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Assembly Line Balancing to Improve Productivity using Work-Sharing Method in Garment Factories

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ABSTRACT

The garment factories are always trying to improve production and the quality of the garments to sustain in the enormous competitive market. This paper is about the productivity improvement by reducing cycle time with work sharing in garment factories. A garment factory manufactures different types of garments. In many types of garment productions, this paper is to improve productivity of lady pencil skirts production process. Overall efficiency of single model assembly line by reducing the non-value added activities, cycle time and distribution of work load at each work station by line balancing. For that, the productivity improvement is shown by two ways. The first way is proper training and supervision for activities and the second is work sharing with same type of jobs and skills. Keywords – Cycle Time, Line Balancing, Productivity, Training, Work Sharing.

KEYWORDS: *Cycle Time, Line Balancing, Productivity, Training, Work Sharing*

I. INTRODUCTION

The garment process is divided into four main stages: designing and clothing pattern generation, cutting, sewing, ironing and packing.

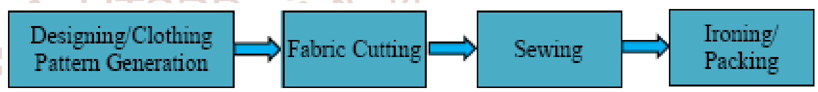

Figure.1 Simply Garment Manufacturing Process

The sewing process is the most important step as it comprises a set of workstations where certain tasks in a given order are processed. Unequal workload among workstations of a sewing line will increase work in process (W.I.P), waiting time, production cycle time and cost. Shop floor managers consider the balance of the line by assigning tasks as equal as possible to the workstation. Tasks will be given to the operators according to their different skill level limits. The line managers or production controllers use their experience in work assignments for the work stations, skill level, and standard period required to complete each task. Manufacturing a product always requires different types of sewing machines and different yarn colors, making it difficult to assign a worker to perform operations just a single machine. There is a maximum number of machines that each worker can use for a particular product. Each operation can be classified as a skill type. Each worker in the team is evaluated for all these skills on standardized tests. The ratings based on time is to perform skills and acceptable quality level for each skill. This rating system allows for incompetent workers who cannot perform certain skills as well. Cycle time is the key to increase as it affects both price and delivery schedule. If a solution had been proposed to improve the current situation, cycle time had been reduced. Reducing the cycle time means more output could be produced to meet the demand. This is very important for the related manufacturer in order to increase their productivity as long as there is no restricting factor. If the worker does not have in appropiate skill for production process, proper training and supervision are essential for better productivity and efficiency.

II. AIMS AND OBJECTIVES OF THE WORK

The aim of this work is to minimize workloads on the assembly line while meeting a target or maximum output. The objectives of the present study are as follows:

- To measure the cycle time for each operation.
- To calculate capacity for each operation.
- To identify the station of bottleneck.
- To determine feasible workstations.
- To reduce non-value added activities and cycle time for each operation.
- To reduce the total amount of idle time.

III. METHODOLOGY

In order to balance a production line in sewing floor, a line was chosen and necessary data was accumulated from the line. Two important attributes have been considered, one is possible standard method for each process and another is considerable time which is the input has been fed to the time study and taken to record the actual individual capacity of each worker. The time is recorded to make each process for each and every worker to find out the number of operator and helper, type of machines and individual capacity. To find out the (standard minute value) S.M.V, process wise capacity, actual capacity line graph, labor productivity and line efficiency are calculated in the following equations. After taking necessary data from the line, a suitable line is proposed with balancing technique. At first, the bottleneck processes are highlighted and then seek solution is to minimize the problem. In this paper, the first one is the proper training and supervision in some operations for the non-value added activities to be better productivity and efficiency. The second is a method to balance the line by sharing workload among equally adept workers who have experience in both the bottleneck process and the balancing process. The balancing process has shared the excess time in the bottleneck process. After balancing the line, total output per day, labor productivity and line efficiency are compared with the line target before balancing. The new manpower has been proposed and final capacity of each worker has been reallocated. Finally, a proposed production layout has been modeled with balanced capacity. And the layout is redesigned.

