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An Expert System for Yarn Spinning Process Planning and Quality Characteristics Control in Textile Industry

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Abstract

This article describes a prototype expert system for yarn spinning process planning in textile industry. This expert system is intended as a consultant to give the technicians interactive assistance for the appropriate process planning in accordance with used materials, required count, and other factors affected yarn spinning by means of many types of machine. Also, this system has the other function that can be compared the standard values with the measured ones for quality characteristics control. VP-EXPERT-a rule-based microcomputer expert system development tool-provides the expert system components for this development. The details of knowledge organization, rule representation, inference reasoning process, and performance of this expert system are demonstrated with the practical yarn spinning operations.

1. Introduction

The textile industry consists of ; producers of natural and chemical fibers, manufacturers of textile machi-

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nery, manufaturers of dyestuffs and processing chemicals, and converts of textile fibers into end-products : yarns, fabrics, garments and industrial products[7]. Of above mentioned, it is said that there exist many kinds of problem-solving domain. This study is dealt with one of their domains, which is focused on the spinning methodology of the various types of yarn in worsted spinning system. The worsted spinning system consists of a complex series of production, together with workers involved, which react as a single complete system. Workers operate groups of machine, transport materials clean and repair equipments. Therefore, numerous parameters to be controlled are involved in each process of yarn spinning. Then, technicians must know how the overall system responds to variations in feed materials, settings and environments [9].

This paper offers to solve the problem that is described above by computer aided expert systems technology. Expert systems solve technical and management problems, rapidly and consistently with computers. This is because expert systems assist to determine the proper setting of the various items of equipments relevant to yarn production. For this reason, this prototype expert system is first focused on the worsted ring spinning process planning and how to control the quality characteristics to be sustained.

There have been much efforts in applying expert systems with textiles. Introduced in 1986, Eexpert has been used as an entry level shell by dozens of textile firms to develop interactive systems for technicians in yarn manufacturing, fabric formation and dyeing and finishing. Applications are not limited to process and machine diagnosis[2]. Doujawa developed the expert system for scheduling in spinning industry. Shao and Kuze also developed a fabric defect validation method by using expert system[12, 4].

These applications represent only a few areas where ES can serve the textile industry. Many other opportunities have textile application potential including systems to perform fabric designs, dyeing and finishing etc.

2. Architecture of the WST-Expert

2.1 Expert System Approach

With the growth of expert system technology, the development of intelligent systems for engineering diagnosis, maintenance, manufacturing process, and design tasks is receiving increasing attention. For yarn spinning process, the technical defined values and proper settings of various equipments often require some level of knowledge for decision making. Therefore, it is an ideal domain for developing an expert system to aid the less experienced technicians performing the given tasks without the expert's helps.

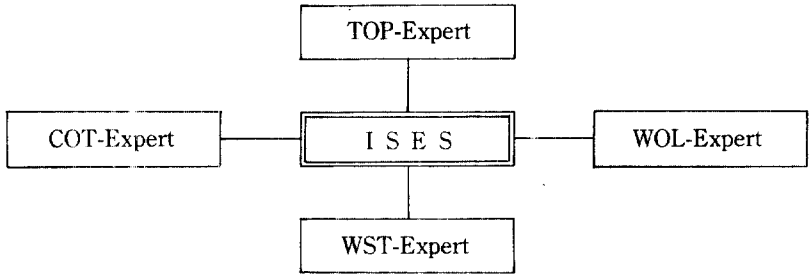
Expert systems are computer programs that capture specialized knowledge about a narrow and well-defined domain and can simulate the reasoning process of a human expert to provide knowledgeable advice about a difficult task[5]. Expert systems should typically consist of four components : a knowledge base, an inference engine, a knowledge acquisition facility, and an input-output interface with an explanation facility. In this study, the knowledge is represented as production systems that are also called rule-based deduction

systems. The rule-based systems are the most widely used and best understood representation systems. If the relations and inferences in the specific domain are mostly of a heuristic nature, then a rule-based system is usually suitable[1].

Therefore, the required knowledges are represented as IF Condition THEN Action rules. The Action part is executed if the condition part provides a match the available facts.

