"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Material)"

Signature : .....

Name of supervisor : **MOHD NIZAM BIN SUDIN**

Date : MAY 2006

KNOWLEDGE BASED SYSTEM FOR MATERIAL SELECTION IN BUMPER BEAM DESIGN

AHMAD TAJUDDIN BIN HAMZAH

A project submitted in partial
fulfillment of the requirement for the award of
the Degree of Bachelor of Mechanical Engineering (Structural & Material)

Faculty of Mechanical Engineering
Kolej Universiti Teknikal Kebangsaan Malaysia

May 2006

"I hereby declared that this thesis is my own work except the ideas and summaries which I have clarified their sources"

Signature : .....

Author : **AHMAD TAJUDDIN BIN HAMZAH**

Date : MAY 2006

"In the name of ALLAH"

Specially dedicated to person who believes in me, especially to my family, my lectures and my friends.

ACKNOWLEDGEMENTS

In the name of ALLAH, the most Gracious and most Merciful

Thanks to ALLAH, for giving permission to complete my thesis. Many people have made contributions to this thesis. Firstly, I wish to acknowledge my supervisors, Mr. Mohd Nizam Bin Sudin for his guidance, supervision and encouragement. He also one of the person to share his own ideal to given me inspiration to develop this material selection system. Secondly, I would like to thanks to all my lectures on KUTKM for teaching me, especially Mr. Ahmad Rivai. His time spent for teaching me about the material selection system in a concurrent engineering environment.

My most heartfelt thanks go to my family, mostly to my father, Hamzah Awang and my mother, Masitah Mohd for their support and providing an environment in which writing the paper was a pleasurable challenge. No forgetting, to my teacher in Visual Basic software programming, Mr. Aswad Johari for teaching me a lot about programming language.

Lastly, I would like to express my special thanks to my friends and those who have contributed their efforts and help in assisting me to complete this system. With the assistant, guidance, and support from all related stake holder have make the project complete successfully and achieve the objective project.

ABSTRACT

This project focuses on the development of Knowledge Based System (KBS) for material selection in bumper beam design. Knowledge Based System (KBS) is an expert system is used to select most suitable material by defining constraints value into the system. The aim of this project is to select the most suitable material for bumper beam. The selection method is based on the material selection requirements such as mechanical properties, physical properties and economic value. The constraint values are selected from the product design specification. The specification values are derived from the experimental work and design calculation. The operation of KBS is defined the materials at hierarchical graph and selecting the most suitable materials by ranks. The top ranking is the materials with the most same with the user's specification values.

Understanding the bumper beam characteristic, material selection process and programming language, it will be an advantage to develop Knowledge Based System in material selection in bumper beam design.

ABSTRAK

Projek in adalah melibatkan pembangunan Knowledge Based System (KBS) untuk proses pemilihan bahan bagi komponen rasuk bumper. KBS adalah sistem yang digunakan untuk memilih bahan berdasarkan kepada keperluan pengguna. Matlamat projek ini adalah untuk membina proses pemilihan bahan yang sesuai untuk komponen rasuk bumper. Proses pemilihan ini adalah bergantung kepada ciri-ciri pemilihan yang diambil kira seperti sifat mekanikal bahan, sifat fizikal bahan and keutamaan kepada bahan yang ekonomi (murah). Ciri-ciri pemilihan ini dipanggil "constraints value'. Nilai 'constraints value' adalah berasal daripada spesifikasi rekabentuk produk. Specifikasi ini diterbitkan daripada eksperimen dan pengiraan oleh pereka. KBS beroperasi dengan mencari jenis-jenis bahan di dalam hieraki dan memilih bahan tersebut berdasarkan kepada kedudukan bahan. Bahan yang berada di atas adalah merupakan bahan yang paling sesuai kerana memenuhi specifikasi yang diperlukan oleh pereka.

Dengan memahami tentang sifat komponen rasuk bumper, proses pemilihan bahan dan bahasa penggatucaraan, ianya akan lebih bernilai dan berguna untuk membangunkan KBS ini.

