the table only to be presented.
It was important to establish criteria for all materials. Using criteria are be chosen materials Each criteria was given qualitative values such as: little, medium, strong, very strong, unspecified. The thirteen criteria and

associated values are presented in Table 2 and constitute expert system database. For each criteria is created a question which expert system rules.

Table 1: Table with materials what can result

Material	Material	Material	Material	Material
OLC 45	15 Cr 9 (15 Cr 08)	18 Mn Cr 11 (18 Mn Cr 10)	19 Mo Cr 11	51 VMn Cr 11
OLC 50	17 Cr Ni 16	17 Mn Cr 10	20 Mo Ni 35	28 Ti Mn Cr 12
OLC 55	18 Cr Ni 20	20 Mn Cr Si 11	34 Mo Cr 11 (33 Mo Cr 11)	20 Ti Mn Cr 12 (21 Ti Mn Cr 12)
OLC 60	40 Cr 10	25 Mn Cr Si 11	26 Mo Cr 11	21 Mo Mn Cr 12
36 Mn Cr Si 13	40 Cr Ni 12	31 Mn Cr Si 11	30 Mo Cr Ni 20	17 Mo Cr Ni 14 (18 Mo Cr Ni 13)

Table 2: Table with criteria and parameters

Nr.	Criteria	Questions	Criteria values (parameters)
1	Requests	How is requested machine	little, medium, strong, very strong, unspecified
2	Peripheral speeds	How is peripheral speed	small, medium, large, unspecified
3	Machine	How is the machine	slight, heavy, unspecified
4	Task	How is the task	without shock, with shock, unspecified
5	Undergo thermal process	What must be undergo thermal process	N, CR, cementation
6	s	What is the value of s	<=16, >16 … <= 40, >40 … <= 100, >100 …<= 160, >160 … <= 250, 11, 15, 16, 25, 30, 40, 60, 63, 100, Epruveta, unspecified
7	Hardness flank HRC	What hardness must have the flank (HRC)	58-62, 60-65, unspecified
8	Hardness core HB	How much is the hardness core HB	250-270, 300-400, unspecified
9	Hardness HB	How much is hardness HB	170-200, 175-220, 190-235, 190-260, 200-220, 200-240, 200-260, 200-300, 210-240, 220-240, 220-280, 230-260, 235, 240-280, 240-300, 250-270, 250-310, 255, 257-350, 260-320, 270-330, 270-360, 280-330, 280-340, 280-350, 280-360, 290-300, 300-350, 300-400, 310-360, 350-450
10	Yield strength $sigma_{02}$	How much is yield strength $sigma_{02}$	360, 370, 390, 400, 430, 440, 450, 460, 495, 500, 520, 540, 550, 560, 580, 590, 600, 620, 635, 640, 650, 670, 680, 690, 700, 750, 780, 790, 800, 830, 850, 880, 900, 980, 1050, 1275
11	Breaking limit $sigma_r$	How much is breaking limit $sigma_r$	610 >=, 630-780, 640 >=, 640-930, 650-800, 670>=, 685>=, 700-850, 700>=, 750-900, 780 >=, 780-930, 780-1080, 790-1080, 800-950, 800-1180, 850-1000, 850-1150, 880-1080, 880-1130, 900-1100, 930-1180, 930-1220, 960-1270, 980>=, 980-1180, 980-1320, 1000-1200, 1000-1300, 1050-1400, 1080>=, 1080-1320, 1100-1300, 1175-1420, 1180-1420, 1200-1550, 1220-1450, 1230-1520, 1250-1450, 1620>=
12	Tension limit contact request sigma H_{lim}	How much is the tension limit contact request sigma H_{lim}	375-540, 1250, 1500, unspecified
13	Tension limit at the request of bending strength sigma F_{lim}	How much is tension limit at the request of bending strength sigma F_{lim}	140-240, 460-550, 425, unspecified

For each material were defined criteria values. In table 3 are presented criteria values for OLC 45 material and in Figure 2 are presented as an example a rule for peripheral speed. In this case this question will run if his turn in the agenda and answered the question “How is requested machine” with: little or medium. If the question “How

is peripheral speed" to respond with "medium" is saved in facts list with function "assert (Peripheral speeds medium)".

