

Chapter 8

Machine Layout, Multi-Functional Workers, and Job Rotation Help Realize Flexible Workshops



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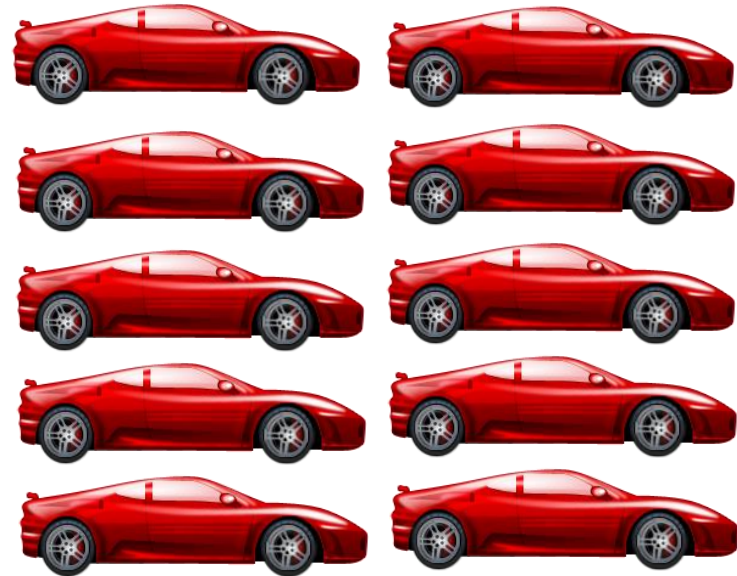
8.1 Shojinka: meeting demand through flexibility

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8.3 Attaining Shojinka through multi-functional workers

8.1 SHOJINKA: MEETING DEMAND THROUGH FLEXIBILITY

- ❖ *Shojinka* (少人化) is attaining flexibility in the number of workers at a workshop to adapt to demand changes.



8.1 SHOJINKA: MEETING DEMAND THROUGH FLEXIBILITY

- ❖ *Shojinka* is equivalent to increasing productivity by the adjustment and rescheduling of human resources.
- ❖ Three factors are prerequisite to realize Shojinka:
 - proper design of machinery layout
 - a multi-functional worker
 - continuous evaluation and periodic revisions of the standard operations routine

