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Strategies to Achieve Labor Flexibility in the Garment Industry

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Abstract

With the astonishing technological progress in industry during the current epoch, companies are facing a dynamic unpredictable market environment that makes survival to a certain extent difficult for them. Consequently, flexibility seems to be the best approach to enable companies to have an effective response to environmental threats such as economic crisis, growing competitors and market demand fluctuation. Among different types of flexibility, labor flexibility seems to have a determining effect in making a system flexible, since labors are one of the most important resources of a company. This project tries to present a new method to achieve labor flexibility as an effective strategy for garment manufacturing companies that faces market demand fluctuations. The final result of the project shows the proposed algorithms are capable of finding the optimum strategic solution for applying labor flexibility on the production line of the case study.

Keywords: *Labor Flexibility, Optimization Algorithms, Simulation.*

1. Introduction

The unpredictable condition of today's market environment compels manufacturing companies to switch to flexibility to enable them to effectively response to market changes [1]. For making a firm perfectly adapted and flexible according to the market demand, all the elements of the system such as product, process, volume, material handling, machine and labor need to be flexible [2]. However among the many elements of flexible factors, labor flexibility is the most challenging factor because of the different aspects of human behaviors that make it as the most valuable resource and the most flexible element of a system. For this reason more attention is needed for applying labor flexibility to companies in comparison to other elements of a system. In every manufacturing system there are many possibilities for the number of labors to perform work and many combinations for the skill level of labor. Thus optimization tools are needed in finding the best solution with regard to the labor cost and the productivity of the system [1]. Nevertheless few researches have been done to propose the methods for applying labor flexibility effectively. This project tries to propose some algorithms for using simulation as a planning tool in garment industry to evaluate different labor flexibility strategies on a case study and finding the optimal labor flexibility solution.

2. Literature Review

Nowadays flexibility is applied as a major competitive tool by organization to adapt to the unstable and changeable environment of the market [3]. The literature review on flexibility has been done to present a comprehensive definition for the concept of flexibility and develop its framework [4]. The most common types of manufacturing flexibility that have been discussed in the literatures are machine, product, operation, material handling, process, routing and labor flexibility [5],[6]. However labor flexibility is one of the foundational factors for flexibility pyramid of a system and consequently needs more effort to achieve [7]. Following a review on the labor flexibility literatures, it has been found that most of the labor flexibility definitions point to functional flexibility. For instance Koste (1999) defined the labor flexibility as the number and variety of operations that a labor can perform with the minimum penalty to the performance and operation process. However labor flexibility can be applied on the firm's workforce in both quantitative and qualitative approaches. Qualitative approach of labor flexibility or functional labor flexibility is the labor's ability to handle different tasks and move between jobs or duties as demand changes. While quantitative approach of labor flexibility or numerical labor flexibility is the ability of company to change the amount of work as demand changes by changing the number of labors or the number of working hours [8], [9]. Hence, based on the numerical and functional aspect of labor flexibility, the most comprehensive definition for labor flexibility is the ability of a firm to change the amount of work by changing the number of labor or number of working hours and the variety of work performed by labor as demand changes with the minimum penalty to the operation processes.

Permanent workers with changeable working hours or temporary workers are examples of numerical labor flexibility. However these approaches may not always be effective and possible, since having many permanent workers are costly and applying temporary labors may affect work quality and job standards of the company. Thus any suggestion for achieving labor flexibility strategies on a case study needs to be evaluated to find the optimized solution with minimum cost and without any penalty to the firm's targets and production. The objective of this project is to investigate the effect of applying numerical and functional labor flexibility on the production time and labor cost of a case study (garment company) and to find the optimum solution.

3. Problem statement

Production lines of most garment industries have similar characteristics. They are mostly consisted of an assembly line that consists of a set of sequential workstations, typically connected by a continuous material handling system. It is designed to assemble component parts of a cloth and to perform any related operations to produce the finished cloth.

