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ระบบสนับสนุนการตัดสินใจเกี่ยวกับการวางแผนการผลิตด้วยเทคนิคฮิวริสติกส์และฟัซซี่ลอจิก

Decision Support System for Production Planning by Heuristic and Fuzzy Logic Techniques

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บทคัดย่อ

ระบบสนับสนุนการตัดสินใจเกี่ยวกับการวางแผนการผลิต เป็นสิ่งที่สำคัญมากกับการเพิ่มประสิทธิภาพของแ ผนกต่างๆ เช่น แผนกผลิต แผนกวางแผน แผนกจัดซื้อ และแผนกการจัดการ งานวิจัยนี้นำเสนอโมเดลระบบสนับสนุนการตัดสินใจเกี่ยวกับการวางแผนการผลิต โดยการใช้หลักการของการวิจัยการดำเนินงาน ฮิวริสติกส์ ฐานกฎจากผู้ชำนาญการทางด้านโรงงาน และฟัซซีลอจิก การตัดสินใจหนึ่งๆ ของแต่ ละแผนกโดยทั่วไปแล้ว ต้องมีการวางแผนเกี่ยวกับวัตถุดิบที่จะสามารถผลิตและส่งมอบสินค้าให้ทันกำหนดเวลาและสร้างความพึงพอใจให้แก่ลูกค้า ยิ่งไปกว่านั้น ระบบสนับสนุนการตัดสินใจสามารถที่จะปรับตารางการผลิต หากมีสายงานการผลิตที่ผลิตล่าช้า นอกจากนี้โมเดลนี้ยังทำให้ของเสียงที่เกิดขึ้นจากการผลิตมีปริมาณลดลงมากกว่า 80 เปอร์เซ็นต์ เมื่อเทียบกับปริมาณของเสียเฉลี่ยที่เกิดขึ้น

คำสำคัญ: ฮิวริสติกส์ ฐานกฎ ฟัซซีลอจิก การวางแผนการผลิต

Abstract

Decision support system for production planning is very important in increasing the efficiency of several departments such as production department, planning department, purchasing department, and managing department. This paper presents a decision support system for production planning model using operation research principle, heuristic rule based from the factory experts and fuzzy logic. A suitable decision for each department on daily raw materials can be planned to serve the customer's due date and satisfaction. In addition, the proposed decision support system can rescheduling the late production line as well.

Furthermore, the wastes from the manufacture are decreased more than 80 percent by this model.

Keywords: Heuristics, Rule Base, Fuzzy Logic, Production planning

1. INTRODUCTION

At present, the production of small and medium enterprises has the highest number and is very important for the development of Thailand. In the condition of severe economic competition, many organizations have to develop themselves to compete at both national and international levels. Things that organizations have to develop are such as reducing lead time, using production machines efficiently, building customer's satisfaction, and seeking appropriate raw materials to match the need in order to maintain the stock products. The small enterprises have fixed assets not more than 50 million baht and employees not more than 50 employees. The medium enterprises are businesses that have fixed assets not more than 200 million baht and employees not more 200 employees [1]. The production system frequently used is integrated subsystem. The small and medium enterprises are different from the large enterprise in many ways. For examples, the large enterprises will need more amount of capital, machines, labors, and high skill and knowledgeable administrators. However, when consider on the problems of production and customer's due date of the small and medium enterprises, the enterprises lack of standards for the production planning system to manipulate the production and resources efficiently. The enterprise wants to reduce the time and production cost. The method for the selection of raw material management can be done by using heuristic rule based system and fuzzy logic that will help the management of machinery flows and accessory of production to reduce the time of production and the time of connection to the next production line [2].

The decision support system for production planning is a technology that uses the computer science knowledge and real working experience experts to reduce the problems that occur from the misconduct of production planner and help to solve some complicate problems [3] This technology can be used to apply with the changeable production system and scheduling design system [2]. Section 2 is Production Planning model. Section 3 is experimental results. And section 4 is the conclusion.

Next detail of this paper explains many theories that are used in this research.

