The Analysis of Project Uncertainty: Based on Job Shop System

Sutinee Pantujit, and Jeerapat Ngaoprasertwong

***Abstract*—**The propose of this paper is to address the problem of scheduling under uncertainty in Thailand Antique Wooden Furniture on simulation events. We consider dynamic events such as job arrivals, uncertain processing times, uncertain lead times, unexpected machine breakdowns and re-order.

A simulation environment developed in ARENA®. The performance measure is a mean flow time of all products. The next step, we used design of experiments and tested factors causing instability. The classical approach is compared with ten dispatching rule from literature via simulation experiments to statistical analysis. The simulation experiments are performed under uncertain experimental settings, i.e. unexpected machine breakdown, variance of processing times, variance of lead times, reorder, lack of materials, absence worker and preempt order.

The result indicated that SLACK/SPT and SLACK were effective in Mean flow times and Make span. RAND, EDD and SDT were effective in Mean tardiness for dynamic flexible job shop under uncertainty. This paper presents an approach for managing uncertainty for each plant, points out the critical activities that should selectively controlled and choose appropriate rules for scheduling method.

***Keywords*—**Dynamic job shop, Uncertainty, Dispatching rules, Production Planning

I. Introduction

JOB shop scheduling problem, JSP is intrinsically complex because of the different routing operations, different processing time and different machines. Addition The problem is further complicated by uncertainty in environment based on real time. Thus, a dynamic scheduling system is more suitable to production application than static one [13].

The environment is full of uncertainties. Uncertainty is an important in process industries. The uncertainty affects to effectiveness in several objective. The classical research considers static environments but nowadays, manufacturing is facing a lot of complex uncertainty problems. Almost traditional studies are case studies which are static manufactures and constant of parameters. Nevertheless [1], as durable activity times are always vague practices. In this paper, we studied a discrete event model for real-time uncertainty in job shop system. We considered all the uncertainty factors.

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Moore and Thomas (1998) said to represent uncertainty:

1. Probable
2. Quite certain
3. Unlikely
4. Hoped
5. Not certain
6. Possible
7. Not unreasonable that
8. Expected
9. Doubtful
10. Likely

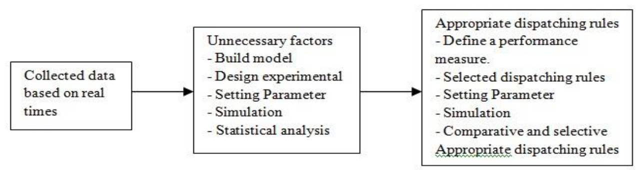

Fig. 1 Framework methodology

We focus on the highly uncertain and high-impact from uncertain. The select of a dispatching rule depends on the objective of scheduling. An Uncertainty in job shop manufacturing in this case follows as:

1) Machine breakdowns: machine breakdown which cannot be controlled. Breakdown events in case study are uniform distribution. If a machine breaks down, no operation can be performed until the end of the time repair.

2) Uncertain processing times: In two products are same types but they differ on processing time which do not have standard time.

3) Uncertain lead times: uncontrolled lead times occur from a low standard supplier. Company have no choice others supplier.

4) Reorder: during production, a customer may change quantity of order which cannot be controlled. A quantity production could be increased or decreased.

5) Lack of raw materials: raw materials lack during process.

6) Absence worker: uncontrolled worker. Preempt order: during production, the first priority is orders from customers. The managers can order immediately.

The main objective of this research is to develop a mathematic tool for providing a job shop schedule that can address uncertainty in process activities. The scope of the uncertain and impact evaluation integrated into the job shop scheduling. A simulation evaluate the duration of each activity in process. Uncertainty in estimating activity is only affected can be statistically represented in frame of the design of experiment theory.