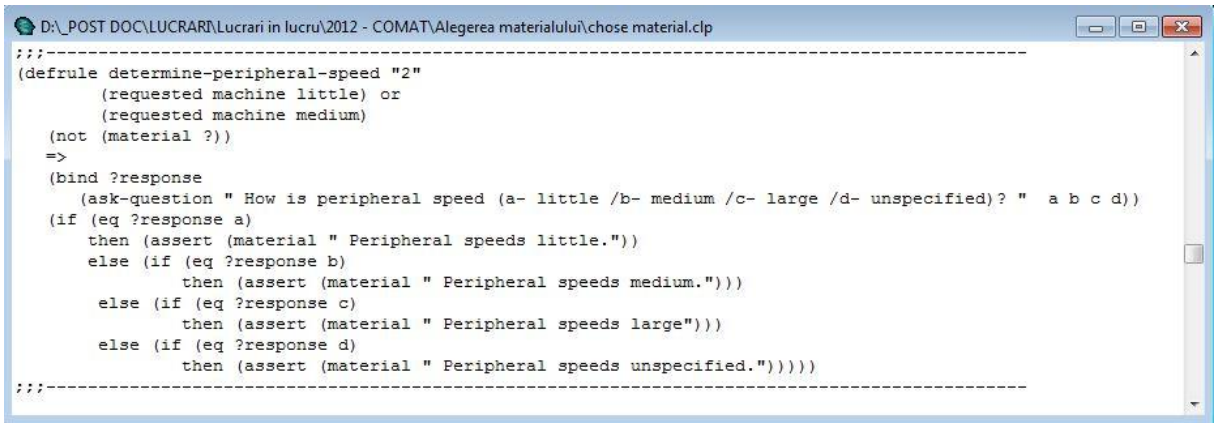

Figure 2: Window with part of application – rule for peripheral speed

Table 3: Table with criteria and parameters for OLC 45

Nr.	Possible questions	Criteria values (parameters)
1	How is requested machine	little, medium
2	How is peripheral speed	small
3	How is the machine	unspecified
4	How is the task	unspecified
5	What must be undergo thermal process	N, CR
6	What is the value of s	<=16, >16 … <= 40, >40 … <= 100
7	What hardness must have the flank (HRC)	unspecified
8	How much is the hardness core HB	unspecified
9	How much is hardness HB	170-200, 175-220, 190-260, 235,
10	How much is yield strength $sigma_{02}$	360, 370, 430, 500
11	How much is breaking limit $sigma_r$	610 >=, 630-780, 650-800, 700-850
12	How much is the tension limit contact request sigma H_{lim}	375-540
13	How much is the tension limit at the request of bending strength sigma F_{lim}	140-240

3. RESULTS

After having been analyzed materials have been determined criteria, questions created knowledge base, data base, rules, inference engine. Using this information was developed expert system for choosing materials using thirteen questions in the form of rules, basing on same number of criteria. are twenty-five possible types of material in data base.
In Figure 3 is shown a dialog window of the application with the first question had five possible answers.

4. CONCLUSION

Using an expert system for choosing materials saves a lot of effort, time and cost. Such an expert system can always be extended without major efforts should be entered in the database of the expert system criteria values for new material.
Program in which was developed the application, CLIPS is a free program open source which provides flexibility and a possible connection with other software to retrieve results.