1.1 Decision Support System

Decision support system is a method to help the decision maker to synthesize the information for the best decision by using computer as a tool to gathering information for

making the decision in problem solving and be able to make decision on the complicate matters to get the best solution. The decision support system has evolution from two main studies which are “The study of the hypothesis for organization decision” at Carnegi Institute of Technology during 1950 to 1960 and “The study of techniques using for work” in 1960 [3]. This beginning points lead to the construction and development of many application programs. The format of decision support system will be filling with reliable information into the database. The information system of other enterprises that relates to decision will compose of models for decision making, process of analysis on the present working condition by experience expert, decision by rule-based, and communication system in term of “what if” analysis. However, what have been received from the system will help to classify the choices of selection by deleting the unsuitable choices of selection.

1.2 Operation Research

Operation research is a form of finding and analysis the working process or a scientific method. Operation research uses to manage, to collect, and to analyze data by using logics and mathematics as tools to help in decision making in order to get the best solution to solve problems for better service and management. Operation research composes of 5 steps [4]. Step 1 : *Definitions of the Problem* are clarification of objectives, determination on choices of selection for the system, and clarification of limits. Step 2 : *Construction of Model* is building a model which depends on the problems. Target function and limits of problems that written in the form of decision variables. Step 3 : *Solution of the Model* will use suitable techniques in the form of well defined optimization techniques. This study will use heuristic to process the finding of results for the system. Step 4 : *Validation of the Model* will let us be able to test the corporation of results received from the previous data with the real results. However, the testing of accuracy won’t be suitable with the problems that never occur previously. And step 5 is *Implementation of the Final Result*.

1.3 Heuristic

Heuristic is a model for complicate problem solving [2]. The complicate problems are those without construction and semi-construction that have inconsistency of variables. Actually, the Heuristic problem solving is a problem solving by using simple rules that occur from previous experiences of the same problem solving. The idea of Heuristic will be dealing with searching, learning, and considering on decision. After that, there will be the repletion of the process again. The examples of heuristic problem solving are unreliable input data,

limited input data, complicate conditional problem, and more symbolic processing than numeric processing.

1.4 Rule Based

Rule Based is a method of expert system which rule based is filling the information received from human expertise and represent such information in the form of *If…Then* rule. These rules can be used with working process on data to receive suitable conclusion or result. Rule based can be used with production planning system [5] and decision making for controlling system and forecasting in the factory to clear out the cloudiness or the inconsistency [6].

1.5 Fuzzy Logic

The fuzzy logic is a branch of new Mathematics. It is important to the information technology. The fuzzy logic is researched by L. A. Zadeh in 1965 [7]. The concept of this technique is all things in the real world, which dos not has certainty. Because of, many events have both certainty and uncertainty. Sometime, may be ambiguous events. Normally, the original discipline has values or degrees of members, which are written by {0, 1}. But, the set of fuzzy logic has values or degrees of members, which are written by [0, 1]. These values have values ranging from 0 to 1.

1.6 Scheduling

Resource management scheduling is building work order and determining on each step or data flow. This will have direct influent on working of hardware [8]. The digital computer system is the designing on each step of working on work and the flow control. General problems of scheduling can be divided into two parts. Part 1 is *Time Constrains*. This type of problem will have predetermined controlling which targets will have the minimum expenses. The examples of scheduling for production process management of production process can be divided into four categories. They are 1) Shortest Processing Time (SPT), 2) Congest Processing Time (LPT), 3) Earliest Due Date (EDD), and 4) First Come First Served (FCFS). Part 2 is *Resource Constrains*. This problem will be very important which resource will be determined before each working process in the real work. The resource should be managed properly to match its existing working process.

2. DECISION SUPPORT SYSTEM FOR PRODUCTION PLANNING (DSS_PP)

In designing the decision support system, the architecture of decision support system for production planning is shown in Fig.1. The step begin when sale department receives order

from customer planning chief will receive order from sale department. After that, DSS will propose scheduling using production database. The process will transfer to factory manager for scheduling approver, factory chief, department chief for production scheduling and production task purchasing chief for materials needs. In case of late production factory chief can ask for production acceleration from planning chief.

Fig.1 The architecture of decision support system for production planning

2.1 DSS_PP Model

The scheduling is separated into 3 modules as shown in Fig.2. Module1 is *Scheduling System* that performs the working process to give the estimation on scheduling, machines, and human ratio. Module 2 is *Purchasing System* which calculate on the quantity of materials using to feed into the production line. Module 3 is *Rescheduling System* when the production line is late. This model can rescheduling when the late production occurs to let chief of planning department issue the rescheduling to solve the problem. The details of all input and output variables is shown in Table 1.