8.1 SHOJINKA: MEETING DEMAND THROUGH FLEXIBILITY

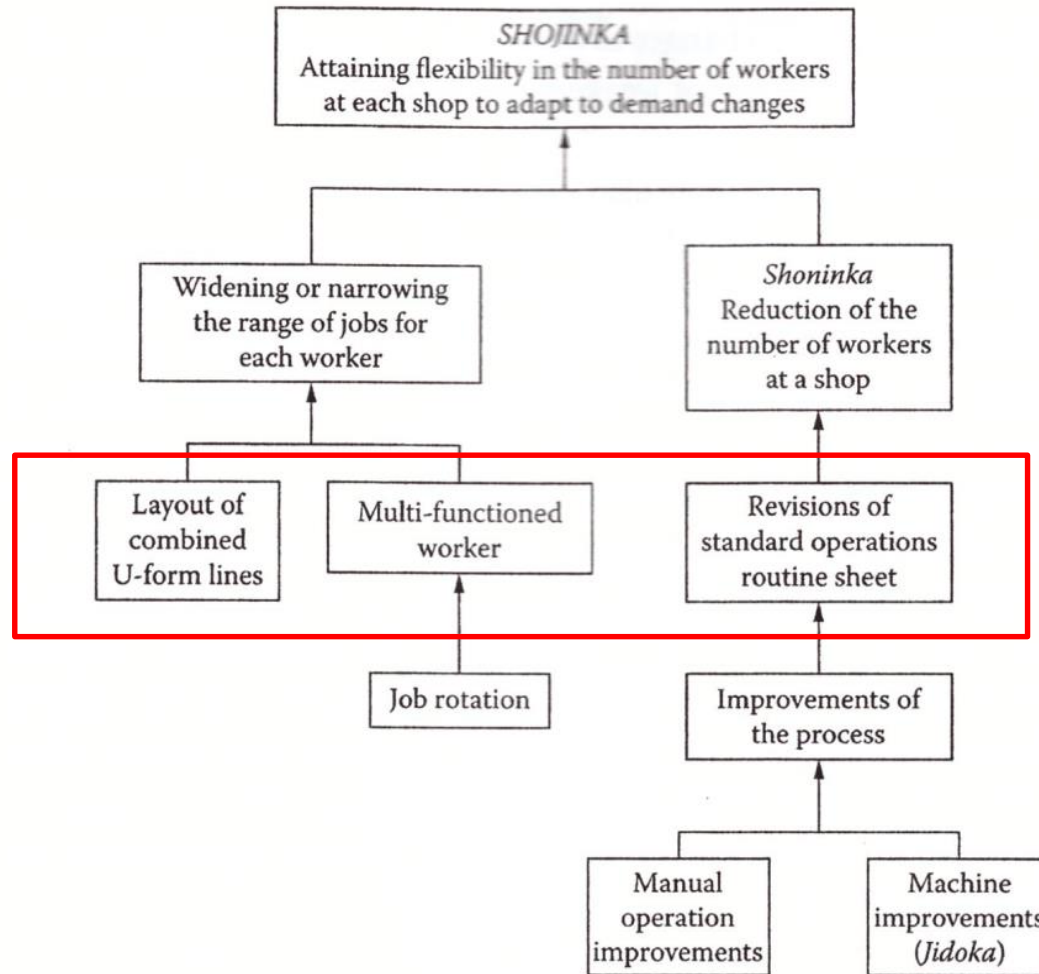


FIGURE 8.1
Causal factors to realize Shojinka.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Under the *U-turn layout*, the entrance and exit of a line are at the same position.
- ❖ The U-turn layout has several variations, such as the concave and circle forms.
- ❖ The most remarkable advantage is the flexibility to change the number of workers for the fluctuation of demand.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

