THE DEVELOPMENT OF A KNOWLEDGE BASED SYSTEM FOR THE RUBBER INDUSTRY

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SUMMARY

The development of a **Knowledge Based System (KBS)** for Rubbers is reviewed. The many activities which lead to the development of a product such as material selection, design, process optimisation and costing are interdependent. Their concurrent execution needs rapid access to digestible knowledge and information.

Interpretation can only be undertaken by knowledgeable personnel. These people take time and money to develop and are inefficient in terms of knowledge transfer. A growing trend in many industries is to overcome some of these problems via the use **of Knowledge Based Systems (KBS)** which are computer based and permanently encapsulate knowledge and data. The need for information, data and knowledge is discussed.

The system described provides a coherent framework of cognate modules capable of continuous expansion and designed to allow for the encapsulation of the users own (confidential) information. The system interacts with a broad bibliographic and topic database and is integrated to various expert system modules in, for instance, Material Selection, Design, Failure Diagnosis and Process Optimisation.

There exists a common need for knowledge and information in all sectors of the rubber industry whether it is for *Material Supply*, the *Manufacturing* or the *End Use*. The effective provision of such knowledge is of mutual benefit to all sectors of the industry.

When dealing with research, process or product development, trouble shooting or optimisation, the classical approach is for in-house personnel to collate public domain information that is available to them, combine that with their own knowledge and then tackle the problem at hand. This approach has a number of drawbacks :

- the sources of PD (Public Domain) information may be limited by the individuals awareness;
- the accuracy, completeness, currency and impartiality of the PD information may be suspect;
- the internal personnel with relevant knowledge may not be available;
- the information must be interpreted by knowledgeable personnel who can be transient with reference to their time with the company.

If we consider the consequences of the classical approach in terms of the failures we have seen in rubber components it assists in our analysis of the need for **Knowledge Based Systems (KBS).**

For failures that in retrospect were avoidable, (the vast majority) two causes can generally be identified; one which blames the human procedure that failed to avoid the problem and one which

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blames the material properties. As both interpretations add value to the debate they have both been included and summarised in Figures 1 and 2.

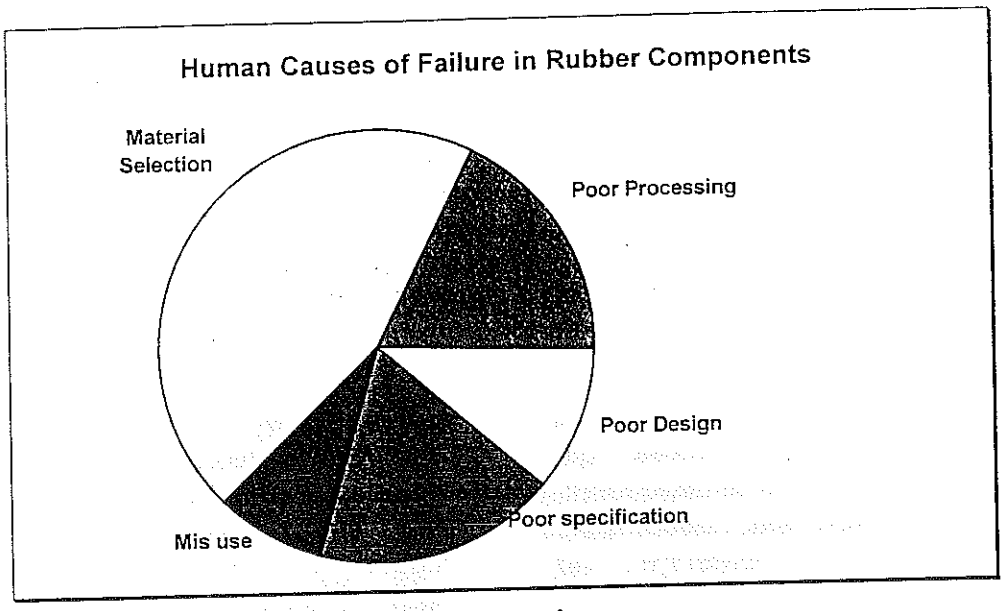

Figure 1

Of the five human causes tabulated, 4 of these, accounting for > 90%, are all avoidable by providing the designer, specifier or manufacturer with the appropriate information or design tools.