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II. Literature review

The environments always affects from uncertainty. The uncertainty in environments is great and complex. In many research studied uncertain factors such as [2] studies processing time, utilization of raw materials, and the employment of operator. This research considered variety of aspects and developed scheduling models. The approach is identity the main uncertainties in firstly. Second, use mathematics approach for classified process uncertain. Finally, scheduling under uncertainties and discuss new ideas. Others uncertainty such as due date and weight are certain too. Others research [3] studied uncertainty from due date, processing times, and processing times. The approach is classified uncertainty by optimality for all scenarios. In the civil projects likely[4], considered factors of uncertainty in real situation such as repair equipment. A technique of research is two projects scheduling and used fuzzy modeling of the work load from the fuzzy/possibilistic approach. Second applied a greedy algorithm and a genetic algorithm are provided to solve FRCPS and FRLP respectively.

The uncertainty in Job shop systems refers to many problems. In many research tried to mange uncertainty such as [7] studied in job shop manufacturing systems. This paper studied on under different arrival and using analysis variance (ANOVA). [3] In a recent studies apply multi-agent approach is compared dispatching rules via simulation experiments to statistical analysis. The uncertain are shop utilization level, due date tightness, breakdown level and mean time to repair. The characteristics of manufacturing systems are dynamic and flexible production.

Riccardo [10] evaluate the problem of scheduling with uncertainty, classified scheduling problem two aspects: (1) the static sub-problem (2) the dynamic sub-problem. The paper used the schedule execution control module simulates the advancement of time and is response for dispatching the activities and selecting the off-line strategies. One of the uncertain often studied are demand of customer [6] This paper present a stochastic programming model with simulation-based optimization. The comparison approach both gamma approximation and safety stock search. The normal approximation can be far from optimal. [7] applied PERT technique and used Monte Carlo Simulation to analyze project schedule uncertainty. At last, considered the sensitivity analysis of each critical activity and controlled. This paper shown how to remove or reduce the impact of uncertainty activity. [13] applied "Earliest Deadline First Scheduling with Adaptive Risk Estimation (EDFRE). Finally, compared it with simple EDF(Earliest Deadline First) scheduling.

III. Methodology

On objective of this paper is to introduce an approach, which allows one to simulate the uncertainty of actual activities in job shop system. In this section, the problem under study is Job-shop manufacturing system. In job-shop manufacturing system [8] the processing time of products is not fixed value, and may vary dynamically with situation. We built model from all relevant process information, characteristics, and data are based on the real system. The production process is as shown in Fig. 2.

Fig. 2 The furniture manufacturing process

Sequence and processing time in each part is deferent. We collected three products for studied. Product type A is main products and high profits of this company. Operation and processing time show as TABLE I.

The uncertainty is analyzed in real system. The proposed of computer simulation based scheduling plan and effective of dispatching rules are analyzed in simulation experiments [9].

TABLE I
Operation and processing time

Operation	Product A	Product B	Product C
1	390(MC2)	75(MC3)	63(MC3)
2	108(MC4)	225(MC5)	125(MC5)
3	90(MC6)	62(MC6)	78(MC1)
4	102(MC8)	40(MC7)	69(MC2)
5	45(MC7)	40(MC8)	135(MC7)
6	125(MC9)	70(MC7)	265(MC8)
7	103(MC8)	240(MC9)	200(M11)
8	20(MC7)	60(MC8)	89(M12)
9	42(MC8)	45(MC7)	1890(M13)
10	240(MC11)	50(MC8)	2400(Supplier)
11	180(MC12)	352(MC11)	210(MC16)
12	1085(MC13)	250(MC12)	10(MC17)
13	35(MC17)	2095(MC12)	63(MC3)
14	390(MC2)	64(MC17)	
		75(MC3)	

Processing time minutes (Machine)

A. Frame work of the proposed methodology

The conceptual model as shown in Fig. 2

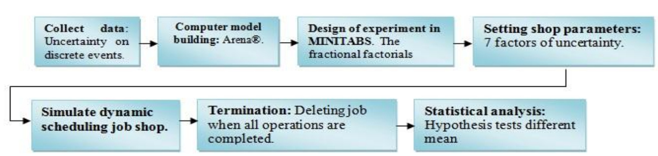

Fig. 3 The conceptual model

Our model applied from [2]. This model has advantage more traditional model are statistical analysis real impacts.