The calculations are as follows:

A. Observed Cycle Time

Observed Cycle Time = Total Cycle time / Number of Cycle Time (1)

B. Basic Time

Basic time = Observed cycle time × Performance Rating (2)

C. Standard Minute Value; (S.M.V)

S.M.V = Basic Time + allowances (Bundle, Machine and Personal) (3)

Allowances is a factor of 15% of basic time.

D. Dedicated Cycle Time

$$\text{Dedicated Cycle Time} = \frac{\text{S.M.V}}{\text{Number of operators worked}} \quad (4)$$

E. Capacity

$$\text{Capacity} = \frac{60}{\text{Dedicated Cycle Time}} \quad (5)$$

F. Labor Productivity

$$\text{Labor Productivity} = \frac{\text{Total output per day per line}}{\text{Number of operators worked}} \quad (6)$$

G. Line Efficiency

$$\text{Line Efficiency} = \frac{\text{Labor Productivity} \times \text{S.M.V} \times 100\%}{\text{Working minutes per day}} \quad (7)$$

IV. CASE STUDY

A case study is made at a Garment Factory situated at Hlaing Thar Yar Industrial Zone-II, Hlaing Thar Yar Township, Yangon Division, Myanmar, which manufactures different types of garments. In many types of garment productions, this paper is only based on lady pencil skirts production process in Figure.2. The information and data are obtained from this factory. In order to balance a production line in sewing floor, a line was chosen and necessary data was accumulated from the line.

Figure.2 Lady Pencil Skirt

To sewing one pencil skirt, there are 30 process need to attach pieces of fabric with back side (shell) 2Nos, front side(shell)long 2Nos, front side(shell)short 2Nos, waistband T.C 3Nos, front side T.C 1No and back side T.C 2Nos. Number of machine utilized is single needle 20Nos, two needles 2Nos and iron 4Nos. Number of workers included is operator 21 persons, helper 8 persons, leader 1 person, clerk 1 person and Q.C 1 person. Totally 32 persons include. Operations of each station and process layout are shown in Figure.3 and 4.

Sr No	Stations	Operations	Position	Type of Machine
1	1A	-Marking (back side Shell& waistband T.C 3Nos)	Helper	Manual
2	2A	-Stitching Back Side Lining2Nos,-Tacking Waistband T.C 3Nos	Operator	Single Needle
3	3A	-Safety stitching with 2 Needle on upper Front side Shell	Operator	Two Needle
4	4A	-Ironing Shell[Back side Darts, Attach fusion at rising],-Marking bottom hem	Helper	Iron
5	5A	-Belt Making	Operator	Single Needle
6	6A	-Belt Topstitch	Operator	Single Needle
7	7A	-Stitching Liningwith waistband	Operator	Single Needle
8	8A	-Belt Reverse In & Out	Helper	Manual
9	9A	-ShellOut Seaming topstitch (L & R)with fusion	Operator	Single Needle
10	10A	-Cutting belt-loop strings, Marking on Shell, Belt loops (4 Nos) tacking	Operator	Single Needle
11	11A	-Waist band tacking AttachLining & Shell	Operator	Single Needle
12	12A	-Tacking fusion for safety stitch of waistband	Operator	Single Needle
13	13A	-Tacking (Waistband 3 Nos & Bottom 3 Nos)	Operator	Single Needle
14	14A	-Tacking attach for kick pleat	Operator	Single Needle
15	15A	-Piping (Belt Loop String)	Operator	Single Needle
16	16A	-Thread Trimming & Remove Marking	Helper	Manual
17	1B	-Matching [Front Side(Shell4Nos & Lining1No) Back Side(Shell2Nos & Lining2No)& Waistband T.C (3Nos)]	Helper	Manual
18	2B	-Repair Station		
19	3B	-Forming Darts [(Back side Shell) & (Front Side Lining)],-Stitching(Front side upper Shell)	Operator	Single Needle