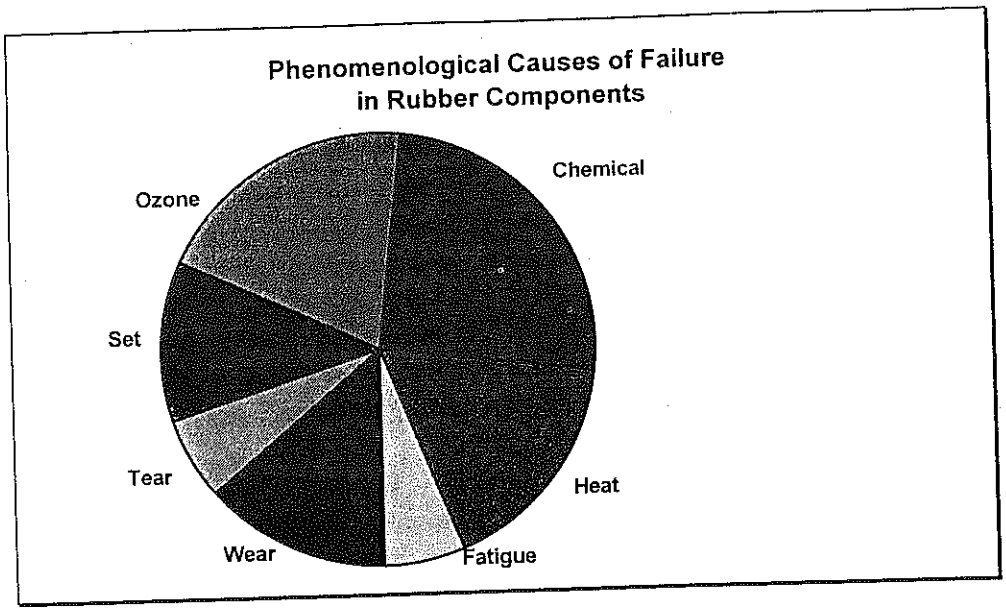

Figure 2

When it comes to material properties, the end use sector in particular have a greater need for knowledge. Some topics, such as Ozone and Heat are relatively easily handled, but chemical resistance is more difficult.

The lack of awareness of chemical resistance is in stark contrast to the massive effort expended on the subjec by the science base over the past 5 years. However, designers do not hav the time or inclination to study the elega but often turgid contributions of th science base. What they need ar guidelines and rules. Designers do stud suppliers' literature which unfortunatel (or purposely) tend to avoid the issue

Chemical resistance data sheets invariably cover Tomato Ketchup (O.K.) to Aqua Regia (not O.K.). All very useful but of more use and requiring little space would be the statement "This material is susceptible to attack by polar fluids such as aromatic hydrocarbons etc. Where specific test data is not available it is recommended that the material should be tested in contact with all anticipated fluids and assessed for volume change (±) and degradation in physical properties".

There is now an attractive alternative to this classical approach and it takes advantage of the massive developments in Information Technology. The alternative that **RAPRA** is advocating and developing is called **Knowledge Based Systems (KBS)**, they permanently encapsulate knowledge and data and present the opportunity to avoid all the pitfalls of the classical approach. Further, dissemination using CD-ROM technology is cost effective and gives the flexibility to meet the needs of all sectors of the industry.

More specifically over the last 3 years RAPRA have developed a structure and a methodology for **a Knowledge Based System** which by virtue of its features, scope, and openness, invites the user to adopt a Knowledge Based Culture which will ultimately result in significant benefits to the company.

THE STRUCTURE

First thoughts concentrated on two aspects:

- where would we find the sources of knowledge and information?
  and
- what form would the Knowledge Base take?

It was fairly obvious from the outset that it would not be possible to author all of the information, text and programs that would be required to give a tool of general utility in the time available. Therefore we examined existing sources for their suitability. The first element available was *Rapra's Bibliographic Database*. This has been built up over the last 23 years and because of its current form can be subdivided or segmented to suit the particular area of interest.

However *Bibliographic Databases* have a drawback in that the sources of information are undisciplined and potentially subject to bias - e.g. a suppliers viewpoint with reference to their materials.