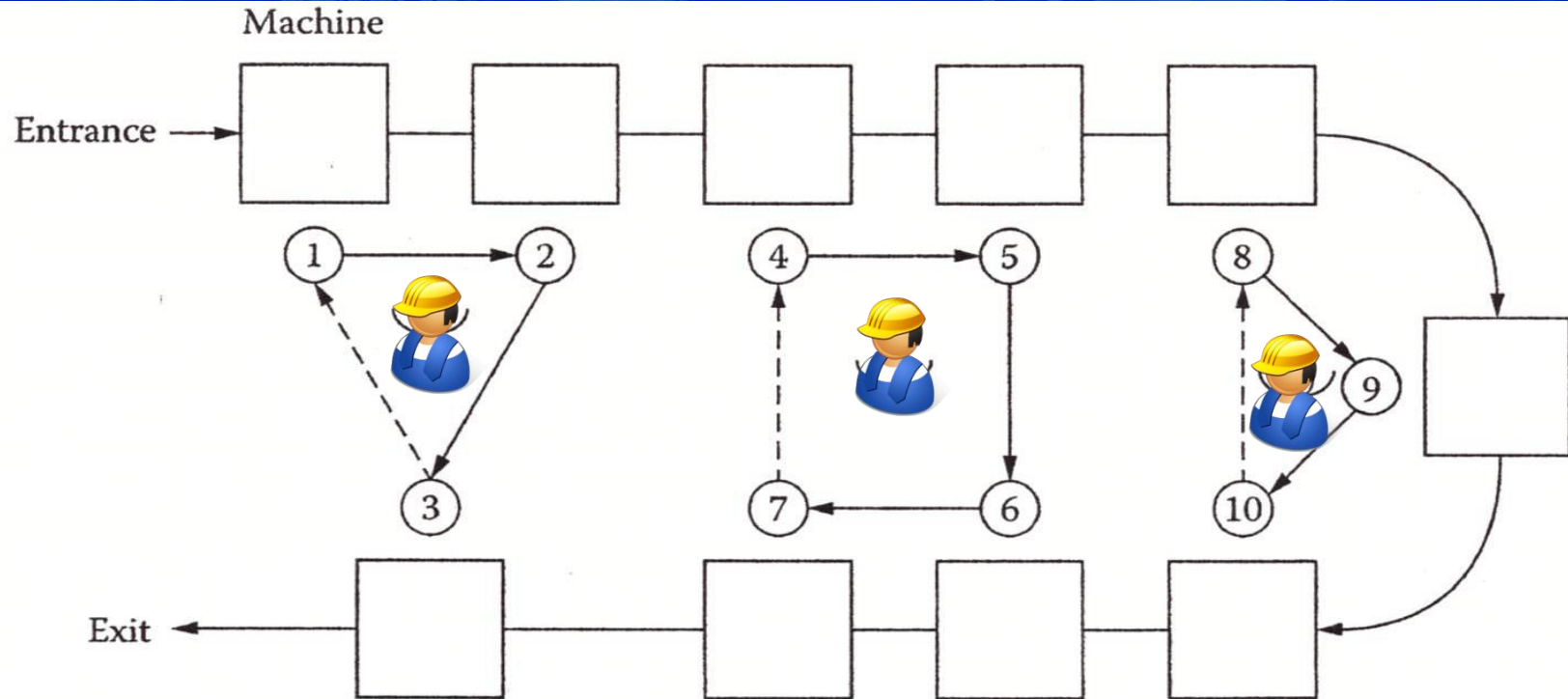


FIGURE 8.2
U-form layout.

A unit of part can pass into the entrance of the process when one unit of output leaves through the exit.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ JIT pull production can be achieved.
- ❖ The quantity of work-in-process can always be constant.
- ❖ Unbalanced operations among workers will be visual.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ There are three major categories of layouts that are improper for Toyota.
 - birdcage layouts
 - isolated island layouts
 - linear layouts

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Under birdcage layout, two or more stands containing the same type of machine can be laid out around the worker.

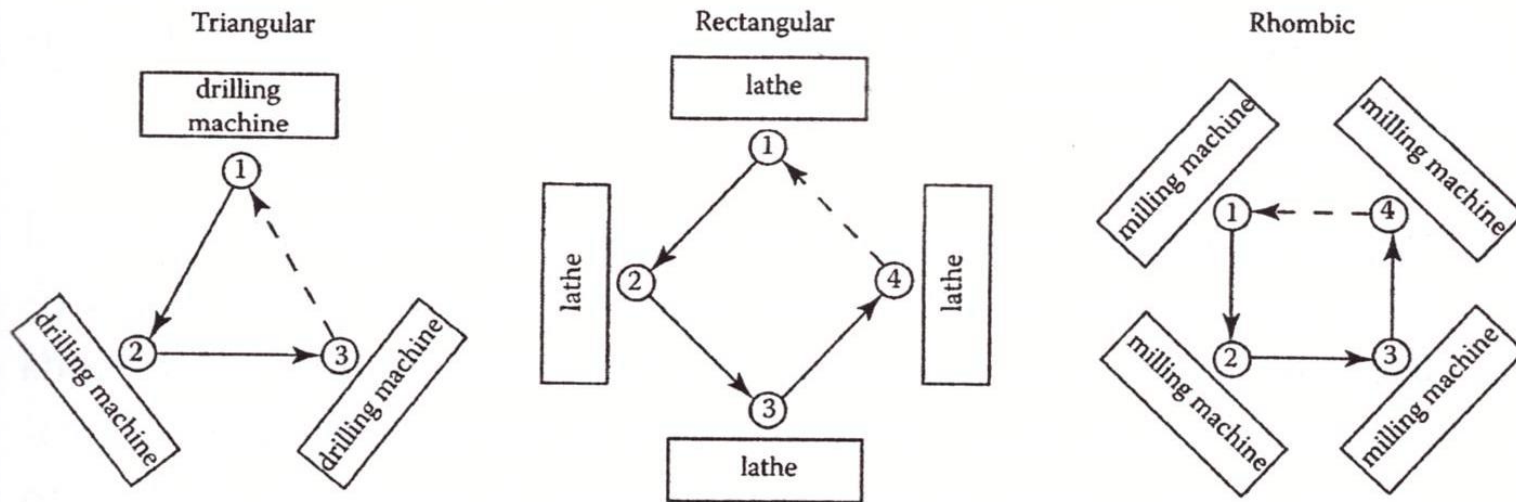
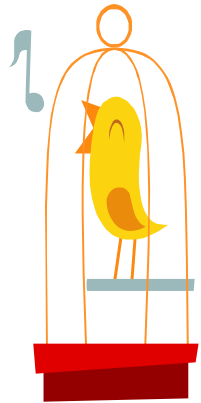


