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Application of Simulation Technique in Weaving Mills

Abstract
Restricted possibilities for flexible working are among the basic problems in order-oriented textile weaving mills. In order to increase production and get orders ready on time, weaving mills generally focus on the speed and performance of the machines. However, the basic problem lies in a lack of organisation which definitively causes bottlenecks. In this study, a weaving mill which produces fabric based upon orders has been chosen as a subject, and this firm's current system has been simulated. After working on the current system, the data were evaluated and the bottlenecks determined. Thus, alternative systems were created instead of the current system, and these alternative systems were compared with this current system. Further, thanks to the improved simulation program, the ordered product's delivery date can be easily estimated. In this way, we aim to give ideas about optimising organisation and estimating the delivery dates of the orders for the weaving mills with this kind of job process.

Key words: *weaving mills, order-oriented textile weaving mills, organisation, bottlenecks, simulation technique.*

Introduction

Production planning and the level of production controlling activities differ with respect to types of production systems. As the amount of product increases and the variety of the products decreases, these activities become simpler to understand [1].

In today's competing and expanding textile market, enterprises must overcome the organisational problems, and production punctuality gains more importance. Besides flawless production, enterprises must determine the bottlenecks in the current system by doing mathematical analyses in order to get the orders ready in time. In weaving mills based upon orders and small lots, the basic problem lies in the lack of organisation and precisely determining the nature of the bottlenecks.

Conducting experiments with a real system and getting results from it are risky and costly operations. Thus, by imitating the operation of a real-world process or system over a specified time, simulation models may be obtained [2]. Simulation technique includes model experiments for the purpose of understanding the behaviour of the system, or evaluating various strategies for its operation. Simulation includes both the construction of the model and the experimental use of the model for studying a problem [3]. Thus, simulation modelling is an experimental and applied methodology that seeks to accomplish the following:

- to describe the behaviour of the systems,
- to construct theories or hypotheses that account for the behaviour observed, and
- to use the model to predict future behaviour, and investigate the effects produced by changes in the system or in its method of operation [4].

This research has been done for the purpose of the job and order flow planning for order-based weaving mills, where many changes in style occur frequently.

Material and Method

The material of this research consists of 60 weaving machine units. 12 of these units have cam shedding mechanisms and air jet filling insertion mechanisms, and 48 units have dobbyshedding mech-

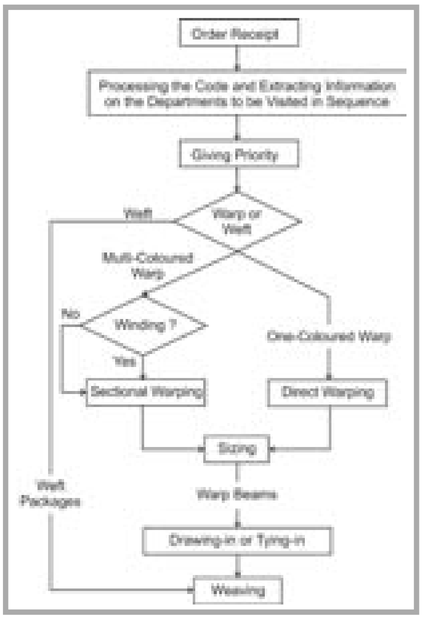

***Figure 1.** The job flow of the current system.*

Table 1. Stochastic conditions and statistical distributions of process times in each process.

Process	Stochastic conditions	Statistical distributions of processes
Winding Process	1. Taking the empty bobbins of the previous order from the machine and putting the full packages of the new order (for one bobbin)	Normal distribution
	2. Putting the empty packages on the machine, tying the yarns and taking the yarn packages when the meter is over (for one package)	Lognormal distribution
Sectional Warping Process	1. Arranging the packages on to the creel according to the design needs (for one bobbin)	Beta distribution
	2. Tying up the yarn ends (for one creel)	Normal distribution
	3. Combing (for one creel)	Normal distribution
	4. Crossing the yarns for sizing (for one unit)	Normal distribution
	5. Crossing the yarns for drawing-in (for one unit)	Normal distribution
Direct Warping Process	1. Passing the yarns through the warp stop motion and combing (for one order)	Beta distribution
	2. Putting and taking the direct warping beams (for one beam)	Lognormal distribution
Sizing Process	1. Putting and taking the warp beams (for one beam)	Beta distribution
	2. Positioning the crossing bars (for one crossing bar)	Triangular distribution
	3. Arranging the direct warp beams on to the creel and taking the empty beams from the creel (for one beam)	Lognormal distribution
Drawing-in Process	1. Manual heald frame drawing-in (for 100 ends)	Gamma distribution
	2. Manual reed drawing-in (for 100 ends)	Triangular distribution
Weaving Process	1. Style changing	Beta distribution
	2. Tying-in only one coloured warp (only for a warp end)	Beta distribution
	3. Tying-in multi-coloured warp yarns (only for a warp end)	Weibull distribution