To overcome this problem the next step was to assemble what we call the **"Topic Base".** This has developed into an encyclopaedic reference to all aspects of rubber materials, processes, products and properties. The capacity to encapsulate these elements with current CD-ROM technology is in excess of 100,000 A4 pages, more than enough to accommodate our needs in the first 2 years and development in capacity will outstrip the growth in the system.

To assist with the more intellectually demanding aspects of design, material selection, process optimisation and so on it was deemed necessary to have activity modules (programs or expert systems) that are integrated with the other elements of the **KBS**.

And finally because we believe this is a philosophy that should be adopted by the industry we have provided the tools for the user to build their own **Knowledge Based Systems (KBS).**

Thus by initially considering what would be the sources of the content of our system we had decided on a structure.

To summarise the structure of our KBS consists of 4 elements, all integrated and all complementary and is as in Figure 3.

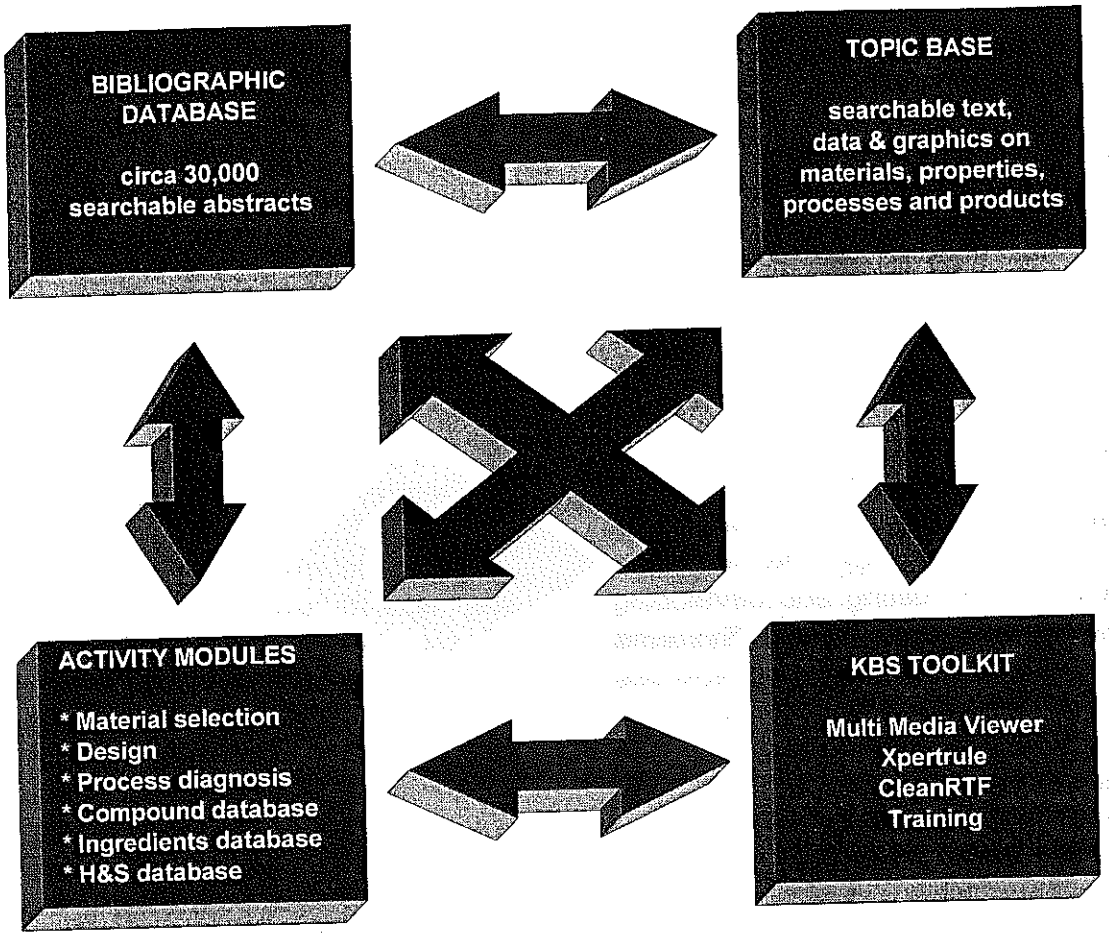

Figure 3

THE SCOPE

Activity Modules

Systems have been designed to interface with the Topic Base and developed in the areas indicated in Table I below.