20	4B	-Stitching two Shell layers(Front & Back),-Marking Front Shellbottom hem	Operator	Single Needle
21	5B	-Safety stitching(Long)with 2 Needle on Front side Shell	Operator	Two Needle
22	6B	-Marking on waistband T.C and Main label stitch	Operator	Single Needle
23	7B	-Size label stitch and Liningside seaming	Operator	Single Needle
24	8B	-Stitch Shellfor kick pleat	Operator	Single Needle
25	9B	-Lining zipper attach	Operator	Single Needle
26	10B	-Ironing (Lining& Shell) Before attach	Helper	Iron
27	11B	-Stick with double tape on bottom hem & press ironing	Helper	Iron
28	12B	-Bottom Hem stitching	Operator	Single Needle
29	13B	-Safety stitch for kick pleat	Operator	Single Needle
30	14B	-Repair Station		
31	15B	-Ironing(In & Out, Zip attach, hem, Darts)	Helper	Iron
32	16B	-zipper safety stitch	Operator	Single Needle
33	17B	-Repair Station		
34	Q.C			

Figure.3 Difference Tasks of Each Station

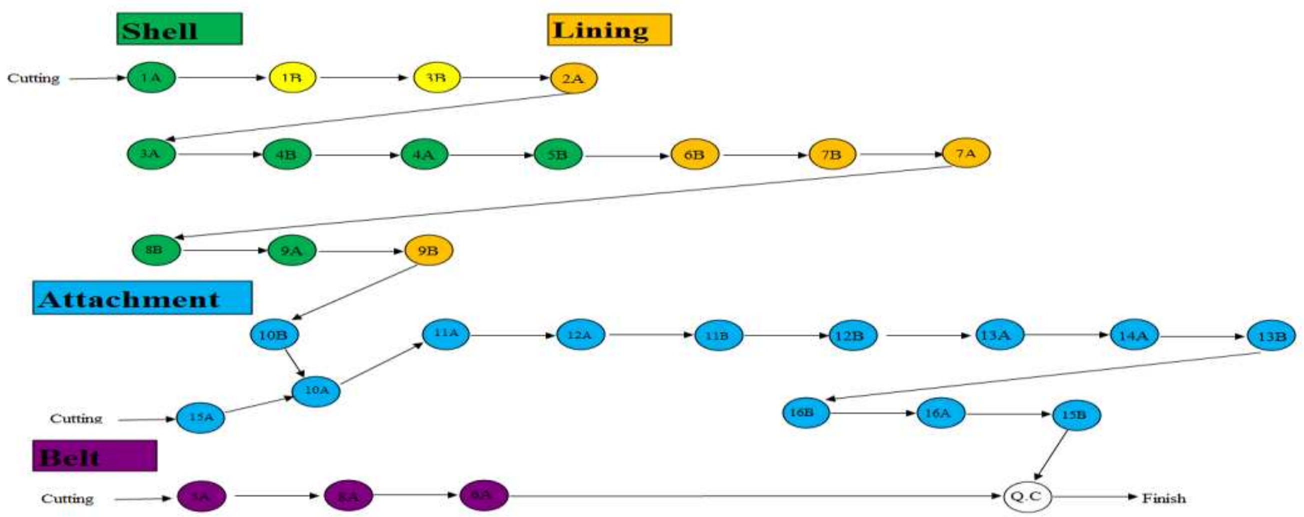

Figure.4 Process Layout

V. DATA ANALYSIS AND CALCULATION

A. Before Balancing the line

Taking cycle time for each operation is done manually and S.M.V. is calculated from the average cycle time with suitable allowance. Before line balancing production scenario is illustrated in Table 1.

Table I. Total Output, Labour Productivity and Line Efficiency Before Balancing

Total output per day	260 units
Total man power	30 operators
Working time	600 minutes
S.M.V	30 minutes
Labour productivity	8.667 units/operator
Line efficiency	43.33%

