Proceedings of the 11th Annual World Conference of the
Society for Industrial and Systems Engineering,
2022 SISE Virtual Conference
October 6-7, 2022

Improving Workplace Layout and Work Environment at a Suit Factory

Y. Shirai and H. Ono

Department of Management Information Science
Chiba Institute of Technology
Chiba, Japan

Corresponding author's Email: yutaka.shirai@it-chiba.ac.jp

Author Note: Yutaka Shirai is a professor of Department of Management Information Science in Chiba Institute of Technology, is specialized in production engineering (production scheduling, factory planning, shipping plan, etc.). Hiroyuki Ono is an associate professor of the same department, specializing in environmental management.

Abstract: In the past, Japanese industrial products were competitive because of their high quality, low price, large-quantity production, and delivery with short lead times irrespective of the complexity of products ordered. Japan's competitiveness, however, has been affected severely by setbacks such as high wages, declining birthrate and aging population, increasing diversification of consumer needs, domestic deindustrialization, environment destruction, and deflation. Therefore, the work environment of production sites must be improved by reducing working hours, upgrading workplace layouts, and reducing unreasonable, wasteful, or inconsistent practices. This study develops a model of workplace layouts of an actual suit factory from the perspective of production management using the RaAP simulation software application. Also, this study analyzes the current layout. It examines proposed layout improvements that reduce working hours and which raise productive efficiency in comparison to the current layout. Furthermore, the study reveals important difficulties in the work environment while measuring working times. Finally, this report presents some proposed solutions to those difficulties.

Keywords: Improvement of Work Environment, Simulation, Workplace Layout

1. Introduction

Along with many other countries, Japan has been forced to cope with erratic business cycles in recent years. The world has been adversely affected by major economic fluctuations such as the Bankruptcy of Lehman Brothers in the fall of 2008 (Shirota and Morita, 2020) and the COVID-19 pandemic in 2020 (Le and Nhieu, 2022). Whereas the financial crisis was the center of attention following the Bankruptcy of Lehman Brothers, the shock waves extended to global manufacturing industries, leading to the de facto bankruptcy of General Motors, the world's largest automaker at the time. General Motors, as a result, shifted to new operations. Moreover, the Japanese manufacturing industry entered a long period of turmoil. In the past, Japanese industrial products were competitive because of their high quality, low price, production in large quantities, and delivery with short lead times irrespective of the complexity of the products ordered. Japan's competitiveness, however, has been affected severely by setbacks such as high wages, declining birthrate and aging population, diversification of consumer needs, domestic deindustrialization, environment destruction, and deflation (Belke and Volz, 2020; Cowling and Tomlinson, 2011).

Not only specialized technical knowledge, but also materials and workers to produce goods, workplace, and production management from the preparation to management of facilities are regarded as important for operating production activities. Therefore, work environments at production sites must be improved by reducing working hours, upgrading workplace layouts, and reducing unreasonable, wasteful, or inconsistent practices.

This study develops models of workplace layouts of an actual suit factory from the perspective of production management using the RaAP simulation software application. Then analyses of the current layout are conducted. This study examines proposed layout improvements that reduce working hours and which raise productive efficiency compared to the current layout. In addition, the study elucidates difficulties in the work environment while measuring working times. Finally, this report presents some proposed solutions to such difficulties.

ISBN: 97819384962-3-3

2. Modeling of the suit factory examined for this study

2.1 Overview of workplace layout

A workplace layout is produced to plan placement of personnel, materials, machinery, and other factors of production and to place them. The layout method most effectively facilitates the achievement of management goals that must be used to avoid waste and confusion in business management caused by laying out such factors of production without policy or order.

2.2 Modeling of suit factory

The following develops a model of a current layout of an actual suit factory using RaAP simulation software, with examination of a proposal for layout improvements that reduce working time and raise productive efficiency. RaAP is made by Computer Engineering & Consulting Ltd. in Japan, and is simulation software that can be verified in consideration of various factors for the design of production lines. The process sequence of suit (jacket) production is (1) making accessories, (2) making front bodies, (3) attaching interfacings, (4) making facings, (5) attaching the facings, (6) making a back, (7) making sides and shoulders, (8) making sleeves, (9) attaching the sleeves, (10) making a notched collar, and (11) attaching the notched collar. Figure 1 exhibits the suit (jacket) outline. Table 1 provides a description of the production process and the number of personnel.