LIST OF CONTENTS

CHAPTER	CONTENTS		PAGES
	DECLARATION		ii
	DEDICATION		iii
	ACKNOWLEDGEMENTS		iv
	ABSTRACT		v
	ABSTRAK		vi
	LIST OF CONTENTS		vii
	LIST OF TABLES		x
	LIST OF FIGURES		xi
	LIST OF SYMBOLS		xiii
	LIST OF APPENDIX		xiv
1	**INTRODUCTION**		
	1.1	Overview	1
	1.2	Problem Statements	2
	1.3	Problem Solving	3
	1.4	Project Objectives	3
	1.5	Goal Statements	3
	1.6	Tasks	3

2	**LITERATURE REVIEW**		
	2.1	Knowledge Based System	5
	2.2	Advantages of KBS in material selection.	7
		2.2.1 Reduced lead-time.	7
		2.2.2 Product Optimization.	8
		2.2.3 Knowledge capture.	8
	2.3	KBS Application in Material Selection	9
	2.4	Knowledge Modeling Approach in KBE	11
	2.5	Material Selection Process	13
	2.6	Selection Strategies for Materials and Processes	14
		2.6.1 Free searching, based on quantitative analysis	15
		2.6.2 The questionnaire strategy, based on expertise capture.	16
		2.6.3 Inductive reasoning and analogy.	17
	2.7	Bumper Beam	19
3	**METHODOLOGY**		
	3.1	Overview	21
	3.2	Analysis and Define the Requirements of Bumper Systems.	23
	3.3	Material Selection Requirements.	26
	3.4	Definition of mechanical and physical properties	28
		3.4.1 Mechanical properties	28
		3.4.2 Physical properties	31
	3.5	Database and Software to develop KBS	31
		3.5.1 Database.	32

	3.5.2	Software.	36
3.6		Material Selection Process	37
3.7		Implementation Material Selection System in Computer	40
	3.7.1	User Interface.	41
	3.7.2	KBS Constraints.	42
	3.7.3	User Input Data.	43
	3.7.4	Material Selection Process in Computer Rule or Language	44
4	**RESULT**		
4.1		Selection Methodology	46
	4.1.1	Constraints.	46
	4.1.2	Formulating in material selection process.	50
	4.1.3	Presentation of the final result.	55
	4.1.4	Printing the result.	59
	4.1.5	Edit the database.	60
4.2		Analysis of results.	62
5	**CONCLUSION**		
5.1		Conclusion	64
5.2		Suggestion and Recommendation for the future work.	66
	REFERENCES		67
	APPENDIX		71

LIST OF TABLE

NO. TABLE	CONTENTS	PAGES
1	Existing software for selection relying.	18
2	Result for pre-materials selection process.	35
3	Performance index.	39/50
4	Constraints limitation.	42
5	Calculation of performance index for each material.	53
6	Result on top 5 based on ranking.	54

LIST OF FIGURE

NO. FIGURE	CONTENTS	PAGES
1	Material selection in product development	2
2	Project Flow Chart	4
3	Architecture of the Knowledge Based System	6
4	Example of free searching strategy.	15
5	Example of questionnaire strategy.	16
6	Position bumper beam structural on car.	19
7	Steps involved in material selection.	22
8	Material selection consideration for bumper beam.	27
9	Materials database selection charts.	32
10	Young's Modulus versus Cost chart.	33
11	Specific Stiffness versus Specific Strength chart.	33
12	Strength versus Toughness chart.	34
13	Young's Modulus versus Density chart.	34
14	Force diagram	38
15	Material selection hierarchy tree.	40
16	User Interface	41
17	User interface for input data	43
18	Flowchart of Material selection process base on performance index.	45

19	User requirement or user constraints.	47
20	Performance index formula in programming language.	48
21	Young Modulus (GPa) versus Density (Mg/m^3) chart.	49
22	The programming language in ranking process.	51
23	The public functions to move the material in the ranking process.	52
24	Result Interface	56
25	Graph Interface (Density)	56
26	Graph Interface (Cost)	57
27	Graph Interface (Compressive Strength)	57
28	Graph Interface (Flexural Strength)	58
29	Print Page Interface.	59
30	Administrator gate.	60
31	Database interface.	61

LIST OF SYMBOLS

A	Area
d	Diameter, distance
E	Modulus of elasticity
F	Force, fundamental dimension force
g	Acceleration due to gravity, function, gram
I	Mass moment of inertia, second moment of area
J	Polar second moment of area, geometry factor
L	Length
M	Moment, fundamental dimension mass
m	Mass, meter
S	Strength
R	Radius, reaction force
σ	Normal stress
τ	Shear stress
ρ	Density
ε	Strain

LIST OF APPENDIX

NO. APPENDIX	CONTENTS	PAGES
A	Interface frmLogin and Programming	72
B	Interface frmUserSearch and Programming	74
C	Interface frmUserSearch2 and Programming	77
D	Interface frmResult / frmResult2 and Programming	80
E	Interface frmGraph and Programming	89
F	Interface frmAddMaterial and Programming	94
G	Interface MDIMaterialSelection	98
H	Interface frmSelectedMaterial	99
I	Interface frmSearchSelection	100
J	Interface FrmDB and programming	101
K	Interface frmMPropertiesPrint and Programming	104
L	Interface frmEditAdmin	106
N	Interface frmAbout	106
M	Material Searching Programming	107
O	Material Selection Programming	110