There are many types for assembly lines and each type has special characteristics. One of the characteristic of an assembly line is the degree of automation [12]. The assembly line in most garment industries are semi-automated or fully manually. For this reason the role of labor in performing jobs in most garment industries are higher than machines. Consequently labor utilization, equalize workload percentage of each operator in assembly line and labor cost are challenging managerial issues in garment industry. This project tries to propose some strategies for garment industries regarding to these challenges. The first strategy is numerical labor flexibility that tries to determine the number of operators in a simple assembly line of a garment industry and distribute workload between them with minimum labor cost and minimum delay in total required time for finishing products.

The case study is the sewing department of a garment company in Malaysia, where all the operations for manufacturing cloths are semi-automated or completely manually. The production quantity and planning of product are based on the customer's order. Normal working hours of the company is 8 hours per day, 6 working days a week. Company has some permanent workers and some temporary labors. In some cases, based on the production quantity and the due time that customers request, the working hours and number of temporary labors are varied accordingly. For instance, overtime, subcontract, out sourcing and increasing the number of workers are the strategies that are done by company when normal working hours is not enough to fulfill demand in the desired due time [10]. This paper uses the case study company to assess the effect of applying numerical and functional algorithms to achieve labor flexibility.

In this paper we assume the company receives an order for producing 3000 pieces of military cloths within 30 working days. According to the companies' rules each working day of company is 8 hours as normal working time and maximum allowed overtime work is 2 hours per day for each worker. Therefore, the maximum possible production working hours for each labor in sewing department during 30 days is 300 hours (30 working days × (8 + 2) hrs/day). Furthermore it is assumed that the labors' skills are classified into 3 levels based on their speed in performing a duty. This classifications are full skill, semi-skill and low-skill workers that each group is able to complete assigned jobs within the standard time, 120% of standard time, and 140% of standard time respectively. In addition, in term of the availability of labors for performing operation process, the basic model is defined as a model in which for each operation one labor is always available and this model represents minimum production time that is possible based on the current production line of the sewing department. The number of operations are required to produce military cloths in sewing department are 36 operation processes, and the maximum required number of labors for performing this order are 36 persons.

The aim here is to apply labor flexibility to have the minimum cost without any penalty to production time and customer due date. To determine the relation between cost and time in this type of contract project, we divide the production cost to two terms: time related cost (TRC) and time unrelated cost (TUC) (refer Equation 1). Time unrelated costs are some costs such as the cost of raw material, factory rent, depreciation, taxes which can be determined before starting the project and can be assumed as predictable constant cost. While time related cost is cost related to production and labor which varies according to the total production time. Hence for minimizing the production cost, we need to minimize the TRC as it is shown in Equation 2. For this reason we do not consider TUC in this research. Instead we will try to minimize the TRC that is a function of production time and labors' wages (Eq.3).

$$\begin{aligned} f(Total\ Cost) &= f(TUC) + f(TRC) \\ &= Constant + f(TRC) \end{aligned} \quad (1)$$

$$f'(Total\ Cost) = f'(\text{TRC}) \quad (2)$$
$$f(TRC) = f(production\ time, labors'\ wage) \quad (3)$$

4. Proposed labor flexibility strategies

After the model of assembly line in sewing department are built and verified using Witness simulation software, two labor flexibility strategies are applied to the model.

4.1 Numerical labor flexibility strategy

The proposed algorithm for numerical labor flexibility strategy is shown in **Figure 1**. Using the proposed algorithm (**Figure 1**) the experiment was conducted on the basic model to improve it by reducing the number of labors.

