

COMPUTER-BASED EXPERT SYSTEM FOR TROUBLESHOOTING EMULSION MANUFACTURE

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INTRODUCTION

A computer-based expert system was developed to diagnose and troubleshoot factory production of bitumen emulsions in South Africa. This was done by a company which operated seven commercial bitumen emulsion factories and one bitumen emulsion research facility. The expert system was intended to assist and supplement the bitumen chemists in supporting production. It was also intended to support experienced production managers at factories where no chemist was readily available. Given the similarities of bitumen emulsion production around the world, this system has international application. Indeed, it is believed that this system is at the forefront of bitumen emulsion production technology.

The paper outlines the expert system, its development and extent, some examples of application, and draws some conclusions about the use of this system in practice. It shows the potential to industry in using such systems to increase access to technology and to capture the valuable practical experience of senior employees.

The system was developed using an outside developer and psychologist to build a mind-map of the knowledge of a very experienced bitumen chemist. From this mind-map, the first flowchart of the system was drawn. Then the potential problems, their possible causes, and batch fixes were added using a small team of bitumen emulsion experts. This system was put into practice for 6 months, and then was updated to add new solutions, products, and to amend causes and fixes.

The body of the presentation follows as slides.

COMPUTER BASED EXPERT SYSTEM **CONCEPT**

- Develop a computer based expert system for troubleshooting problems in bitumen emulsion production
- Similar systems exist in some other industrial processes which use complex materials
 - *i.e. chlorine manufacture*
- Capture the knowledge of the company's experts
 - *especially those with many years of experience*
- A hierarchy of responses
 - *most probable cause listed first*

COMPUTER BASED EXPERT SYSTEM

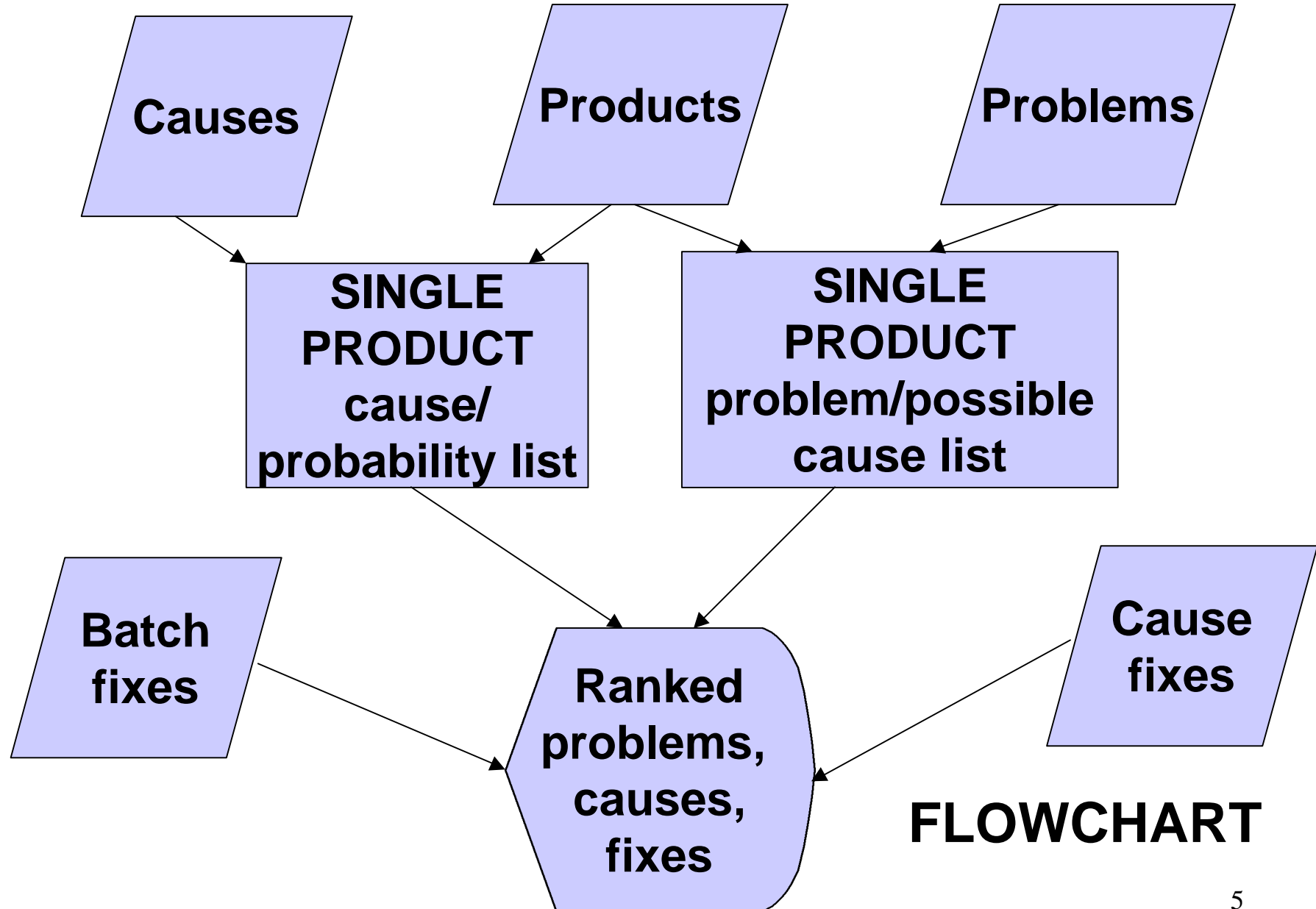
GOALS FOR THIS SYSTEM

- Raise the technical capacity of all factories in a large company to a common level
- Capture the practical experience of senior employees before retirement
- Give factory managers a tool to help solve smaller production problems without external assistance
- Assist central technical services with the remote diagnosis of more complex problems
- Generally assist bitumen chemists in problem solving
- Use for training new technical and production staff