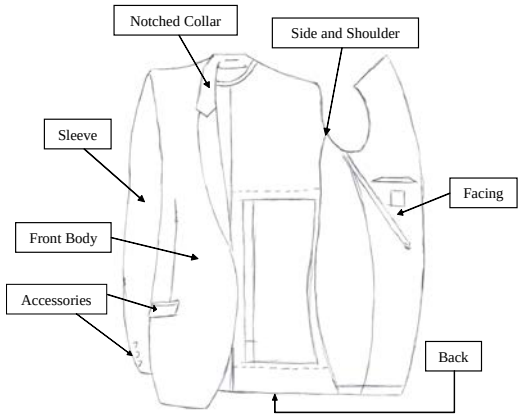

Figure 1. Outline of a suit (jacket).

Table 1. Description of the suit (jacket) production process and the number of personnel

	Process Title	No. Workers	Process Description
(1)	Accessories	4	Producing accessories such as pockets and buttons
(2)	Front body	6	Producing the front side of a jacket to make the basis of the jacket
(3)	Attaching interlining	4	Fixing the outer material of the front body with a basting thread to fit the outer material to the interlinings
(4)	Making facing	8	Producing the fabric continuing from the front placket on the back side of the front body of a jacket
(5)	Attaching facing	6	Fixing the facing produced in the process of making facing to the main unit
(6)	Back	3	Producing the back side of the jacket and fixing it to the main unit
(7)	Inserting sides and shoulders	6	Producing the sides and shoulders of the jacket and fixing them to the main unit
(8)	Making sleeves	5	Producing the sleeves of the jacket
(9)	Attaching sleeves	4	Fixing the sleeves produced in the process of making sleeves to the main unit
(10)	Making notched collar	2	Producing the jacket collar
(11)	Attaching notched collar	3	Fixing the collar produced in the process of making collar to the main unit

ISBN: 97819384962-3-3

Figure 2 portrays the model of the current work floor layout. In Proposal A for an improved layout, the stages after the facing production process have been moved to the back of the factory. Final processing has been placed near the doorway to reduce working time. Figure 3 presents the model of this Proposal A for an improved layout. Proposal B for an improved layout aims at reducing the working time by moving the first stages to the back of the factory in sequence and by placing the final stage near the doorway to improve the moving distance between stages. Figure 4 is the model of this Proposal B for an improved layout. The numbers in the figure correspond to numbers assigned to the stages. The doorway in each model is fixed in place.

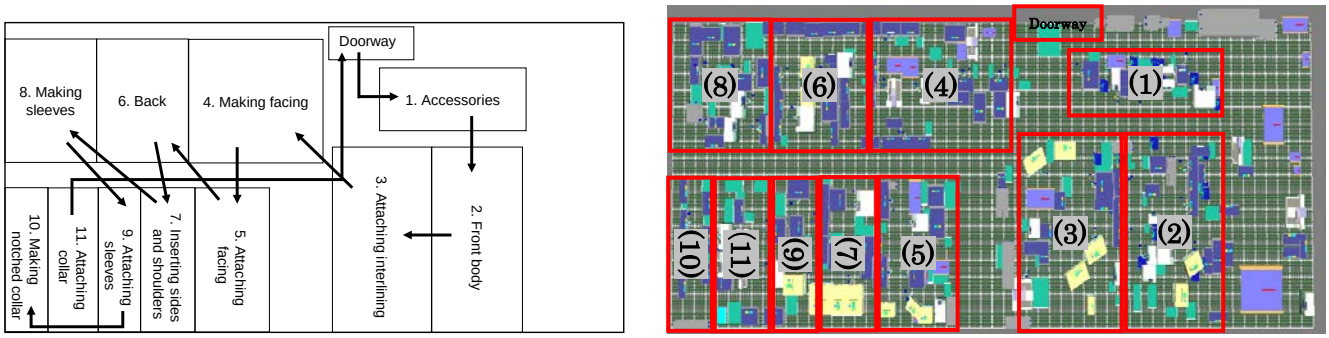

Figure 2. Model of the current layout.