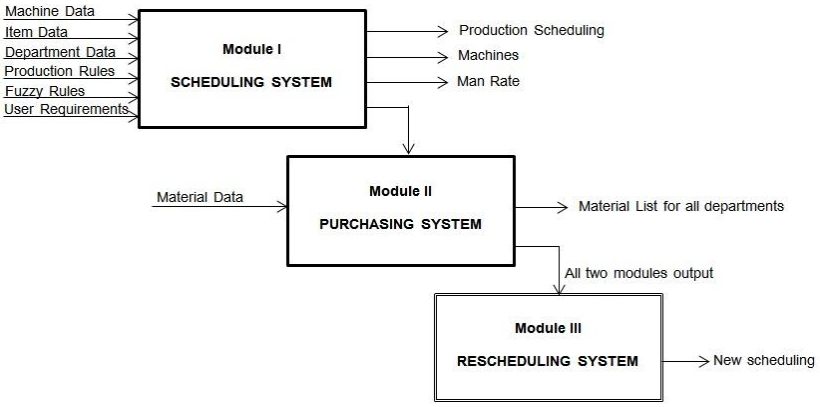


Fig.2 PP_SME Model

Table 1. Input and Output Variables of DSS_PP Model

No.	Modules	Input Variables	Descriptions	Output Variables	Descriptions
II	SCHEDULIN	Machine	All machines in the	Scheduling	Scheduling for

	G SYSTEM	Data Item Data Department Data Production Rules Fuzzy Rules User Requirements	process All items in the process All department in the process Process cons train and rules Requirements for scheduling selection	Machines Man Rate	production goods All machines for production goods All man rate for production goods
II	PURCHASING SYSTEM	Material Data	All materials in the process	Materials List for Department	All materials for goods production per department per machine
III	RESCHEDULING SYSTEM	All two modules output	Output of both modules	New Scheduling	New scheduling for late production problem

3.2 DSS_PP Algorithm

The construction of scheduling for this model is Just In Time (JIT) type which the production will proceed on continually. Production of each day will be transported to the next department without waiting for the end of production and proceed to the next departments. There are 2 types of scheduling. Type 1 is *Normal Scheduling* which is a regular method of production with the least expenses and most effective time use. Type 2 is *Express Scheduling* which is a method of rapid production. This method is suitable for customer who needs production as soon as possible. The cost for express scheduling will be higher than the normal scheduling because of the O.T. (Over Time) process. The more details of PP_SME algorithm of four steps is shown in Fig.3.

Step 1: If there are available machines, then calculate the production rate.
If there is non available machine, then wait for the production one more day.

Step 2: If the production is a express scheduling type, then calculate O.T. (Over Time)

Step 3: Check number of available machines each day, If the machine use is less than the number of available machines then decrease the machine use. If the machine use is more than the number of available machines then wait for the next day.

Step 4: Produce production scheduling, machine scheduling, and man rate scheduling.

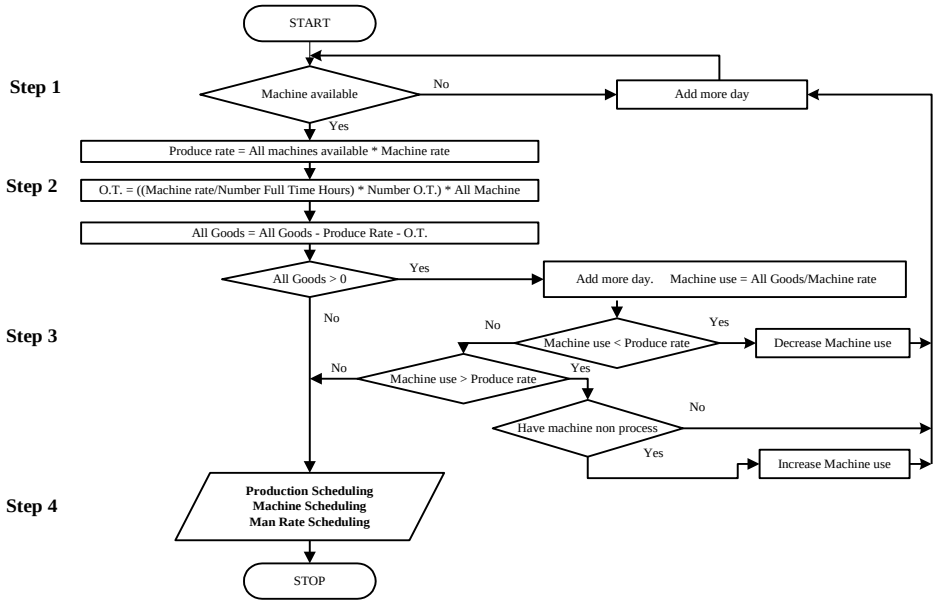
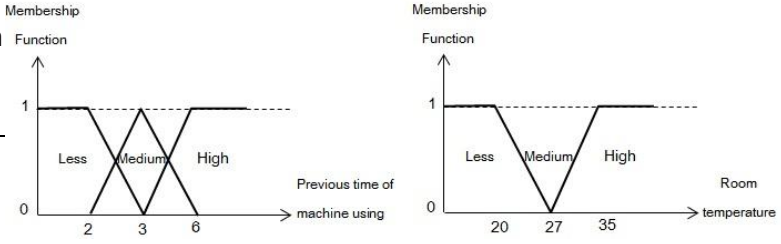