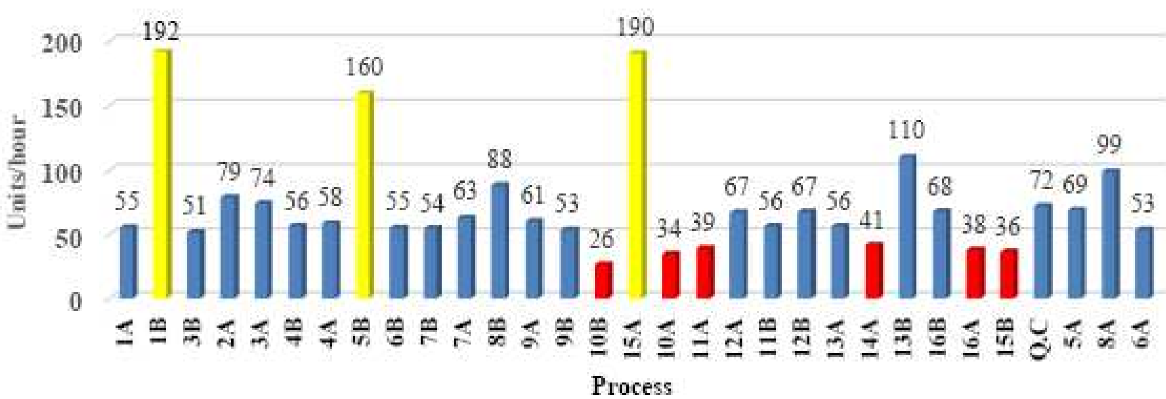

Figure.5 Hourly Process Capacity at Stations Before Balancing

Figure.5 is the plotting process wise capacity in a line graph. It shows the variation of each process as the upper capacity is 192 pieces per hour where the lower capacity is only 26 pieces per hour. This shows the imbalance situation in the line and bottleneck condition throughout the process of the whole garment making as lots of work in process (WIP) in the line. (Red cell signifies the capacity in bottleneck conditions and yellow cell shows levelling out capacity).

B. Identifying the Bottleneck Process

Some variations in process capacity is identified in Figure.5. The lower capacities are the bottleneck processes as production flow would stick on the bottleneck points. Comparing total capacity of each process, the bottleneck processes are process No.(10B), (10A), (15B), (16A), (11A) and (14A). Large work in process (W.I.P) of total production has been stuck in these bottleneck processes.

C. Eliminating the Bottleneck Process

Balancing method is very crucial to make the production flow almost smoother than the previous layout. Determining working distance, type of machines and efficiency, workers who have extra time to work after completing their works, have been shared their work to complete the bottleneck processes. Six bottleneck processes are previously identified which have been plotted in Figure.3.

Process No.(10B) and (15B) are both manual operations and these are making ironing. These two processes have been trained to reduce the non -value added activities (such as work arrangement, busy in searching time (bundle flow)) and unnecessary burst (reduce number of bursts). Process No.(10B) is the ironing of lining and shell before attach. In shell ironing, the operator pressed the iron on side seam of skirt with four bursts for one side. After one burst, the operator replaced the iron on table and picked up for next burst. The number of bursts are needed to reduce and train about ten cycle times. Finally, the operator can be made with two bursts for one side. In this process, there are four side seam. If the operator makes four bursts for one side, it will be totally sixteen bursts. If the operator makes only two burst for one side, it will reduce eight bursts. Therefore, it can reduce times for ironing process.

Process No.(15B) is the ironing of (In/Out, Zip attached, Hem, Darts, kick pleat) whole body finished product. The operator pressed the iron on product at swing arm board and on table. And the operator has more loading on non-value added activities. The operator is trained about ten cycle times to reduce non-value added activities and press the iron on product only on table. Finally, the operator can be only made on table and reduce non-value added activities.

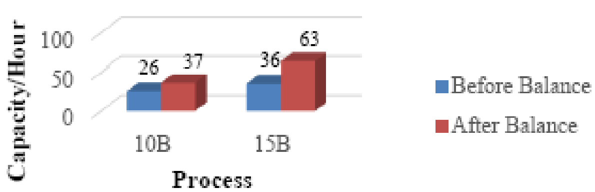

Figure.6 Capacities Change in Process No.(10B) and (15B)

Process No.(10A) and (15A) have been made by the same type of machine and same type of job. These two processes have been shared. Operator who work in the process No.(10A) works for three jobs and operator who work in process No.(15A) works in the first process, and has extra time to work after completing the first work. Therefore, operator of process No.(10A) works only one job and the operator in process No.(15A) works in the first process and then it makes the last two jobs of process No.(10A).

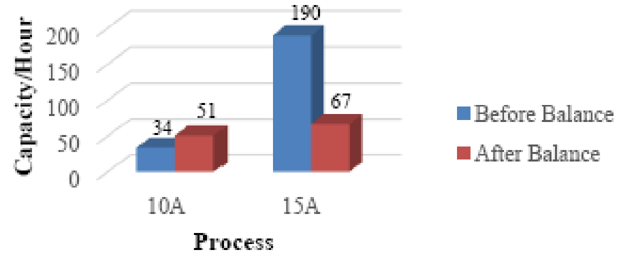

Figure.7 Capacities Change in Process No.(10A) and (15A)

Process No.(16A) is the manual operation of thread trimming and removing marking. Process No. (10A and 11A) have to cover the marking made in process No.(15A) so that the operator in process No.(16A) has only one job for manual operation of thread trimming.