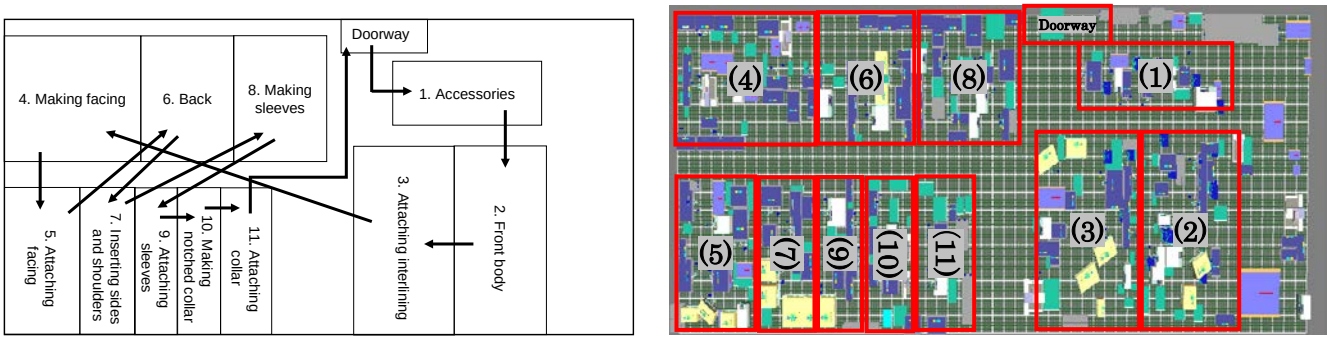

Figure 3. Model of Proposal A for an improved layout.

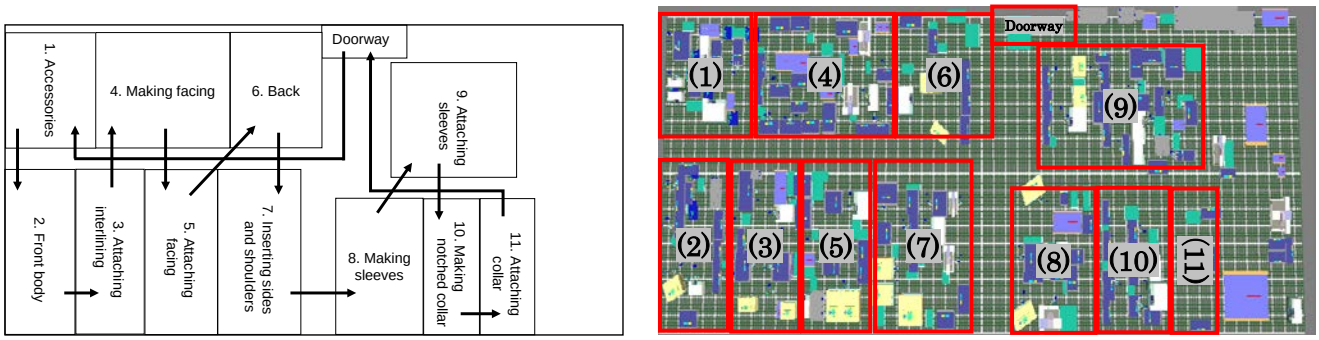

Figure 4. Model of Proposal B for an improved layout.

3. Simulation

3.1 Preconditions for the simulation

We will perform a simulation of each layout model described in Chapter 2 using the following preconditions.

(a) All workers walk at the same speed
(b) All workers have the same work capacity.
(c) They produce 10 suit parts at each stage.
(d) The starting time is the moment the first worker starts the work process. The finishing time is when 10 sets of finished suits arrive at the doorway, which marks the end of simulation.
(e) Working hours of workers vary depending on tasks at each stage and on the working hours measured at this suit factory used for the simulation. Table 2 presents the working hours at each stage. The simulation is performed by adding certain dispersion to these working hours.