The inference engine, which contains the reasoning technique, executes the program by matching the known input facts with the knowledge in the knowledge base to draw conclusion, in this system, the backward-chaining reasoning was adopted and it starts from a goal(each window-level) to check if the goal can be supported by the available facts.

The complete expert systems of future study will consist of the following modules in Figure 1. Thus, the scope of this study is limited to the WST-Expert system, but further extension of ISES encompassing other yarn production systems and studies can be expected.



Note ; ISES : Integrated Yarn Spinning Expert Systems
TOP-Expert : Top Making Expert System
COT-Expert : Cotton Spinning Expert System
WST-Expert : Worsted Spinning Expert System
WOL-Expert : Woollen Spinning Expert Systems

Figure 1. Module Diagram of ISES

A rule-based expert system development tool, VP-Expert, was selected as environment for the development of WST-Expert. In WST-Expert, special features include an inference engine that uses the backward chaining for problem-solving, and the confidence factors that let you account for uncertain information in a knowledge base.

The current structure of the WST-Expert is illustrated in Figure2. It contains a knowledge base, an inference engine, an interactive user-interface with windows in explanation facilities, and an input-output facility that contains a knowledge base editor. The knowledge base for this system includes rules for spinning

domains, type of yarns, used materials and its blended ratios, spun count, the various mechanical factors and their values, et. Those required knowledges for building an expert system can be acquired from both textile experts and knowledge engineers.

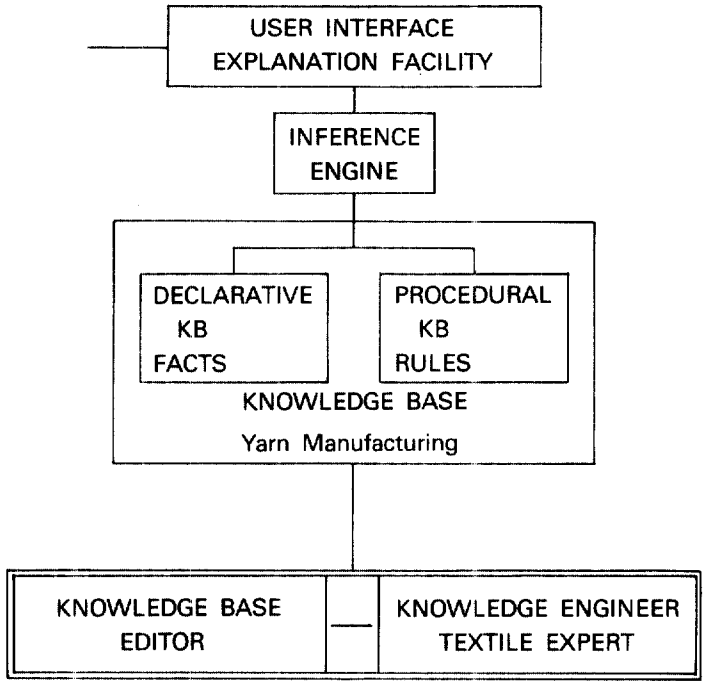
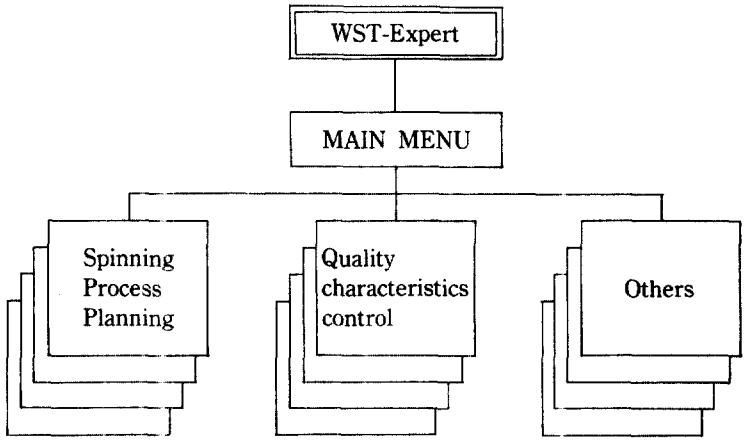