B. Discrete events simulation model

The approach for tests main effects is computer simulation. A simulation analysis in ARENA® based on discrete events system. Simulation-based approaches are widely used in job shop manufacturing. For example, [1] the model is of discrete-event system simulation type, where events occur at discrete of time on the simulation clock. In this case, the approach is analyzed using discrete-event system simulation in ARENA. The model generates an entity by normal distribution. The attribute of the entity are products, sequence and start time. All assumption models are as follows:

1. The production process is terminating system.

Available times are 8 hours per days.

2. The skill workers are equal.
3. Allow one production on one machine.
4. A job once taken up for processing should be complete before another job is taken.[13]
5. Non parallel machines.
6. Unlimited resource.

C. Design of experiments with several factors

We applied the 2^{k-p} fractional factorial methodology for generate design. We investigates seven factor Unexpected Machine Breakdown (A), Uncertainty of processing times (B), Uncertainty of lead times (C), Uncertainty of Re-order (D), lack raw materials (E), Absence worker (F), and Preempt job (G) each at two levels. The objective is each factor affect with mean flow time and how the factors interact. In this case, we selected 2^{k-p} fractional designs as show in TABLE II. For the experimental evaluation of nine dispatching rule. A job shop consisting of 17 machines.

TABLE II
SELECTED FRACTIONAL DESIGNS

Number of factor k	Fraction	Number of runs	Design generators
7	2_{IV}^{7-2}	32	F = $\pm$ABCD G = $\pm$ABDE

Design Generators are E = ABC, F = BCD, G = ACD for default and alias structure follow as.

$$I + ABCE + ABFG + ACDG + ADEF + BCDF + BDEG + CEFG \quad (1)$$

An experimental unit is the object on which a measurement is taken. A factor is an independent variable whose values are controlled and varied by the experiment. The experiments are seven factors. Each factors setting both 5% and 20%. The level is the intensity setting of a factor

D. How dispatching rules affect the effectiveness of process

Two dispatching rules are being analyzed. We considered tests of hypothesis on the difference mean and variance unknown. The tests statistic assumed that variance not equal. The parameters of interest are the Mean tardiness and Makespan for two dispatching rules scheduling. Using α = 0.05, we would reject if $T_0 > t_{\alpha,n_1+n_2-2}$. The assumption of normality appears quite reasonable. In this case, we scheduled under uncertainty and collected ten dispatching and traditional.

E. A heuristic procedure for job sequencing and due date assignment

Dynamic job shop scheduling is a frequently occurring and highly relevant problem in practice, so it becomes more important [10]. We assigns due date [11] based on a procedure relying on the total work content of a job (TWK). Set the value of C4 at 1.4.

$$d_k = r_k + C_4 \times (sum\ of\ the\ processing\ times\ of\ all\ operations).$$

The objective function focuses on the tardiness-based performance and make-span. The performance measures simultaneously. [12] Mean tardiness ($\bar{T}$)

$$\bar{T} = \sum_{i=1}^{n} T_i$$

Comparative both traditional and ten dispatching rule based on uncertainty factors from precious section.

We consider ten dispatching rules:

1) Short Processing Time (SPT): Choose to work with a short processing time before.
2) Earliest Due Date (EDD): Selected with the fastest delivery before.
3) Longest Processing Time (LPT): Selected with longest processing time before.
4) Smallest Ratio by Dividing Processing Time (SDT): Selected a Minimize ratio of processing time divided by the total all processing time.
5) Longest Ratio by Dividing Processing Time (LDT) Selected a Maximize ratio of processing time divided by the total all processing time.
6) Smallest Ratio by Multiplying Processing Time (SMT): Selected a Minimize ratio of operation time divided by the total all processing time.
7) Longest Ratio by Multiplying Processing Time (LMT) Selected a Maximize ratio of operation time divided by the total all processing time.
8) SLACK, We can established slack as
9) Smallest Ratio Slack Time