Table 2. Working hours at each stage

	Title of Process	Number of Workers	Working Time (s)
(1)	Accessories (4 workers)	1	281
		2	207
		3	345
		4	208
(2)	Front body (6 workers)	1	138
		2	105
		3	181
		4	380
		5	331
		6	213
(3)	Attaching interlining (4 workers)	1	264
		2	278
		3	170
		4	141
(4)	Making facing (8 workers)	1	103
		2	100
		3	60
		4	53
		5	69
		6	95
		7	74
		8	69
(5)	Attaching facing (6 workers)	1	45
		2	110
		3	21
		4	150
		5	74
		6	26
(6)	Back (3 workers)	1	185
		2	329
		3	166
(7)	Inserting sides and shoulders (6 workers)	1	66
		2	45
		3	71
		4	78
		5	30
		6	34
(8)	Making sleeves (5 workers)	1	175
		2	188
		3	303
		4	99
		5	140
(9)	Attaching sleeves (4 workers)	1	203
		2	155
		3	245
		4	111
(10)	Making notched collar (2 workers)	1	231
		2	52
(11)	Attaching notched collar (3 workers)	1	129
		2	191
		3	227

Fifty-one workers stand by at their main positions. Workers in charge of the accessory process begin assembling suit parts when the work time starts. When they place the assembled suit parts at a certain location, the workers assigned to the next stage go and pick up the suit parts. They carry the suit parts to their work positions and begin the next stage. Workers engage in production in this flow from (1) making accessories, (2) making front bodies, (3) attaching interfacings, (4) making facings, (5) attaching the facings, (6) making a back, (7) making sides and shoulders, (8) making sleeves, (9) attaching the sleeves, (10) making a notched collar, and (11) attaching the notched collar. They transport the suits that completed the stage to the doorway, which is the end of the entire process.

ISBN: 97819384962-3-3

3.2 Results of model simulation

In the current layout, the work process starts near the doorway and continues to the back of the factory. As a result, production of 10 suits required 1 hour 56 min and 33 s.

Proposal A for an improved layout is the same as the current layout in terms of the placement of accessory processes, the first stage in which parts are received, near the doorway. In Proposal A, however, the stage of facing production and subsequent stages are moved to the back of the factory in sequence; the final stage occurs near the doorway. Placing the final stage near the doorway caused a waste of time in the transportation of parts from the stage of attaching interlinings to the stage of producing facings. Consequently, producing 10 suits required 2 hours 3 min and 29 s.

Proposal B is a layout that improved the moving distance between stages by relocating the first stages to the back of the factory in sequence and placing the final stage near the doorway. Starting the work process in the back of the factory and moving the final stage near the doorway caused reduced moving distances of the workers. Consequently, producing 10 suits required 1 hour 52 min and 30 s.

3.3 Discussion about the entire simulation

Table 3 displays the durations of the processes in the models obtained from the simulation. Comparison of the durations of simulation (working time) of the current layout and of Proposal A took 416 s longer in Proposal A. The stage of facing production and the subsequent stages were placed in the back of the factory. Also, the distance between the final stage, i.e., attaching collars, and the doorway was reduced to reduce the time for transporting finished suits to the doorway, which was a difficulty with the current layout. However, this difficulty caused additional moving distances to other stages and a longer duration of simulation of Proposal A than with the current layout.

Comparison of the duration of simulation of the current layout and of Proposal B indicated that it was 243 s shorter in the case of Proposal B. The difference between the current layout and Proposal B is the placement of the first stage, i.e., the accessory process, at the back of the factory and relocation of the final stage, i.e., collar attachment, to a place near the doorway. This arrangement decreased the travel time among the stages of producing the backs of jackets, attaching sleeves, and attaching collars, which was longer in the current layout and Proposal A. However, the simulation duration was not reduced considerably from the current layout because of slight increases in travel time for other stages.

Results of the simulation of the current layout and the two improved layout plans indicated Proposal B as the optimal option. Starting the work process near the doorway leads to a delay in downstream processes because of the extended travel distance of workers during processes, despite the initial high efficiency. Relocating all parts to the back of the factory in the first stage to start the process reduced the overall travel distance of the workers, which decreased the duration of the simulation.

Table 3. Duration of simulation of each model

	Current Layout	Proposal A for Improved Layout	Proposal B for Improved Layout
Simulation Duration	1 hr. 56 min. 33 s.	2 hr. 3 min. 29 s.	1 hr. 52 min. 30 s.

4. Improving the suit factory work environment

A better work environment can be created by discovering the following problems with the work environment while measuring working hours at a suit factory and solving such problems.

(a) Adjusting the desks and chair height

A considerable number of workers were witnessed to tend to work with an unnatural posture because of inappropriate heights of desks and chairs. Their postures can be improved by replacing the desks and chairs with those having easily adjustable height.

ISBN: 97819384962-3-3

Figure 5. Example of a worker with an unnatural posture.