Fig.3 DSS_PP Algorithm

3.3 Decision Support System for Machine selection

Some departments have many machines for production. Sometimes, these machines are used to make goods hardly. Therefore, some machines are breakdown suddenly. This situation is effected to damage of goods. Furthermore, the number of bad goods must be eliminated by burning. Therefore, fuzzy logic is used to selecting machines. The procedures of selecting machines for production by fuzzy logic can explain as follows:

1) Defining input variables for selecting machines for good manufacturing by fuzzy logic. The previous time using of machines and the room temperature are important variables in fuzzy rule making. The fuzzy logic of the previous time using of machines is less (less than 3 hours), medium (between 2 and 6 hours) and high (higher than 3 hours). The fuzzy logic of room temperature is low (less than 27 degree Celsius), medium (between 20 and 35 degree Celsius) and high



(a) (b)

Fig.4 Real number conversion to fuzzy Chart

Figure 4 shows input conversion. There are 2 inputs that are used to selecting machines for production and room temperature. Next step, we converse input variable to fuzzy logic. For example, the previous time of using machine is equal 2.5 hours. If we converse from input variable to fuzzy logic then the fuzzy logic value is between less and medium. If the previous time of using machine is equal 3.5 hours then the fuzzy logic value is between medium and high. This research uses IF <condition> THEN <action> to create fuzzy rules. Therefore, we can receive nine rules from selecting machines for production.

Table 2. Nine rules from selection machines for production

Fuzzy Rule	**Membership Function**		**Machine Matching**
	Want Machine	**Previous time using machine**	
1	Less	Less	High
2	Less	oMedium	Medium
3	Less	High	Less
4	Medium	Less	High
5	Medium	Medium	Medium
6	Medium	High	Less
7	High	Less	High
8	High	Medium	Medium
9	High	High	Less

2) This step makes the fuzzification. This research uses an equation for conversing input values to degree values. However, we use membership in the form of a triangle. It can be shown at equation 1.

$$triangular(x:a,b,c) = \begin{cases} 0 & x < a \\ (x-a)/(b-a) & a \le x \le b \end{cases} \quad (1)$$

$$0 \qquad b \le x \le c$$

where x is the input variable.

a is the real value of fuzzy logic for the less previous time of using machine.

b is the real value of fuzzy logic for the medium previous time of using machine.

c is the real value of fuzzy logic for the high previous time of using machine.

3) This step is the inference from the data in Table 2. For example, if we want a machine, which is less or medium wanted using then the time of previous using machine is medium or high value. Therefore, we consider fuzzy logic at number 2, 3, 5 and 6. After that, Max-Min method is used to compare value of these fuzzy logics. In this step, Min method is used for AND condition and Max method is use for OR condition.

4) The result fuzzy by fuzzification is made in this step. We converse the fuzzy set to real value by using COG (Center of Gravity). The output in this step is machine matching. Furthermore, the temperature matching is made the same 1-4 step of the machine matching.

5) The average between machine matching and temperature matching is calculated in this part. If this value is similar 1 then this machine is selected for production.