IV. DISCUSSION

A. Main Factors

From the analyzed two steps from p-value, factors affects with the mean tardiness (TABLE III) are A, B, D, F, G and interaction of B*F and D*G. The only large effects are G (Preemt order), B(Processing time) and A (Breakdown Machine). And the analyzed two steps from p-value, factors affects with the makespan (TABLE IV) are A, B, D, F, G and interaction of B*F. The only large effects are G (Preemt order), D(Reorder) and B(Processing time). The experiment includes due date based rules: EDD SPT. All rules are tested under two levels of uncertainty: 5% and 20%.

TABLE III
ANALYSIS OF VARIANCE OF MEAN TARDINESS

Source	DF	F	P
Machine Breakdowns	1	21.42	0.000
Processing Time	1	74.35	0.000
Reorder	1	20.97	0.000
Worker absence	1	16.01	0.000
Preemt order	1	1269	0.000
Processing Time* Worker absence	1	7.49	0.007
Reorder* Preemt order	1	110.21	0.000

TABLE IV
ANALYSIS OF VARIANCE OF MAKESPAN

Source	DF	F	P
Machine Breakdowns	1	21.42	0.000
Processing Time	1	74.35	0.000
Reorder	1	20.97	0.000
Worker absence	1	16.01	0.000
Preempt order	1	1269	0.000
Processing Time* Worker absence	1	7.49	0.007

In relation TABLE III and TABLE IV, factors affect with mean tardiness are G>B>A>D>F and factors affect with makespan are D>G>B>A>F. We conclusions that the process is insensitive to Preempt order, the mean tardiness is high. And then, we test statistical for difference mean and variance not equal both 7 factor and 5 factors.

The numerical results from Fig. 3 A two-side 95% and confidence interval. We can discuss inv mean 5 factors and 7 factors not difference in mean with t-test. So on, we can conclude that factor D and E are unnecessary factors. We can ignore it in consider next chapter.

B. Comparative dispatching rules proper complexity of environments

The proposed that its superior performance for mean tardiness and makespan. SPT and SLACK/SPT provide smaller values for the mean tardiness SLACK/SPT and SLACK provide smaller values for the makespan.

TABLE V
SCHEDULING WITH NINE DISPATCHING RULES

Rule	Mean tardiness	Make span
Traditional	5.057	509.25
SPT	3.406	571.59
EDD	4.924	538.25
LPT	5.525	572.52
SDT	5.542	573.72
LDT	5.555	574.40
SMT	5.554	574.31
LMT	5.555	574.40
SLACK	5.043	533.26
SLACK/SPT	4.783	523.63

The results of the simulation study are present in TABLE V. The results indicate that the SPT show as the best rule in all case for mean tardiness. The rule is more effective than the traditional rule. Table V presents the average of the mean tardiness and Make-span by dispatching rules in sets of 32 test problems, and for all nine job shop models examined.

V. CONCLUSION

From case study, the environments are various and complex. There are many uncertain factors in manufacturing but a few factors affect to mean tardiness and Makespan. In this case, the large effects of performing are unexpected breakdown machine, uncertainty of processing times, re-order, an absence of worker and pre-empt order. The scheduling problem for job shop system with uncertain five factors is studied to find can minimize Mean Tardiness and Makespan.

Numerical computational results show that the SPT is more effective than traditional scheduling 32.65% for mean tardiness. For Makespan, SLACK/SPT is more effective than traditional scheduling 8.97% in the enterprise manufacturing with uncertain several factors in production process.

Using these common methodologies, a model can potentially address planning and scheduling problems under uncertainty within a wide array of filed. Future, you should address appropriate directions for planning and scheduling under uncertainty within correctly factors.

As future work, we shall concern the general problems, taking into account resource constraints and more dispatching rules such as number of machines in other case because this case is flexible machine.

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