COMPUTER BASED EXPERT SYSTEM **BUILDING BLOCKS OF THE SYSTEM**

- **PROBLEM** hard evidence that there was a problem (usually shown by failure to meet a test)
- **CAUSE** possible causes, ranked by probability. **The most common cause was listed first, and the least likely cause was listed last.** Causes were often expressed in production terms: i.e. soap-feed rotameter level too low or bouncing.
- **FIX** there were 2 fixes. The fix of the cause, and also the fix for the failed batch of emulsion

COMPUTER BASED EXPERT SYSTEM



COMPUTER BASED EXPERT SYSTEM
PRODUCTS COVERED

- Covered all the emulsion products of the company, and it was easily expanded to cover more as needed:
 - *cationic and anionic stable grade*
 - *cationic and anionic spray grade*
 - *cationic and anionic premix grade*
 - *microsurfacing cationic SBR modified emulsion*
 - *SBR modified emulsion*
 - *hi-float premix grade*

COMPUTER BASED EXPERT SYSTEM
CAUSES AND PROBLEMS COVERED

- Covered 80 causes (though only some applied to any one product). Examples:
 - *common ones such as bitumen content out of specification, incorrect bitumen/soap temperature*
 - *unusual problems such as steam leaking into mill, bitumen acid value too low*
- Covered 26 problems (such as not meeting the SABS specification tests). Examples:
 - *emulsion is dirty/coarse (fails residue on sieve)*
 - *emulsion is thin, i.e. viscosity is too low*
 - *emulsion does not mix*

COMPUTER BASED EXPERT SYSTEM **FIXES COVERED**

- Provided fixes for both the cause and for the batch of defective emulsion. Environmental reasons prompted our action to rework batches in preference to dumping.
- Example: for pre-mix MS grades, where emulsion is thin, i.e. viscosity is too low
 - *CAUSE 3 (out of 16): problem with soap feed*
 - *CAUSE FIX: fix the soap feed. Consider checking for a warm soap pump, a partially blocked soap line, or dirt in the soap tank.*

COMPUTER BASED EXPERT SYSTEM **BENEFITS AND DIFFICULTIES IN PRACTICE 1**

- Major help for new technical staff
- Main problem was that it was too powerful and gave too much information
- Ranking by probability was good in theory
 - *in practice, obscure causes were too easily accessed*
 - *tendency to concentrate on unlikely causes without first checking common causes*
- Excellent for solving the more obscure problems
- Security was at a very high level
 - *giving many problems for access*

COMPUTER BASED EXPERT SYSTEM
BENEFITS AND DIFFICULTIES IN PRACTICE /2

- Used by even experienced bitumen chemists in planning for a field trip
- The training need was easy to under-estimate
 - *computer skills were needed to use system*
 - *extensive formal training was needed to ensure problems were methodically investigated*
- Invaluable for emergency assistance (when no proper support available)
 - *a smaller version is needed with only the common problems loaded*

COMPUTER BASED EXPERT SYSTEM
EXAMPLE /1

Premix MS grade (hi float type emulsion)

- The possible problems are:
 - *binder content incorrect*
 - *emulsion does not mix*
 - *emulsion is dirty/coarse (fails residue on sieving)*
 - *emulsion is thin, i.e. viscosity is too low*
 - *flux content is low*

COMPUTER BASED EXPERT SYSTEM **EXAMPLE /2**

POSSIBLE CAUSES

- bitumen content is higher than specification
- pH of emulsion incorrect for pH of soap
- incorrect bitumen/soap temperature
- contaminated bitumen
- bitumen grade is too hard
- hard water used for soap manufacture
- contamination of finished product
- soap not manufactured to specification
- emulsifier or dope degradation
- bitumen acid value is too low
- contaminated soap
- too little emulsifier
- transfer pump not coping
- problem with soap feed
- pH of soap incorrect
- type and chemical composition of bitumen
- mill worn (rotor and stator)

CONCLUSIONS

The use of an expert system proved a valuable tool to bring technical assistance to all factories in a large production company. It proved its ability to bring the expertise of a binder chemist to the staff at the production level. Used in this manner, it was able to give first level assistance to solve production problems. It is however not a complete substitute, particularly when the problems get more complex, and the expert system proved most effective when backed up by a binder chemist.

It also proved a very powerful tool for accessing the more obscure problems and causes, which was very useful. The bitumen industry generally relies heavily on experience, particularly in practical applications. The expert system is a good tool to capture that experience and allow its use in later generations.

The difficulties in its application were found to be in training and, paradoxically, the system proved almost too powerful. The introduction of the expert system was found require extensive training to get effective performance. Simulation training in problem solving is especially valuable, but is a significant resource commitment. Inadequate basic computer skills, even for regular computer users, also proved a problem.

The expert system also caused problems because its power allowed the user to quickly drill down from the most common to the uncommon causes of problems. The uncommon causes were often the more interesting, so in practice, time was wasted by chasing possible causes that had only ever occurred once in ten years! This could be overcome by training, and by progressively slowing the system down as it got into the more uncommon problems.

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