FIGURE 8.3
Types of birdcage layouts.



8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ The production quantity per worker is high but the inventory of semi-finished inventory at each station is also increased.
- ❖ *Production balancing* and *synchronization* among stations are difficult to achieve.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Under the *isolated island layout*, a multi-functional worker handles different types of machines in accordance with the sequential order of processing a part.

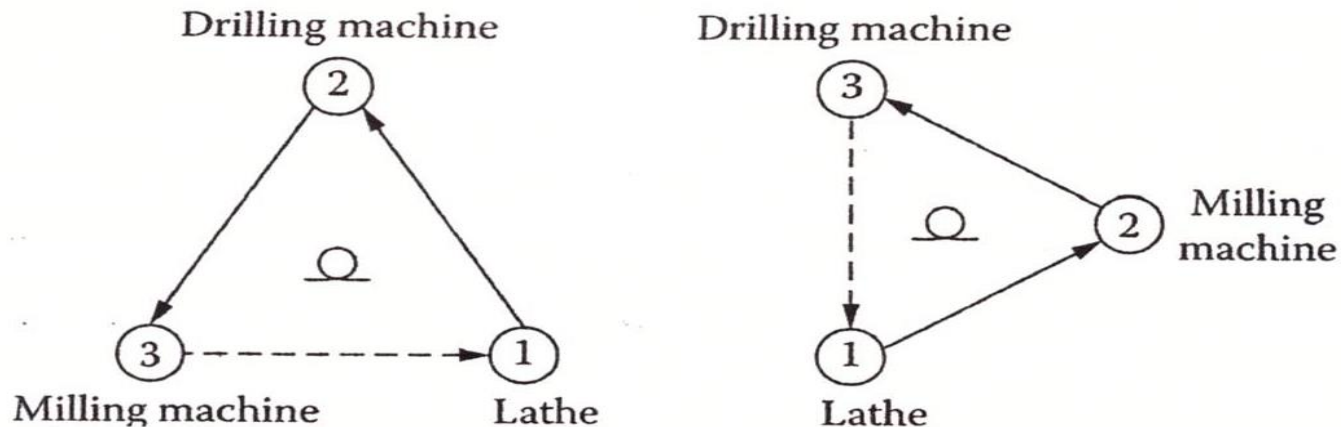


FIGURE 8.4
Isolated island layouts.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

Advantages of isolated island layout

- ❖ It enables a continuous and smooth flow of products among different types of machines.
- ❖ It also ensures a continuous walking route with the least distance for each worker.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

Disadvantages of isolated island layout

- ❖ Workers are separated from one another and cannot help each other.



- ❖ Reallocation of operations among workers to respond to changes in demand is difficult.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Under the *linear layout*, a multi-functional worker handles different types of machines that are laid out in a linear form.