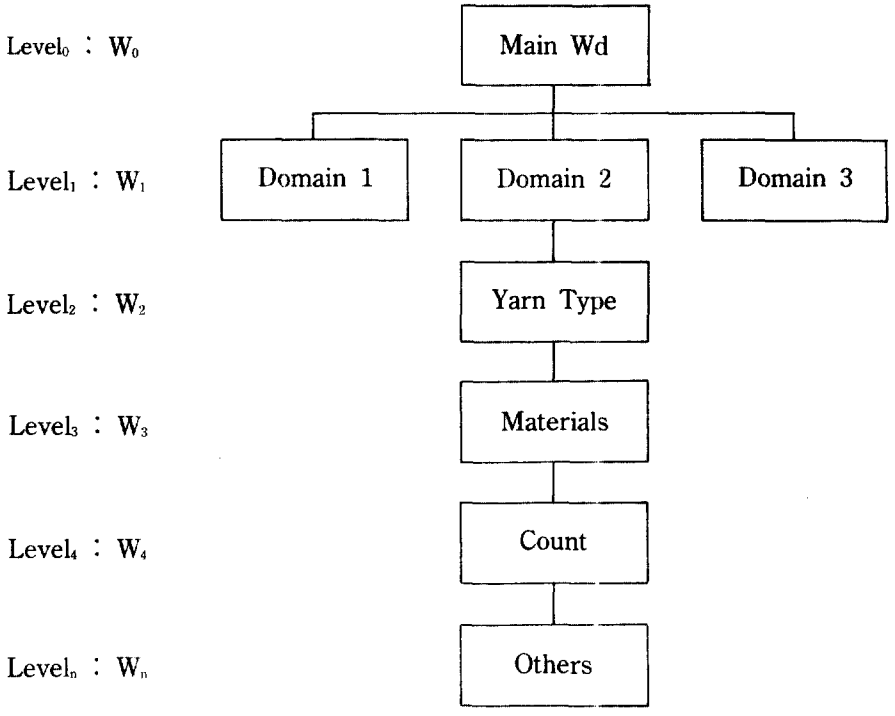
Figure 2. Architecture of WST-Expert System

2.2 Implementation

For the complete development of WST-Expert an incremental approach was followed, concentrating on an experimental system for a subset of the problem-domain so as to get some idea of the difficulties involved. In the first stage, WST-Expert was developed to restrict to drawing process among the overall processes. This system was implemented on an IBM compatible PC 80386/33 using VP-Expert tool[3]. The procedures of system for user-interface are followed as Figure 3. Each procedure shows level of windows which can be extended according to asserting the new facts Users select the required default of each variable through the windows, which offer the valuable informations to users.



(a) Menu Diagram



(b) Level Diagram

Figure 3. Block Diagram for User-Interface

3. Applications

3.1 Yarn Spinning Process Planning

In general, process planning is defined as the function within a manufacturing facility that establishes which manufacturing processes and parameters are to be used (as well as those machines capable of performing these processes) to convert a piece part from its initial form to final form predetermined (usually by a design engineer) from an engineering drawing[6¾. The process expert selects an operation sequence and processing parameters which satisfy operational, functional, economic, and quality constraints.

Mainly, the spinning domains in staple fibres are divided into three system : cotton spinning, worsted and woollen spinning. In this study, WST-Expert offers the problem-solving in the worsted spinning system. The worsted spinning is intended to be primarily of relevant to the spinning of wool in a worsted-spinning mill, from recombing through to yarn packages. Since every worsted spinner is also concerned to know the use of wool or wool blends[8].

Figure 4 illustrates a worsted yarn spinning process of company selected in this study. The whole process consists of the following subsets ; top making, recombing, drawing, spinning, and yarn finishing process. WST-EXPERT system is aimed to determine the required parameters about each part of process. The features of process are very complex, labor-intensive, efficient variety of products and large or small lot size, etc. Therefore, it is needed to consult with the requried knowledges according to any circumstances. For these reasons, this is the purpose which is intended to develop this expert system.