anisms and rapierfilling insertion mechanisms. The following units are also incluted into the system: 2 sizing machine units, one direct warping machine unit, one sectional warping machine unit and one winding machine unit.

The current system consists of winding, sectional warping, sizing, drawing-in, tying-in and weaving from which multi-coloured material obtained is producedand direct warping, sizing, drawing-in, tying-in and weaving from which one-coloured material is produced. The job flow of the current system is shown in Figure 1.

The first step in our research was to determine the stochastic conditions in the processes. As stochastic conditions, process times show variety each time the process times that are carried out by the worker were measured for every single stage of the process. After obtaining the values of each stochastic process, these values were evaluated in the Input Analyser menu of Arena software by using the mean square errors, and so the statistical distributions of every single stochastic process time were determined.

This evaluated data was used as input to form the simulation program of the current system. After doing so, the simulation model of the current system was run with 120 units of order so that the results may be obtained.. The results of the current system were analysed, and the bottlenecks (in the current system) were determined. In order to eliminate these bottlenecks, different alternative systems were devised, and comparisons of the current system and the alternative systems were done. As a result, the defective units in the current system were easily determined, and the production time control of every single order was guaranteed.

The results obtained from the current and the alternative systems were evaluated by using the SMART technique (Simple Multi Attribute Technique).

The comparison value of each alternative is obtained, and according to the compar-

Table 2. Average number of orders waiting in the queue of each department, for the observed current system and the alternative systems for optimisation.

	Departments and parameters	current system	alternative system 1	alternative system 2	alternative system 3	alternative system 4
Department	Direct Warping	0.27	0.26	0.27	0.34	0.27
	Sectional Warping	15.82	21.51	20.98	22.02	21.63
	Sizing Sectional Beams	0.04	0.35	0.02	0.02	0.02
	Sizing Direct Beams	0.53	0.02	0.31	0.37	0.35
	Drawing-in	36.38	7.32	0.69	7.4	0.71
	Weaving-Cam	11.44	25.79	24.21	24.65	23.39
	Weaving-Dobby	34.09	48.69	51.79	48.41	51.02
Parameters	Number of Workers in Drawing-in	6	10	-	10	-
	Number of Automatic Drawing-in Machine	-	-	1	-	1
	Number of Workers in Tying-in and Style Changing/Shift	3	3	3	4	4

Column group header: Average number of orders waiting in the queue in the departments for the particular systems:

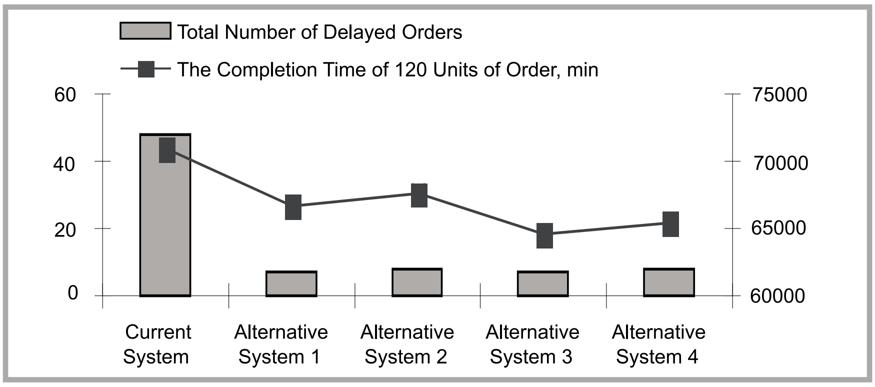

Figure 2. The total number of delayed orders waiting in the queue of the drawing-in department, and completion time of 120 unit of orders for each system.