Process No.(11A) is the single needle operation of waist band tacking to attach lining and shell. The operator is trained to reduce the number of bursts in tacking to attach lining and shell and it is trained not to appear for marking.

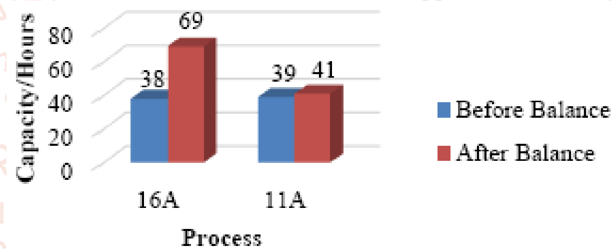

Figure.8 Capacities Change in Process No.(16A) and (11A)

Process No.(14A) and (13B) have been made by the single needle operation and same type of work station for making the kick pleat. Process No.(14A) is the tacking attach for kick pleat. It has more loading on non-value added activities of reverse in-out after completing the process. Process No.(13B) is the Safety stitch for kick pleat. After completing the process No.(14A), the product hangs over to process No.(13B). When the product reaches to process No.(13B), the operator makes reverse in and out for stitching process. Therefore, process No.(14A) has not been worked reverse in and out before the product hangs over to process No.(13B).

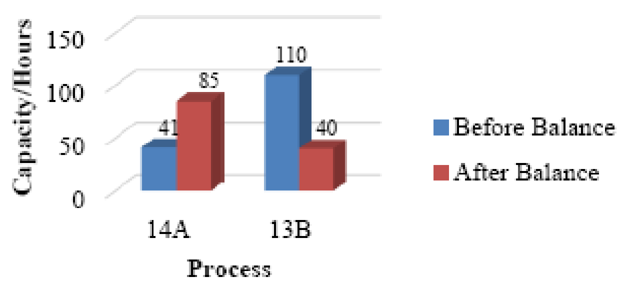

Figure.9 Capacities Change in Process No.(14A) and (13B)

Even after balancing six bottleneck stations, there are some stations which have much more capacity than others. These are process No.(1B) and (5B). These two stations situate as imbalance in the line and level out the workload. Therefore, these two stations have to share works.

(1B) is the process of matching [Front and back side (shell and lining) and waistband T.C (3nos)] and (1A) is the process of marking (back side shell and waistband T.C 3nos).

Both have been made by manual operation and these have been shared by two processes. Operator who works in process No.(1B) has been worked for 50 minutes per hour in her first process, capacity 161 pieces and then has been work in the process No.(1A) for last 10 minutes to make additional 9 pieces for overall capacity of 64 pieces.

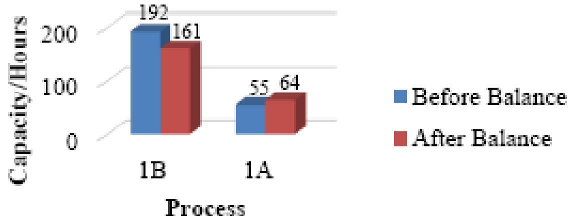

Figure.10 Capacities Change in Process No.(1B) and (1A)

Process No.(5B) and (3A) are both two needle operations for making safety stitch. As a result, they can share their work. Process 5B can work for 50 minutes and share with process 3A for last 10 minutes.