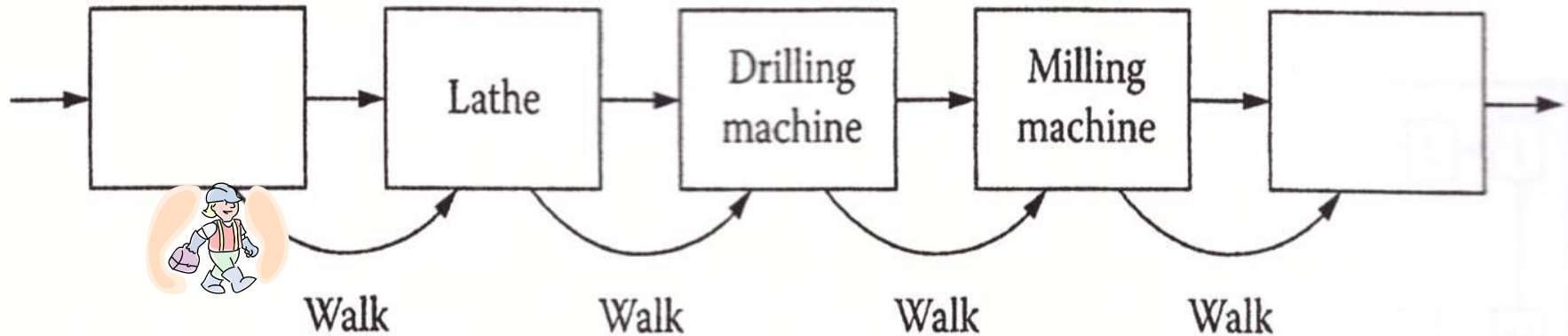


FIGURE 8.5
Linear layout.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ The linear layout allows products to flow smoothly and quickly among machines.
- ❖ It cannot reallocate operations among workers.
- ❖ It may requires a fractional number of workers, such as 8.5 workers.



8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Toyota combines several U-form lines into one integrated line.
 - Can overcome the problem of fractional numbers of workers.
 - Can reallocate operations among workers.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Suppose there is a combined process that consists of 6 different lines (A-F).