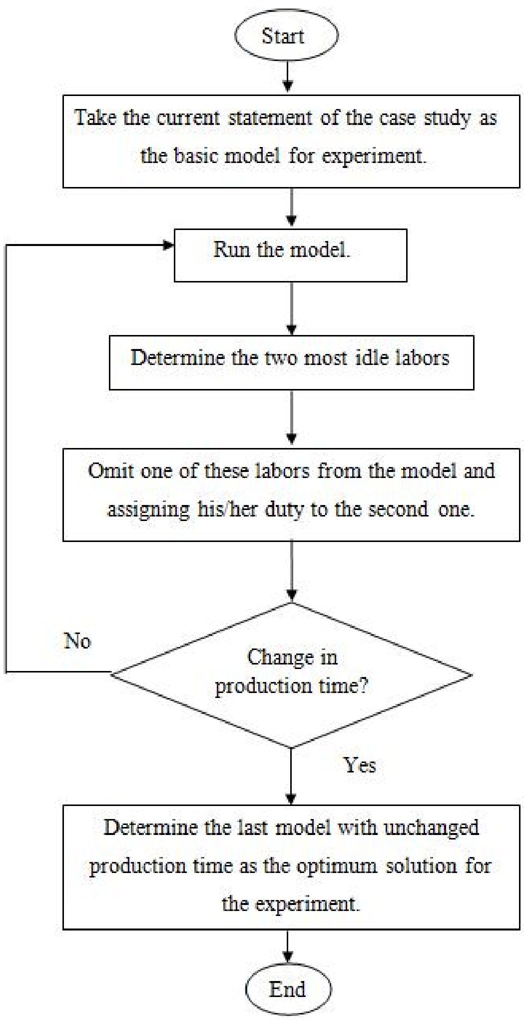

Fig. 1 The algorithm of numerical labor flexibility strategy.

According to this algorithm in each model two most idle labors will be selected and then the duty of one of them will be added to another labor and the first labor that now does not have any job will be omitted from the model. The next step is running the model to test the result of labor reduction on the total production time. If the total production time changed favorably, the new model replaces the model and the reduction of labors will be continued in the same way until no reduction in production is possible.

By performing the experiment based on the proposed algorithm, the numbers of labors were decreased from 36 to 20 labors without any penalty to production time. The production time at each stage of the experiment is shown in **Figure 2** based on the number of labors in each model. As it has been shown in **Figure 2** by reducing the number of labors from 36 to 20 persons the production time do not change, but after reducing the number of labor from 20 persons to 19 persons, the production time changes dramatically. Thus at this point the experiment was stopped and no more labor reduction is done.

Figure 3 shows the inverse relation between number of workers and the cost of workers when the number of labors reduces from 36 to 20 persons. On the other hand it can be seen in **Figure 3** after reducing the number of labors from 20 to 19 workers, even though the number of labors reduces, labor time and cost increases. This is because of increase in the overtime wage of the labors as production time increases beyond the normal work time..

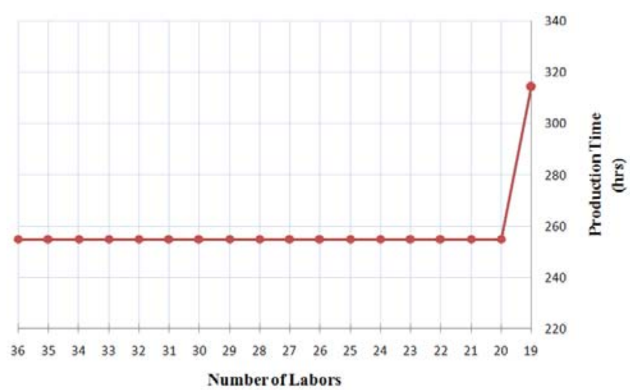

Fig. 2 Total production time versus the number of labors.

4.2 Functional labor flexibility strategy

In this strategy the effect of changing the skill level of labors will be investigated on the optimum solution from the numerical labor flexibility strategy with 20 full skilled labors or model No.17 and then the number of full skilled labors in the model will be reduced by substitution with low-skill or semi-skill labors without any penalty to production time. The algorithm of this strategy is shown in **Figure 4.** In this algorithm when the substitution of labor makes significant change in production time, the skill level of worker will be increased one step higher to decrease the production time again. This will continue until the all possible skill level of all the workers were tested.