Table I
Activity Modules

Area	Breadth	Comment
Material Selection - **Rubacams**	All commercially available polymers inc. subgenerics and TPEs	Selection by service conditions, chemical resistance and property wish list. Technical and supplier information.
Injection moulding Flow Analysis - **Fillcalc V**	Rubber and thermoplastic materials simulation in the mould situation	The ability to predict flow characteristics, weld lines, vent points and provide flow balancing.
Compound database - **CompBased**	All commercially available polymers	As provided by raw material suppliers, formulation, processing and finished property data. Compatible with commercial systems. Linked to Material selection.

Ingredients database - **CompBased**	Standard compounding ingredients	Identity, Suppliers, Applications, Density, % active ingredient etc. Compatible with commercial systems. Linked to Compound database. Linked to BRMA Code of Practice.
Cure calculator - **Curecalc**	Cure time calculator	Heat Transfer and curing model using transient cure calculations (ex. FILLCALC V). User input of basic dimensions and material characteristics.
Design - **Spring**	Generalised, load bearing components	Analytical design rules, design methodology, properties of particular concern, classical errors, failure avoidance.
Test Equipment Database - **TestBased**	Polymer test equipment	Suppliers name, address and telephone number. Range of equipment supplied.
Compound Hardness Calculator - **Hardcalc**	All polymer types, carbon black grades and some major white fillers	The user can calculate the effect of loading of filler and oil in terms of the resultant hardness. Calculations can be inverted to calculate filler or oil loading.

Topic Base

The topic base covers materials, properties, design, compounding, processing, environmental and applications/ products.

It is encyclopaedic in coverage and also forms the working environment for all the other elements of the **Knowledge Based System (KBS)**, i.e. the *Bibliographic Database and Activity Modules* will be launched from here.

Table II
Topic Base Scope

Area	Breadth	Depth
Materials	All commercially available polymers inc. TPEs	Advantages, disadvantages, chemical resistance, applications, trade names, suppliers and addresses.
	Major Polymer suppliers technical information	Key articles on raw material grades, compounding, processing and properties.
	Compounding ingredients	Key articles on material descriptions, compounding, influence on processing and properties
Properties	Generic polymer	General & electrical, mechanical, chemical and radiation, dynamic, costs.
	Typical Formulations for major polymer types	Specific physical properties and influence of compounding ingredients.
	Testing	Physical Testing of Rubber 3rd Ed Brown,RP. Guide to Test Equipment.

Processing and conversion	Dry rubber, latex	Moulding, extrusion, calendering, fabrication, dipping, rubber to metal bonding.
Environmental	European perspective	Legislation, monitoring, hazards, health and safety, BRMA Code of Practice.
Specifications and Standards	BS, CEN, DIN, ISO, NT	Properties, products, processes (Also covered by Bibliographic Database).
Products		Typical applications, major suppliers with addresses.
Review Reports	All Polymers (inc. T/P)	Full RAPRA Review reports with abridged abstracts and inhibited print and copy facilities.

BIBLIOGRAPHIC DATABASE

It is useful to describe the RAPRA Abstracts Bibliographic Database in full as this forms a very significant element of the **Knowledge Based System (KBS)** and a safety net in the event that no data is available in the *Topic Base*.

Rapra's main database, RAPRA Abstracts, was launched in 1972 and is now recognised as the world's most comprehensive specialising in rubbers, plastics, adhesives and composites. It contains over 450,000 references, added to at the rate of 3,000 per month, and is available on-line via various hosts such as Orbit, Data-Star, Dialog, ESA, or STN.

In addition to the main file, specific sub-files exist covering Adhesives Abstracts, Polyurethanes and New Trade Names (registered and unregistered trade names).

CD-ROM

All references abstracted since 1986, some 220,000, are also available on CD-ROM, which provides a user friendly, menu-driven search mode on compact disc with help pages at each stage. The Disc is updated every two months with approximately 35,000 abstracts being added each year. Separate Plastics and Rubber Materials Discs are also now available, and a backfile disc with references from 1972 to 1986 (220,000).