CHAPTER 1

INTRODUCTION

1.1 Overview

Science computers with elaborate software programs have not only become invaluable tools for computer-aided design and manufacturing (CAD/CAM) processes, but are also emerging rapidly as potentially powerful tools for materials selection. Some of companies offer expert systems for selecting their product's with the best meet a particular set of requirement, environmental consideration and geometric compatibility. For example, the bearing design guide developed by Furon, a manufacturer of structural bearings. S.M Sapuan et al. (2002) was developed a prototype knowledge-based system (KBS) for automotive engine components is one of KBS in Malaysia.

In the past few years new technologies and technique have appeared both in the industry. The industry needs tools to handle its problem effectively, and the computer science (CS) and AI communities have to take these demands into consideration. KBS are one of the results of this process, as the combination of conventional and new programming technologies can solve problems easier, more cheaply, and with lower risk than former approaches.

Today, material selection process is most important activities for product development process. It is because material selection plays as important a role for each activity in the total design model part, started with conceptual design, product design specification and detail design. However, material selection process is plays the secondary important activities after manufacture. In Figure 1 showed the concurrent engineering activities in the industry to day.

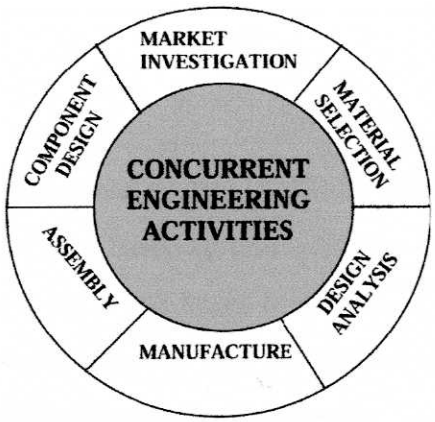

Figure1: Material selection in product development.

1.2 Problem Statements :

Nowadays, there are many scenarios in design element. One of scenarios is the problem regarding the design element. The problems are:-

- Take more time in material selection process for one components or product.
- Do the same works in material selection process and it is cost so expensive.
- At the most basic level, design engineers could use table of material properties in handbooks. However, data sheets are incomplete and once published, they are difficult to update.
- Some of material selection process is not produce the good result. It is because the procedure of selection process is not related with design data, analysis and other factor.

1.3 Problem Solving :

- Develop the expert system that it can operate the job such as material selection designer. All knowledge from material selection designer will transfer to this system.
- Content the system with update material database.

1.4 Project Objectives :

- To apply knowledge based system (KBS) for material selection.
- To integrate knowledge based system with material database.
- To collect all database in one frame or software.
- Develop one material selection process with consider to mechanical properties, physical properties and economic.

1.5 Goal Statements :

- To increase in availability of material properties through improved processing techniques.
- Generate material application to been towards more efficient use of existing materials.
- Make material selection process become easier and very effective by using computer-aided system (KBS).

1.6 Tasks :

- To study knowledge based system software.
- To study material selection consideration and procedure.