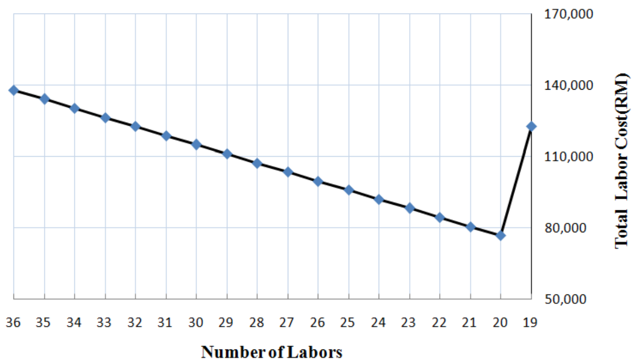

Fig. 3 Total labor cost versus the number of labors.

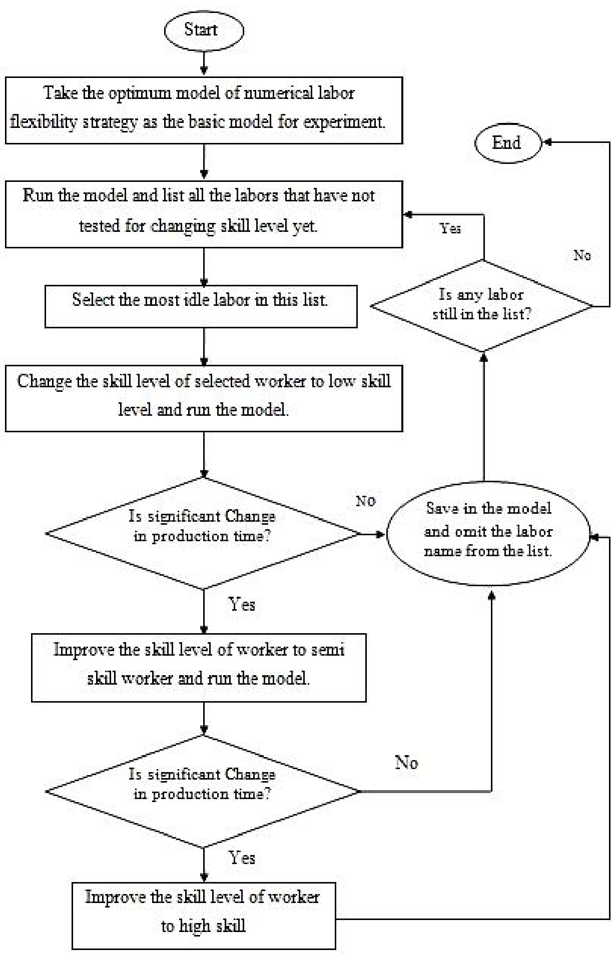

Fig. 4. The algorithm of functional labor flexibility strategy.

At the end of this experiment, 16 combinations of labors with different skill levels were found without any penalty to the production time (refer **Figure 5**).

For finding the best combination of labors we consider the combination with minimum labor cost (refer **Figure 6**). In **Figure 6** the changes of labor cost in the model is shown versus the changing in the skill level of worker. It shows that the labor cost is not constant among those models with minimum production time and varies as the combination of labors changes in the models. However among all of these combinations, there is one combination consisted of 11 low skill labor, 4 semi skill labors and 5 full skill labor which resulted with the minimum cost. Therefore this model is the optimum combination of labors in term of number of labor as well as the skill level of labors [12].

5. Discussion

Here we focus on the statistical result of the simulation model during the different steps of experiment and investigate the changes in the model specifications through each step of experiment. The details of some steps of first experiment (Numerical labor flexibility experiment) are shown in **Table 1**.

Model No.1 shows the specification of the basic model of current sewing production line. As it was mentioned before, in the basic model it is assumed that for every single process, one labor is allocated and this labor is always available to perform process when it is required. The labors are sorted from the busiest to the idlest labor. It can be found from Table 1 that in the basic model (Model No.1) more than half of the total numbers of 36 workers have more than 50% idle time. Thus the experiment was performed by reducing the number of labors to distribute duties between labors more effectively.