Table 3. Performance criteria of systems and ranking values of system performance criteria; 1 Average number of orders waiting in drawing-in department, 2* Total number of delayed orders, 3* Completion time of 120 units of orders (min).*

Systems	Performance Criteria			Ranking Values			Comparison Value
	1*	2*	3*	1*	2*	3*	
Degree of weight %	-	-	-	20	40	40	-
C. System	36.38	48	70960	1	1	1	1.0000
A. System 1	7.32	7	66600	0.1858	0	0.31	0.1636
A. System 2	0.69	8	67593	0	0.02	0.47	0.1986
A. System 3	7.40	7	64584	0.1880	0	0	**0.0376**
A. System 4	0.71	8	65429	0.0006	0.02	0.13	0.0629

ison values, the alternative systems are evaluated, and the best system that has the minimum comparison value is chosen.

Results and Discussion

The process times of stochastic conditions were evaluated in the Input Analyser menu of the Arena software by using the mean square errors, and so the statistical distributions of every single stochastic process time were determined. In Table 1, the stochastic conditions and the statistical distributions of each process time were given.

The results of the current system according to the average number of orders waiting in the queue of each department parameter are given in Table 2.

The graphic notation of the average number of orders waiting in the queue of the drawing-in department is given in Figure 2.

When examining the average number of orders waiting in queue of drawing-in department presented in Table 2, there is an evident difference between the current system and the alternative systems. According to this parameter, it is seen that the best results were obtained from alternative systems 2 and 4, in which an automatic drawing-in machine was used instead of manual drawing-in. From Figure 2 we can that the best results were obtained in alternative systems 3 and 4 in respect of the completion time of 120 units of orders.

To summarise this data, and so to evaluate which system's performance is better,
- the completion time of orders,
- the total number of delayed orders, and
- the average number of orders waiting in the queue of the drawing-in department,

are chosen as performance criteria, and next the SMART technique was applied in order to designate which system is better.

The performance criteria and the grading values of system performance criteria are given in Table 3. In this table the performance criteria of each system were ranked between 0 and 1 in each column. By giving a 0 to the minimum values and giving a 1 to the maximum values the ranking values of the performance criteria in Table 3, the comparison values of each system were obtained. The weighted degrees given were determined by observing the priorities of the performance criteria determined by the weaving mill where the measurements were made.

When a general evaluation is made according to the performance criteria listed above, it can be said that the best system for the mill with this engine park is the alternative system number 3. The value that was obtained by using the SMART technique is approximately 0.04, which is the smallest value compared with the others. In order to minimise the performance criteria, the smallest value was chosen. So, as a result of adapting the simulation program for a weaving mill that has the same engine park and job flow, if this weaving mill prefers manual drawing-in with 10 workers and 4 workers for tying-in and style-changing processes, it will obtain better performance compared with the current conditions. The most important thing is, if this system is preferred, it will get more orders ready in time, and it will be respected in the market. Also in this system the improvements in the average number of orders waiting in the queue of drawing-in department, the total number of delayed orders and the completion time of 120 units of orders are 79.65%, 85.41% and 8.98% respectively.

Conclusions

- Weaving mills that have the same job flows can use this program to enter data such as engine park (according to the capacity) and the number of workers. In this way, the necessary isolation of bottlenecks and optimisation can be easily determined. Also, with the use of the simulation program developed in the study, definite due-dates can be given to customers. When increasing productive capacity, this program guarantees the exact prediction of the choice of machine. When making a business plan, departments that have residual or insufficient labour can easily be specified, and the necessary arrangements can be made.

- Nowadays, weaving mills particularly based upon small lots and orders must respond rapidly to changes in style. It is essential to know the current situation in the enterprise in order to process the orders on time. In order to give accurate due-dates to the customers, it is essential to predict the short-term future situation and to keep production under strict supervision. For this purpose, by developing a suitable simulation program for an enterprise, the situation of the enterprise in the short-term future can be predicted.

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