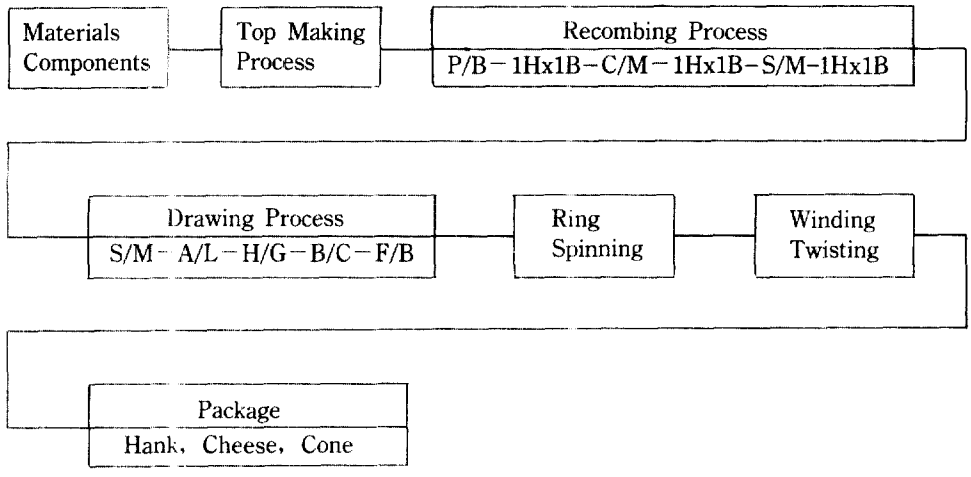


Figure 4. Diagram of Yarn Spinning Process

Table 1. illustrates an example of practical spinning job referred to drawing process for wool/polyester blended yarn production.

Table 1. An Example of Drawing Process Plan

Prs	M/C	D/B	D/R	Out g/m	Del m/min	Nip guage	Remarks
1	S/M	15	15	17	80	35~40	
2	A/L	8	8	17	80	35~38	
3	H/G	3	8	6.4	75	30~35	
4	B/C	2	8	1.6	64	28~35	
5	F/B	2	13.9	0.23	35~40	—	U%=5~6, CV%=1.4
6	SP	1	16.1	1/70	8350 rpm	200m/m	Tr.No=SBA 31 820Z

Note : Prs ; Process, M/C ; Machine, D/B ; Doubling, D/R ; Drafting, Del ; delivery

Also, the following list illustrated in Figure 5 is a partial view implemented this system built in the backward-chaining reasoning.

```
RULE 1
IF      Domain = Worsted OR
        Domain = Woollen AND
        Use type = Woven AND
        Material 1 = Wool 60 AND
        Material 2 = Polyester 40 AND
THEN
            P11 = SM  15  15  17  80  35R40
            P12 = AL  08  08  17  80  35R38
            P13 = HG  03  08  6.4  75  30R35
            P14 = BC  02  08  1.6  64  28R35
            P15 = FB  02  13.9  0.23  35R40
            P16 = SP  01  16.1  1D70  8350rpm  200mm
            PlP16 = 1 ;
RULE 1A
IF          R1P16 = 1
THEN
            P16A = le15.5  195  1.23  le5  le33
            P16B = le16.4  177  1.58  le10  le49
            P16C = le18.4  170  2.03  le20  le62
            P16D = le19.5  141  3.60  slub2  le20 ;
```

Figure 5. List for Backward-chaining of WST-EXPERT System

Workers can be assisted through the output screen that implemented the application with spinning process planning by this system as shown in Figure 6.

〈This expert system = WST-Expert = derives
the adjustable spinning process planning
for the given factors as follows.〉

〈Spin Table of Drawing Process〉

S.N	MC	DB	DR	OG	DEL	NIPG
1	SM	15	15	17	80	35R40 CNF 100
2	AL	08	08	17	80	35R38 CNF 100
3	HG	03	08	6.4	75	35R35 CNF 100
4	BC	02	08	1.6	64	28R35 CNF 100
5	FB	02	13.9	0.23	35R40	CNF 100
6	SP	01	16.1	1D70	8350rpm	200mm CNF 100

(Press any key to conclude the consultations)

Description :
S.N-Process Order, MC- Machine, DB -Doubling
OG -Output(gram/m), DEL-Delivery, NIPS-Nip Gauge

Figure 6 Output Screen of Spinning Process Planning

3.2 Quality Charateristics Control

There are two major divisions in the matter of quality of the product. The first has a visual, and perhaps a tactile, impact but has little or no effect on the ease with which the product may be processed. The second category is characterized by the effect of flaws on the cost of processing. A staple fibre yarn may have acceptable visual and tactile quality but may give endless troubles in processing[10]. The number of end-breakage influence the direct manpower expenditure, the waste produced, and the loss productivity. Especially, the irregularities in spinning influence the yarn quality, and the end-breakage frequency. In addition, the frequency of end-breakage supplies direct information on yarn quality. This system offers the establishment of standard values and admissible tolerances to discriminate the measured ones in processing.