Comparing the final statistical result of labors in model No.17 (optimized model) with others in Table 1 shows the busy time of labors that perform the same duty through all the steps of experiment do not change until the last model.

For example the busy time percentage of labor011 that had been assigned to one operation from first step is the same p (71%) in all the steps of experiment. On the other hand the percentage of busy time of some labors that during the experiment more processes were added to them were increased. For instance the busy time percentage of labor004 at first is 10.5% however after assigning two other operation processes to this labor, its busy time percentage was increased to 50.33% in the final model.

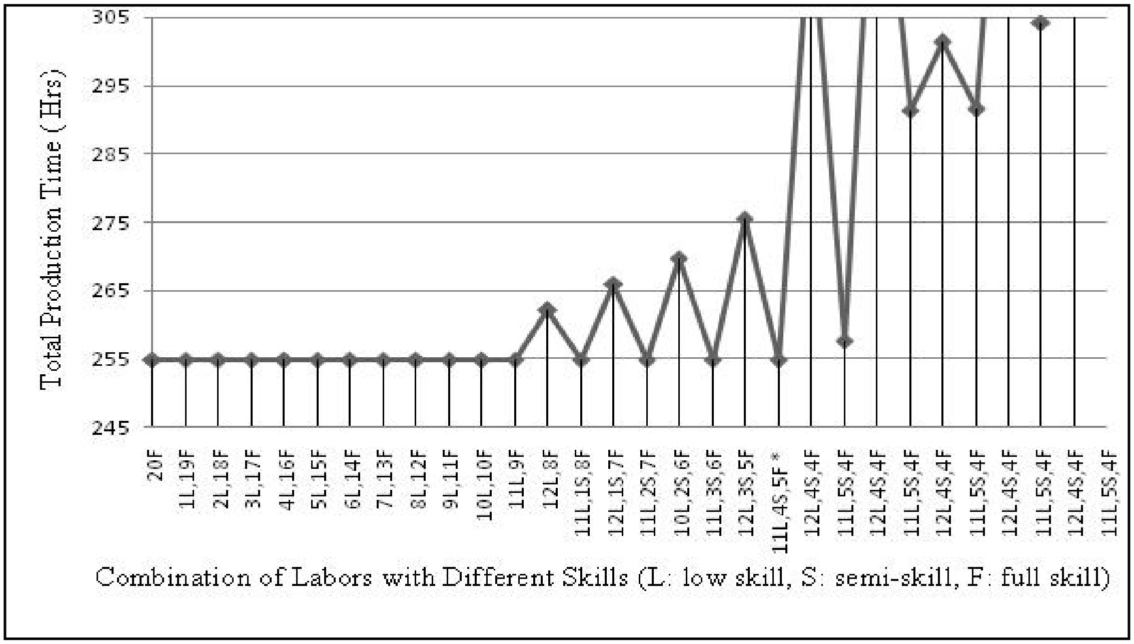

Fig. 5. Combination of labors with different skills versus production time.