Within the **KBS** *the Bibliographic Database* will be available at a range of levels as indicated in the Table III.

Table III
Bibliographic DataBase Options

Level	From	To	Updates	Coverage	Comments
Basic	1984	Date	Annual	Rubber Technical	circa 35,000 abstracts
Full	1972	Date	Bi Monthly	Rubber Technical and Commercial	circa 120,000 abstracts
Comprehensive	1972	Date		All topics (Rubber, TP & T.Set)	As per full CD-ROM
Patents	1994	Date	Bi Monthly	All topics (Rubber, TP & T.Set)	New from JAN 1994, Additional sector

The **standard Knowledge Based System (KBS)** will contain the Basic version but users can upgrade within the capacity of the CD.

PUBLIC DOMAIN AND IN HOUSE DATA/ KNOWLEDGE

A further feature deemed critical by the users was to be able to use the technology for their own **KBS** development and to interface with the RAPRA system. In order to meet this need several steps have been taken:

- **Annotation:** The user can append an annotation to any or every topic or abstract in **the Knowledge Based System (KBS)**. This resides on their hard disk and remains linked even if the system is updated.
- **Open dataBaseds:** The databases will have an open, industry standard, database structure such that the user can copy, add to or amend the data and integrate it with other databases they may be using.
- **Mapping:** The topics in the RAPRA system have been fully mapped and identified to enable the user to link (via Hot Jumps) from their own **Knowledge Based System (KBS)** or application and thus make fuller use of the RAPRA data without duplication.
- **Training:** All users of the system are offered training in the software techniques used to facilitate the building of their own systems.

Many of the Knowledge encapsulation techniques that Rapra use are within the scope of any company that uses PC based word processing. Several of the industrial collaborators involved in the development of the system are actively working on their own **Knowledge Based Systems (KBS)**. They comment that "The technicalities present no difficulties, the problem is persuading the potential users in the company to adopt the culture". **KBS Rubber** contains a facility (button) to jump to the users own **Knowledge Based System** which resides on their hard disk.

To that end the CD comes with various tools to enable the user to build the own **Knowledge Based System (KBS)** and make jumps back into RAPRA's topic base. These include the Multi Media Viewer 2 Publishing Tool Kit, expert system shells (CLIPS and XpertRule) and full training on the building of their own **KBS**.

IMPLEMENTATION

It was considered crucial if the system was to achieve general utility that the scope coverage and detail should be extensive. If this was the case the volume of material in the system would be far beyond our ability to effectively catalogue by manual means. Therefore it was essential to have search and retrieval routines that would allow the user to rapidly access the piece of information they required at that point in time.

This had already been achieved in the *Bibliographic Database* via the Clarinet Clearview software which allows full free text searching using Boolean logic (and, or, not) on your search criterion. This permits almost instantaneous access to the relevant data. However, the inclusion of diagrams, graphical data, full colour illustrations and full connectivity with other windows programs was not straightforward.

Many systems were examined and eventually the choice of the Microsoft® MultiMedia Viewer was made. This is a development of the Windows™ Help system with specific facilities for full free text searching, the incorporation of images, multi media elements and hypertext or hypergraphic hot jumps. Further the crea-

documents to be included with little extra effort. Connectivity to and from other Windows™ applications, can be implemented with appropriate knowledge of Windows™ programming.

THE FUTURE

The quantity of information available to the designers and specifiers of rubber products is considerable but its quality in terms of accessibility, clarity, and credibility is less than satisfactory. This promotes confusion which is the antithesis of awareness. Lack of awareness is responsible for the vast majority of product failures diagnosed by Rapra over the past 25 years, and by implication, it is responsible for the more numerous but less visible problems of over - design and compromised product quality.

There is a need, and now an opportunity, to improve the situation by the encapsulation of large quantities of information, data, rules and relationships into an affordable and accessible IT product. This approach offers the most cost effective means of knowledge transfer on a massive scale.

RAPRA has a vision and an intention to create a continuously growing and developing **Knowledge Based System (KBS)** such that whatever the needs of the designer, technologist or end user there exists, in a readily accessible form, the information or knowledge to meet their needs.

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