(b) Aisles that are narrow and difficult to pass

Many aisles at the workplace were apparently narrow and difficult to pass (Figure 6). Therefore, casters will be attached to chairs. The workers will acquire habits of frequently pushing the chairs under desks.

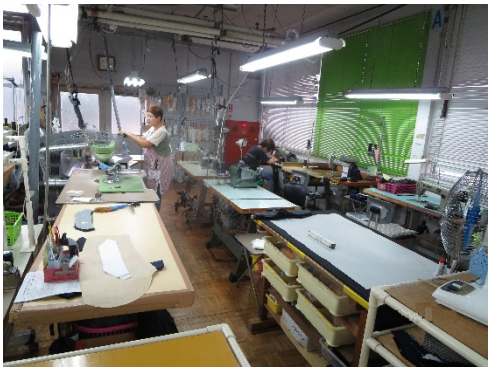

Figure 6. Example of a narrow aisle.

(c) How to place a basket for placing suit parts

Baskets containing suit parts are placed randomly on the floor, which might obstruct the passage of workers (Figure 7). Therefore, the position and direction of baskets will be arranged to keep them along the desks and to prevent them from sticking out into the aisles.

Figure 7. Example of a basket sticking out to an aisle.

(d) Long hours of simple tasks

The result of a questionnaire survey taken by the workers included a response that long hours of simple tasks distracted them from concentrating on their work. Therefore, the workers will be reminded often to increase concentration during work.

(e) Noises

Sounds of sewing machines and other machines were unavoidable because of the type of the factory, the occupational noises might cause disruption of sleep or activities, discomfort, irritation, disgust, and other psychological effects, and effects on physiological functions such as autonomic nerves and the endocrine system might cause symptoms such as headaches, tinnitus, and nausea. Results of a questionnaire survey taken by the workers revealed that some workers were affected by such symptoms. Such symptoms are difficult to detect other than through subjective observation and reporting. Therefore, constant attention to workers' health is necessary. If such a symptom appears, then measures such as the use of earplugs should be taken to an extent that they do not interrupt work processes or communication.

5. Conclusion

After this study used RaAP simulation software to develop models of workplace layouts of an actual suit factory from the perspective of production management, the current layout was analyzed to examine the production efficiency of the proposed layout improvements. Results led to a proposal for an improved layout that would achieve shorter working time and higher production efficiency than the current layout. Furthermore, the study revealed difficulties in the work environment while measuring the working time and presented proposed solutions to such difficulties.

Issues remaining for future study include a simulation that considers individual abilities of workers to develop a workplace layout with high production efficiency and creation of a better work environment by developing proposals for additional work environment improvement.

6. References

Belke, A. and Volz, U. (2020). The Yen exchange rate and the hollowing out of the Japanese industry. *Open Economies Review Springer*, 2020; 31: 371–406.

Cowling, K. and Tomlinson, P.R. (2011).The Japanese model in retrospective: industrial strategies, corporate Japan and the 'hollowing out' of Japanese industry. *Policy Studies, Taylor & Francis*, 2011; 32(6):569-583.

Drira, A. Pierreval, H. and Gabouj, S.H. (2007). Facility layout problems: A survey. *Annual Reviews in Control, Elsevier*, 2007; 31(2): 255-267.

Le, M.T. and Nhieu, N.L. (2022). A Novel Multi-Criteria Assessment Approach for Post-COVID-19 Production Strategies in Vietnam Manufacturing Industry: OPA–Fuzzy EDAS Model. *Sustainability*, 2022; 14(8): 4732.

Nik Mohamed, N.M.Z., Ab Rashid, M.F.F., Mohd Rose, A.N. and Ting, W.Y. (2015). Production Layout Improvement for Steel Fabrication Works. *Journal of Industrial and Intelligent Information*, 2015; 3(2): 133-137.

Riyad Hossain, Kamruzzaman Rasel, Md. and Talapatra, S. (2014). Increasing Productivity through Facility Layout Improvement using Systematic Layout Planning Pattern Theory. *Global Journal of Researches in Engineering*, 2014; 14(7): 70-75.

Shirota, Y. and Morita, M. (2020). Performance Analysis of Japanese Manufacturing Industry before and after Lehman Shock. *International Journal of Trade, Economics and Finance*, 2020; 11(5): 87-91.