Table 2. illustrates a standard criteria of quality characteristics in spinning. The technicians must contol the appropriate mechanical adjustments according to Table 2 if not desired product on processing.

Table 2. A Standard Values of Quality Characteristics Control of Yarn Evenness and Strength in Spinning Process

Grade	U%	CV%	Strength (g/mm^2)	Eng-breakage (/hr/400spls)
A(lsee than 15%)	Less than 15.5	Less than 1.23	Great than 195	Less than 33
B(less than 50%)	Less than 16.4	Less than 1.58	Great than 177	Less than 49
C(less than 75%)	Less than 18.4	Less than 2.03	Great than 170	Less than 62
D(less than 100%)	Less than 19.5	Less than 3.60	Great than 141	Less than 200

Figure 7 illustrates the output screen to discriminate the required yarn quality grade regarding as Table 2. If the testing results in single yarn are as follows ; U% is 15.0 and CV% is 1.45, this system offers to determine that U% is A-Grade and CV% is B-Grade as shown in Figure 7.

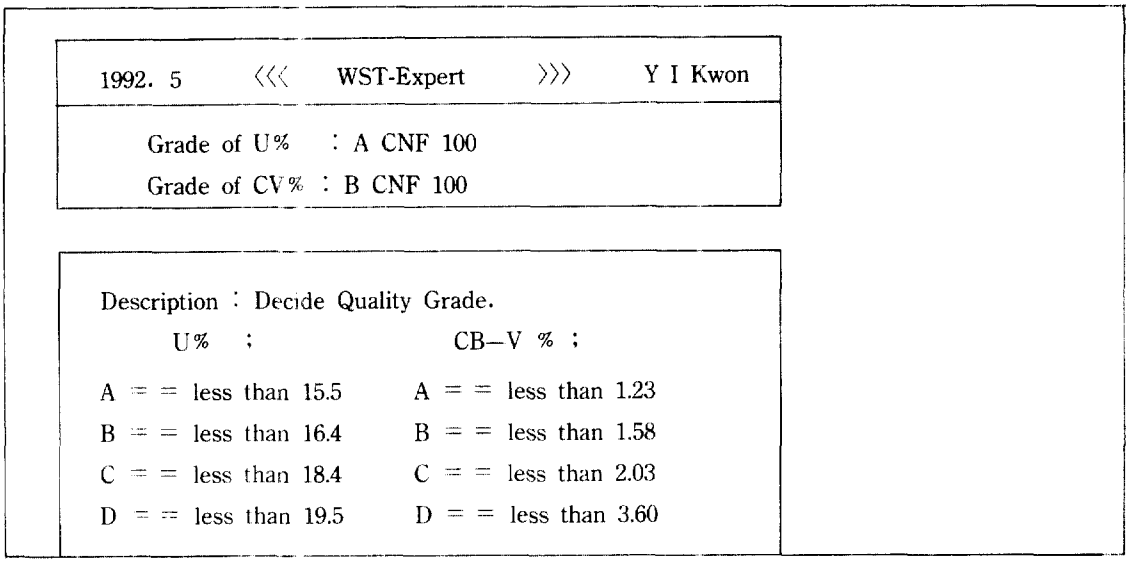


Figure 7 Output Screen of Quality Characteristics Control

4. Conclusion

This article described a prototype expert system for the worsted yarn spinning process planning and quality characteristics contorl. This system can give efficiently and rapidly the less experienced workers advices in determining the appropriate parameters relating with each process. Also, this system can give decision making on evaluation the yarn grade and other informations about quality control, productivity, maintenance, etc. It is believed that a system like this would manage the vast, useful textile database.

The further studies will be expected to develop the complete expert system of ISES, and it is sure that those efforts will be contributed to enhance the productivity in yarn production.

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