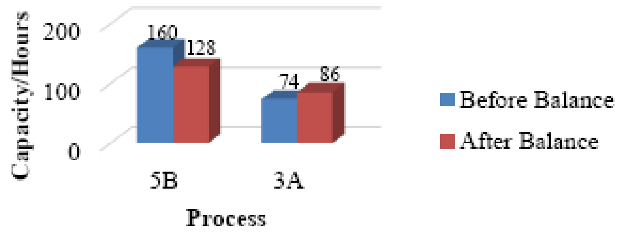

Figure.11 Capacities Change in Procss No.(5B) and (3A)

D. Proposed Balanced Workload Distribution

Balanced		Previous		Process No		Previous		Balanced	
S.M.V	Units/Hr	S.M.V	Units/Hr			S.M.V	Units/Hr	S.M.V	Units/Hr
1.09	64	1.09	55	1A	1B	0.31	192	0.31	161
0.76	79	0.76	79	2A	3B	1.17	51	1.17	51
0.81	86	0.81	74	3A	4B	1.07	56	1.07	56
1.03	58	1.03	58	4A	5B	0.38	160	0.38	128
0.87	69	0.87	69	5A	6B	0.75	55	0.75	55
1.12	53	1.12	53	6A	7B	0.35	54	0.35	54
0.95	63	0.95	63	7A	8B	0.68	88	0.68	88
0.61	99	0.61	99	8A	9B	1.13	53	1.13	53
0.99	61	0.99	61	9A	10B	2.27	26	1.64	37
1.17	51	1.74	34	10A	11B	1.07	56	1.07	56
1.46	41	1.55	39	11A	12B	0.89	67	0.89	67
0.90	67	0.90	67	12A	13B	0.54	110	1.49	40
1.07	56	1.07	56	13A	15B	1.66	36	0.95	63
0.71	85	1.45	41	14A	16B	0.89	68	0.89	68
0.89	67	0.32	190	15A					
0.87	69	1.60	38	16A					

VI. RESULT AND DISCUSSION

Changing from previous to proposed balance method, there are considerable improvements. Labour productivity has been increased from 8.667 to 12.33. In a day, the production increases from 260 to 370 pieces in working time 600 minutes with manpower 30. Line efficiency improves from 43.33% to 57.68%.

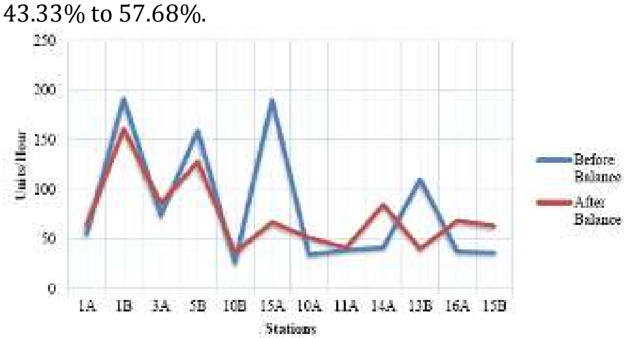

Figure.12 Comparison of Hourly Process Capacity at Stations

Figure.12 illustrates variation in each process capacity per hour after implementing proposed balancing method. The eight operations at bottleneck condition are above or very close to the other capacity per hour. So, the effect of bottleneck operation has been minimized by this balancing method. As a result of the balancing process, total output per day, labour productivity and line efficiency increase. Imbalanced ratio has been minimized from 53% to 40%.

Table II. Total output, Labour Productivity and line efficiency after balancing

Total output per day	370 pieces
Total man power	30 operators
Working time	600 minutes
S.M.V	29.01 minutes
Labour productivity	12.33 units/operator
Line efficiency	59.63%

VII. IMPROVEMENT

Table II. shows the new target which can be the further chance of improvements to balance the line. Maximum outputs have been increased to 370 pieces a day which was previously recorded to 260 pieces a day. Before balancing the line, 2600 pieces of garments have been produced for 10 days where these have been produced for 7 days after balancing the line. It saves three-days lead time for that style and productivity increase 42.3%. The difference production for one day is 110 pieces. The wage of workers is 800 kyats for one product, it saves 88000 kyats for one day. For three days, it saves 264,000 kyats. The more the productivity increases, the larger amount of order receives.

VIII. CONCLUSION

The balancing process relates to the type of machine because the machine utilized in the bottleneck process and the balancing process should be the same. Proposed layout model has been followed the logic of modular system (one worker works more than two processes who is skilled on all processes and these combination of skilled workers finish their work in piece flow production) and traditional system (one worker only works in one process and all the workers who may be skilled or their work in bundle flow production is not finished) both together where only modular production system can be applicable with a series of skilled workers to achieve more productivity. On this occasion, skilled workers in the appropriate production process, proper training and supervision are essential for better productivity and efficiency.

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