3. EXPERIMENTAL RESULTS

The DSS_PP Model is test with Siam Brother Company Limited the first company in Thailand which produces polyethylene core (rope) and ring net. The company is in Samutprakarn province. There are 30 core types and 30 ring net types. Fig.4. shows the production line for core and ring net. The production line for core has 5 steps (A -> B -> C -> F -> G) while the production line for ring net has 7 steps (A -> B -> C -> D -> E -> F -> G) where A is plastic spray, B is spiral, D is spindle, D is wave, E is set ring net, F is Q.C., and G is package. For example, the process of core production item Type 250/6 for the amount of 3,000 kg. The normal production rate is shown in Table 3.

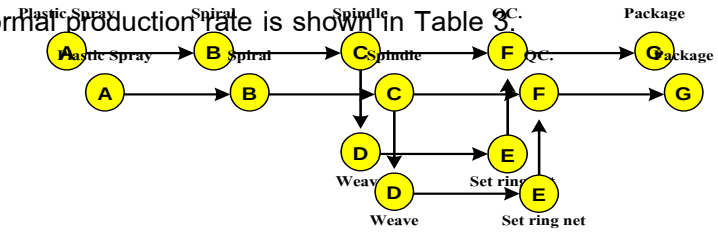


Fig.5 Production line for core and ring net

Table 3. Production rate for core type 250/6

Department	Number of machines or man rate	Production rate/machine or man rate/day (kg.)

A: Plastic Spay	2	1,000
B: Spiral	5	200
C: Spindle	5	300
F: Q.C.	2	2,000
G: Package	3	1,000

For the *normal scheduling*, the productions are completed for the first lot on the fifth day for 1,000 kg, the second lot on the sixth day for 1,000 kg, and the third lot on the seventh day for 1,000 kg consequently. The number of 27 machines were used with 32 workers (one machine/one worker for Q.C. staff and 6 workers for packages). The time used for production is 7 days as shows in Table 4. For the *express scheduling*, the company will be able to finish the production for the first lot on the fifth day for 2,000 kg, and the last lot on the sixth day for 1,000 kg. The company uses 20 machines with 25 workers. The time used for over time is 19 hours. The total time of production is 6 days as shown in Table 5.

Table 4. Normal Scheduling for core type 250/6

Department	**1**	**2**	**3**	**4**	**5**	**6**	**7**
	Produc t rat	**Product rat**	**Product rat**	**Product rat**	**Product rat**	**Product rat**	**Product rat**
A: Plastic Spay	2/2,000	1/1,000					
B: Spiral		5/1,000	5/1,000	5/1,000			
C: Spindle			4/1,000	4/1,000	4/1,000		
F: Q.C.				1/1,000	1/1,000	1/1,000	
G: Package					1/11,000	1/1,000	1/1,000

Table 5. Express scheduling for core type 250/6

Department	**1**	**2**	**3**	**4**	**5**	**6**
	Produc t rat	**Product rat**	**Product rat**	**Product rat**	**Product rat**	**Product rat**
A: Plastic Spay	2/2,000	1/1,000				
B: Spiral		5/1,000 +5/1,000	5/1,000			
C: Spindle		O.T. 8 hrs.	4/1,200+3/800	4/1,000		
F: Q.C.			O.T. 8 hrs.	1/1,200	1/1,000	
G: Package					2/2,000	1/1,000

The results of decreasing bad goods from some departments are shown at table 6.

Table 6. Decreasing rate of bad goods

Department	Normal production plan (kg.)	DSS_PP model (kg.)	Decreasing rate of bad goods (%)
A: Plastic Spay	51	5	90.20
B: Spiral	72	12	83.33
C: Spindle	34	8	76.47
	157	25	84.08

4. EXPERIMENTAL RESULTS

From the presentation on the decision support system for Decision Support System for Production Planning (DSS_PP) algorithm, this method uses knowledge and skill from experience expert and uses the principles of operation research, heuristic, rule based to receive the decision making and fuzzy logic. The data are kept in the production database which will be used to build scheduling both for normal and express scheduling. The experimental results indicate that DSS_PP algorithm can use in Siam Brother Limited, Thailand to reduce time and inventory space. DSS_PP algorithm can produce effective and fast scheduling. The customer satisfaction with normal scheduling and express scheduling can help the SME to complete among others company effectively. Furthermore, this research can decrease the bad goods and burning bad goods in during production at 84 percent.

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