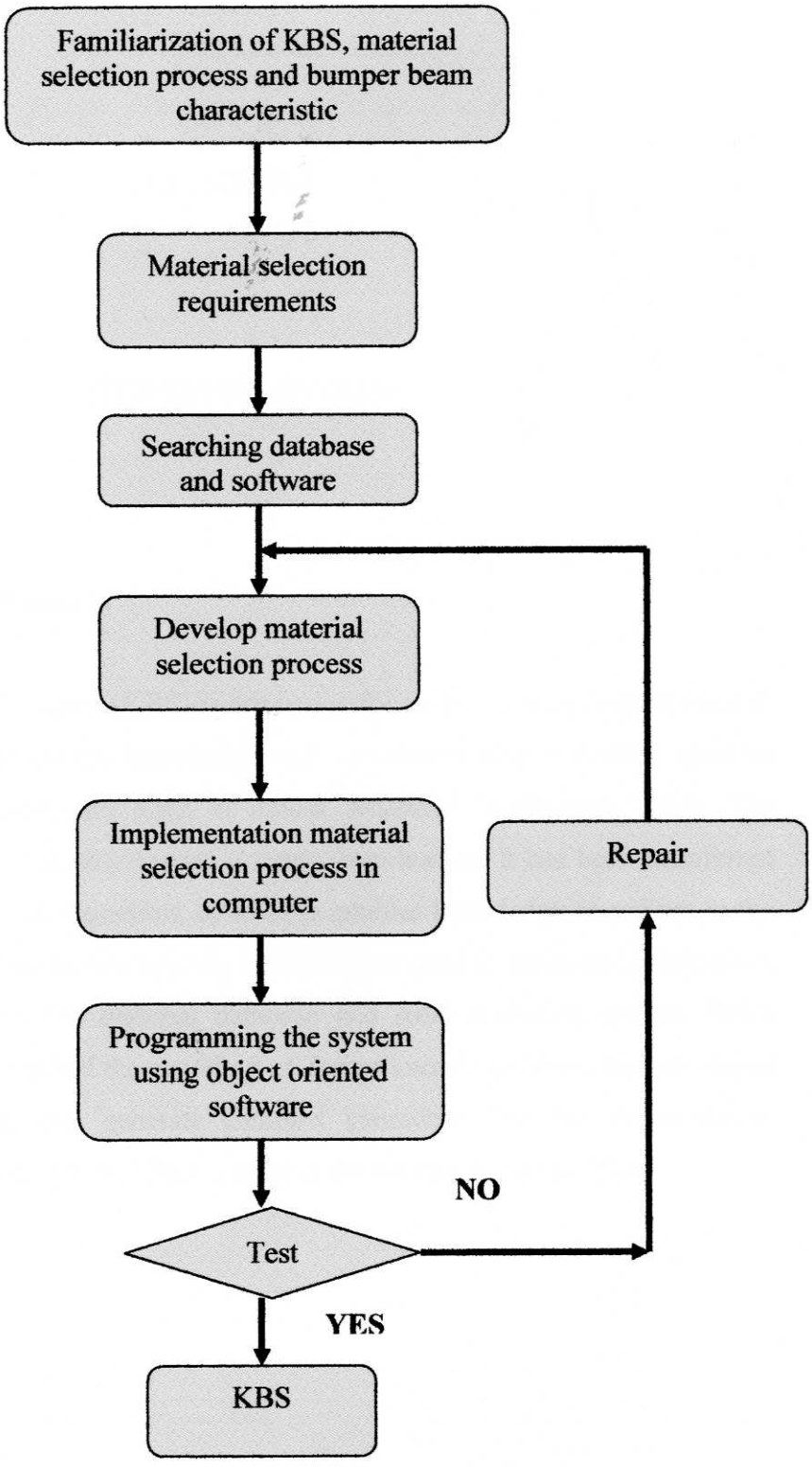

Figure 2: Project Flow Chart.

CHAPTER 2

LITERATURE REVIEW

2.1 Knowledge Based System

Knowledge Based System (KBS) is not just software but it is an 'expert system' because it has a capture expert knowledge and sometimes also generates creative solutions. That why, sometimes KBS is called Artificial Intelligence, (AI). The knowledge and intelligence on this system is come from human. It has been transferred to computer by implementing equations, or rules to enables knowledge recycling. In the Figure 3 shows the relationship between the various tools used in the material selection, including knowledge base, the material database and solid modeling system. Pablo Bernell- Garcia (2002) described the encoding of design knowledge from domain expert into computer codes that can generate complex geometric data has demonstrated significant savings in manpower and time resources for routine design problem.

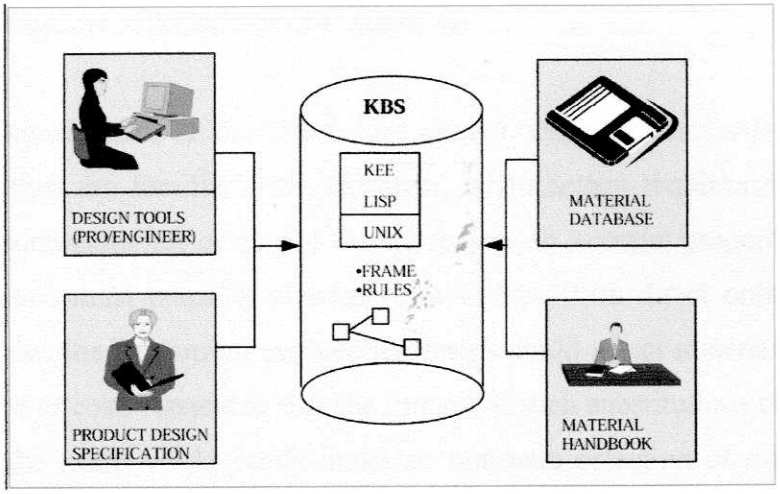

Figure 3: Architecture of the Knowledge Based System

S.M Sapuan (2002) stated that KBS are software program designed to capture and apply domain-specific knowledge and expertise in order to facilitate solving problems. Languages can be used as a means to build KBS. Prasad B (1997) described the Knowledge-based engineering (KBE) deals with processing of knowledge. KBE is a process of implementing KBS in which domain specific knowledge regarding a part or process is stored together with other attributes.