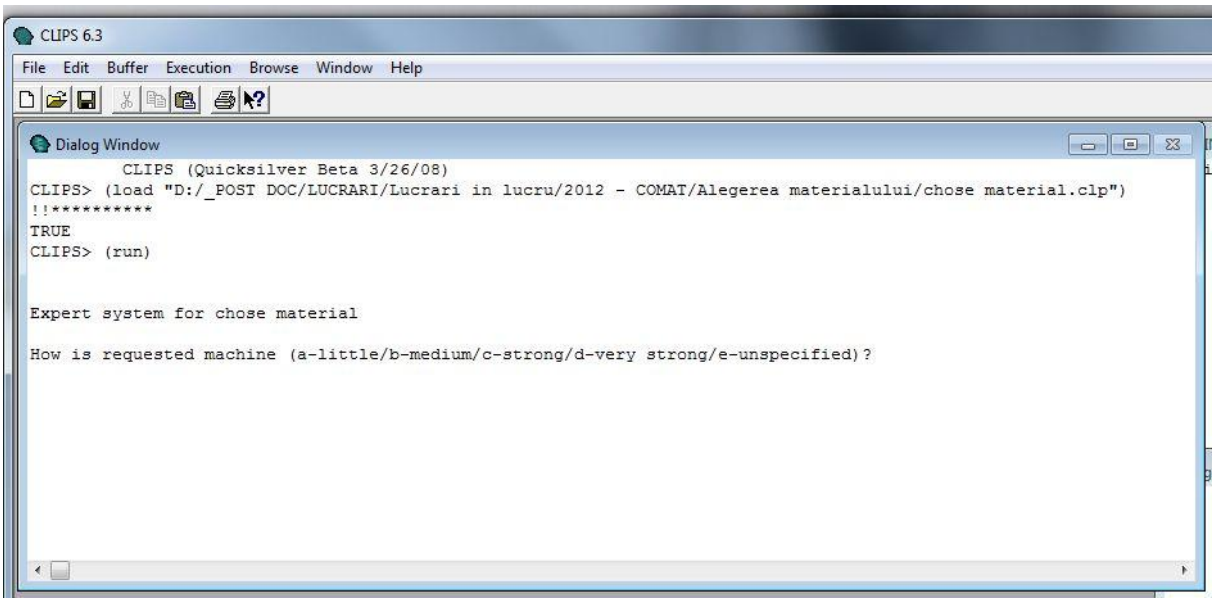

Figure 3: Window with part of application – first question

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REFERENCES

[1] Ahn, H. et al. *Hibrid Genetic Algorithms and Case-based Reasoning Systems for Customer Classification. Expert Systems*, July 2006, Vol.23, No.3.
[2] Angeli, C., Atherton, D. *A Model-based Method for an Online Diagnostic Knowledge-based System.* Expert Systems, July 2001, Vol.18, No.3.
[3] Blanning, R.W. *Management Applications of Expert Systems*, Information and Management, 1984. 6, pp. 311–316.
[4] Butilă, E. V., Sistem expert pentru alegerea materialelor roţilor dinţate, Prasic 2006, Vol. II, Organe de maşini. Transmisii mecanice, ISBN (10)973-635-825-9, (13)978-973-635-825-8, 9-10 Noiembrie, Braşov, România, 2006
[5] Cârstoiu, D.I. *Sisteme expert*. Editura All, Bucureşti, 1994.
[6] Daizhong S., Design Automation with the Aids of Multiple Artificial Intelligence Techniques. Concurrent Engineering: Research and Applications, vol 7, No. 1, 1999, pp. 23-29.
[7] Dehelean, N.M. *Sistem expert dedicat proiectării transmisiilor mecanice*. Teză de doctorat. Universitatea Politehnica din Timişoara, 1998.
[8] Moldovean G., Velicu D., Angrenaje cilindrice şi conice, Vol. I. Calcul şi construcţie. Editura Lux Libris, Braşov 2001.
[9] Moldovean G., Velicu D., Angrenaje cilindrice şi conice, Vol. II Metodici de proiectare. Editura Lux Libris, Braşov 2002.
[10] Mogan G., Butila E. V., Expert Systems for the total design of mechanical systems with gears, Product Engineering, Springer, 2004, pp 141-160, ISBN 1-4020-2932-2 (HB), ISBN 1-4020-2933-0 (e-book).
[11] http://ro.wikipedia.org/wiki/Limbajul_de_programare_CLIPS, accessed 2012
[12] http://clipsrules.sourceforge.net/, accessed 2012