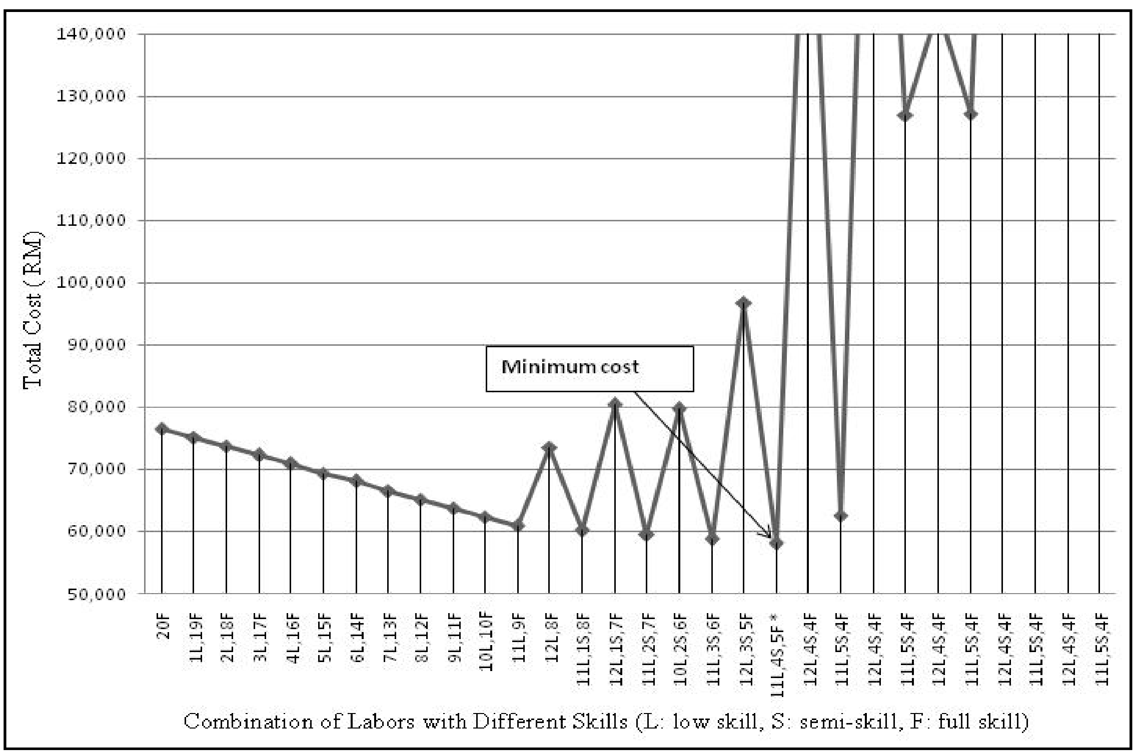

Fig. 6: Combination of labors with different skills versus labor cost.

Table 1: The changes in the busy time percentages of each worker on some selected models in experiment one.

Model No. 1		**Model No. 7**		**Model No. 13**		**Model No. 17**		**No. of allocated processes in last model.**
36 Labors		**30 Labors**		**24 labors**		**20 labors**		
Name	% Busy	Name	% Busy	Name	% Busy	Name	% Busy	
L001	99.88	L001	99.88	L001	99.88	L001	99.88	1
L016	95	L016	95.03	L016	95.04	L026	99.32	2
L019	77.26	L019	77.2	L019	77.14	L002	95.06	2
L013	75.47	L013	75.47	L013	75.47	L016	95.05	1
L006	74.43	L006	74.43	L006	74.43	L035	83.68	2
L018	73.19	L018	73.19	L018	73.25	L019	77.09	1
L011	71	L011	71	L011	71	L013	75.47	1
L012	68.17	L012	68.17	L012	68.17	L006	74.43	1
L030	66.41	L030	66.42	L030	66.41	L018	73.25	1
L010	61.79	L010	61.78	L010	61.79	L011	71	1
L015	59.79	L015	59.78	L015	59.8	L036	70.81	5
L021	54.24	L021	54.31	L032	57.05	L012	68.17	1
L023	53.46	L023	53.45	L021	54.36	L030	66.38	1
L005	50.33	L005	50.33	L023	53.48	L010	61.82	1
L031	49.75	L031	49.76	L004	50.38	L015	59.76	1
L026	49.57	L026	49.57	L005	50.33	L032	57.04	8
L002	48.35	L002	48.35	L031	49.74	L021	54.33	1
L029	46.76	L029	46.77	L026	49.58	L023	53.5	1
L035	43.82	L035	43.82	L002	48.35	L004	50.41	3
L014	39.86	L014	39.86	L029	46.72	L005	50.33	1
L017	39.45	L017	39.49	L035	43.82			
L008	26.54	L008	26.54	L014	39.86			
L028	14.29	L007	19.2	L017	39.42			
L003	13.87	L036	17.04	L036	31.33			
L009	13.29	L028	14.29					
L020	10.5	L003	13.87					
L004	10.5	L032	13.48					
L022	9.49	L009	13.29					
L025	8.34	L020	10.5					
L034	7.15	L004	10.5					
L007	4.75							
L036	4.36							
L024	4.36							
L032	3.97							
L033	2.38							