In other mean, S.M Sapuan (2000) defined the KBS comprises expert knowledge capable of assisting the user in an interactive way to solve various problem or queries. KBS is a computer system which attempts to represent human knowledge or expertise in order to provide quick and easily accessible knowledge in a practical and useful way. KBS have the ability to accomplish cognitive tasks, which currently require a human expert. They can automate real time use of existing expert knowledge, explain its reasoning process and is readily extensible.

Marcus Sandberg (2005) described the core of the system is the product model where product and process knowledge is stored. External database are used for tabled data or graph material selection. Input to the KBS system is usually customer's specifications, which in turn several kinds of output when being processed. The system software is object-oriented and can therefore perform demand-driven calculation.

2.2 Advantages of KBS in material selection.

S.M. Sapuan (2001) described that design engineers normally rely on the materials that they are familiar with. However, when design requirements exceed the constraints of such materials or exceed the constraints on material properties, concurrent engineering teams must consider alternative materials. With direct online access to a material database, the concurrent engineering teams could select material that a lighter, stronger and lower cost. Assuming that the impact of such substitutions can be analyzed or simulated, the teams could easily make an optimum selection of materials for the available process, converse materials for each process and thus, reduce material waste.

White (2003) emphasized the importance of computer-aided materials selection as books have several drawbacks as they are often outdated before reaching the bookshelves. It is very difficult to index them to find answers or to sort data in the manner of your choice.

Marcus Sandberg (2003) stated the most obvious benefit from using a KBS is reduced lead-time. It is also easier to optimize products. By capturing knowledge, staff turnover is not big problem. Because time demanding routine tasks are automated more time for creative solutions are given.

2.2.1 Reduced lead-time.

The major benefit is that KBS systems reduce the lead-time. This is highly pronounced for product development of products with the following properties:-

- Product with high degree of similarity between versions. The higher similarity the more knowledge can be re-used.

- Products requiring a large amount of design configurations (e.g. geometry configurations, material alternatives, etc). Design configurations are suitable to be controlled by rules.
- Product with a large number of design processes (e.g. FEA, cost calculation, weight calculation). These design process can be performed automatically in a "one button push" matter f all needed input is given to the KBS.

2.2.2 Product Optimization.

Optimizing the design is easy – trial and error goes fast. The user can try many "what ifs" and come to a conclusion after a radically smaller of time than before. The computer can also search for best configuration within a specified range.

2.2.3 Knowledge capture.

Staff turnover is no longer a big problem for companies using KBS because base knowledge is stored in the product model. This also implies that companies can reduce their outsourcing activities when basic knowledge is stored and handled by the KBS.

2.3 KBS Application in Material Selection

S.M Sapuan et al. (2002) described material selection is usually carried out by design and material engineers. Many systems are available to help the designer to choose the suitable materials. At the basic level, a designer can select materials from material handbooks. However, selecting suitable materials with respect to the mechanical properties is a big task due to incomplete and non-availability of proper material records. Therefore, industrialists have implemented computer based system and material selection tools. Knowledge based systems are one of the procedures was designed for material selection.

Now day, many knowledge based system in material selection has been reported. It started by (Nielson et al., 1986) with development of KBS for consultancy in selection of polymer materials. After that, (Bullinger et al., 1991), (Bergamaschi et al., 1989), (Nitshe et al., 1990) and (S.M. Sapuan et al., 2002) developed knowledge-based system for material selection of polymer-based composites and ceramic matrix composites material. Boose (1986) used KBS for selecting the best fibers for aircraft parts of Boeing such as rudders, spoilers, elevators and cowl components. Thurston and Crowford (1991) used KBS in selection of polymer material for bumper systems in automobiles. Fehsenfeld et al. (1989) employed in the selection of composites materials for automotive leaf springs.

S.M Sapuan (2001) stated one of the important companies is material suppliers. However, a computer tool is needed for concurrent engineering teams to select the best material. They require a comprehensive tool such as KBS to select the material in less time. Thus, KBS can be accessed by other in the concurrent engineering team through an on-line network. New developments in Information technology (IT) such as KBS now provide the means to deliver an enormous amount of data. The problem of making reliable and rational selection of materials for developing novel or improved artifacts is becoming increasingly essential as the number of novel materials with unaccustomed properties increases and KBS has the capability to carry out this task.