A comparison of the percentages of busy time of labors in the optimized model (Model No.17) with other models in the first experiment shows that in all models at least there is one labor with less than 50% idle time, while in the optimized model (model No.17) no labor has less than 50% idle time. In fact in each step of the experiment the number of labors with more than 50% idle time decreases smoothly until it reaches 0% in the optimized model of first experiment (refer **Figure 7**).

In this section, the result of the second experiment will be discussed. As it was mentioned before in the second algorithm the combinations of labors with different skill levels were applied to the model with the optimized number of labor (final result of the first strategy, that is, model No.17) and finally the optimized model with best combination of labors and different skill levels were found. The idle time percentages of labors in the final optimized model are presented in **Table 2.** By comparing the busy time percentages of labors with other models in both experiments, it can be found that task allocation of labors and work distribution between labors in this model has improved.

Fig. 7. Labors percentages in the models with more than 50% idle time

Finally the analytical results of both experiments are summarized as follows:

1. Job combination of those labors that their busy time percentage is more than 50% will result in a significant increase in total production time. Hence for reducing the number of labors without any delay in the total production time, it is suggested to combine the jobs of labors with busy time less than 50% only.

2. Using high skilled workers who can perform jobs faster is not always the best solution in minimizing production time in an assembly line. Sometimes by allocating low skilled workers to the production assembly line, the total labor cost can be decreased without any penalty to production time. For finding the cheapest combination of labors with different skill levels in a production assembly line, the cycle time of those labors that have more slack time (idle time) can be increased and the effect of this increase on the total production time can be investigated by using simulation. Some combinations do not have significant effect on the total production time, while some of them increase total production time. However by using simulation, the optimized combination of labors with the lower cost and lowest total production time can be attained.

Table 2. Specifications of labors in the optimized model (model No.17).

Name	% Busy	Avg Job Time	Labor skill
Labor001	99.85	2.52	Full
Labor011	99.34	2.51	Low
Labor036	99.27	1	Low
Labor026	99.2	1.25	Full
Labor012	95.29	2.41	Low
Labor002	95.09	1.2	Full
Labor016	94.95	2.4	Full
Labor030	92.93	2.35	Low
Labor019	92.71	2.34	Semi
Labor013	90.7	2.29	Semi
Labor006	89.45	2.26	Semi
Labor018	87.83	2.22	Semi
Labor015	83.78	2.12	Low
Labor035	83.66	1.41	Full
Labor032	79.82	0.5	Low
Labor021	75.93	1.92	Low
Labor023	74.83	1.89	Low
Labor010	71.69	1.81	Low
Labor004	70.56	1.19	Low
Labor005	70.32	1.77	Low

6. Conclusion

Two algorithms for numerical and functional labor flexibility were proposed. The effectiveness of these algorithms was investigated on a case study (a garment company) by using simulation. The purpose of this study is finding the optimized solution for the case study after testing the results of each alternative labor flexibility strategies on the production time and production cost of the case study. The following conclusions can be drawn from the research:

1. By applying the first strategy (numerical labor flexibility) on the case study, the numbers of labors were reduced from 36 persons to 20 persons without any penalty to production time.

2. Taking the optimal solution after the application of numerical flexibility it is then subjected to the algorithm for the functional labor flexibility. The solution was further improved when the number of full-skill labors was decreased from 20 to 5 persons without any penalty to production time. At the final stage the optimal model with the lowest labor cost was obtained by using 20 labors including 5 full-skill labors, 4 semi-skill labors and 11 low-skill labors without any penalty to production due date.

These results indicate that it is possible to achieve optimum labor flexibility strategy in a production assembly line of a garment factory through both numerical and functional flexibility algorithms proposed in this paper.

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