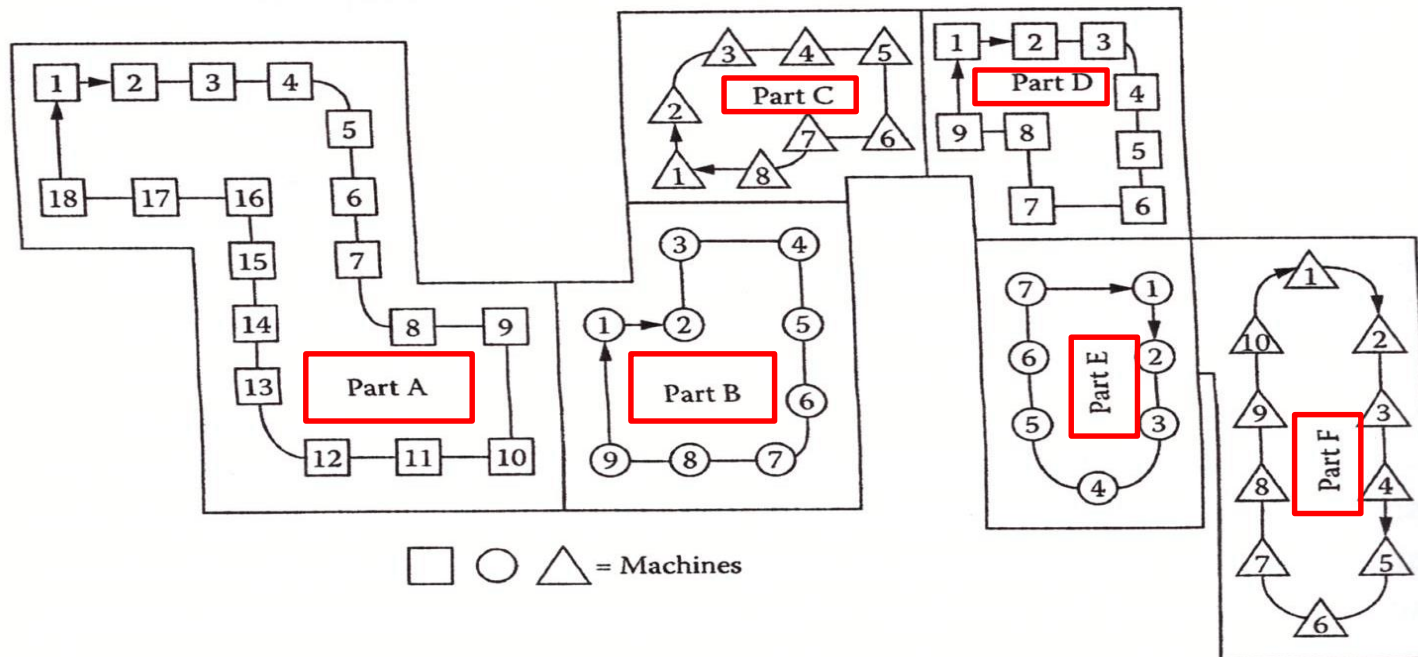


FIGURE 8.6
Combined line making six kinds of parts (A-F).

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ According to the monthly demand in January, the cycle time of this combined process is 1 minute per unit and 8 workers are involved.

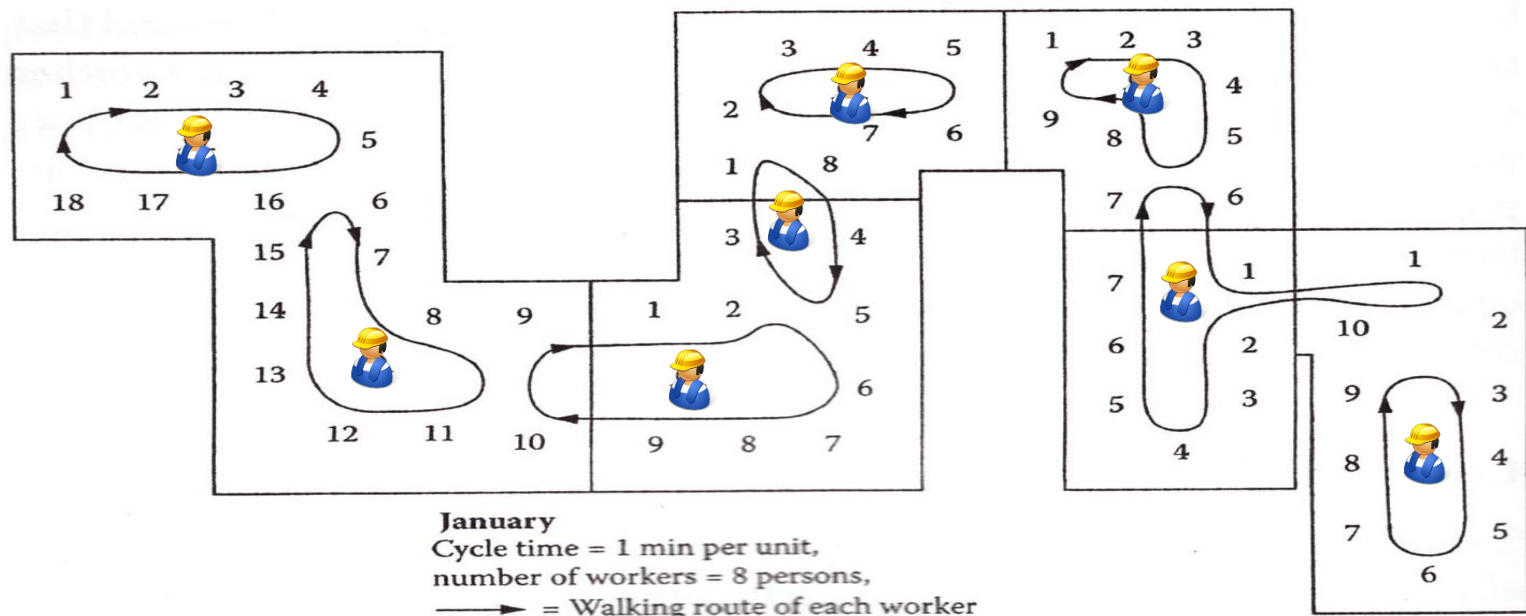


FIGURE 8.7
 Allocation of operations among workers in January.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ In February, the monthly demand is decreased and cycle time is increased to 1.2 minutes.

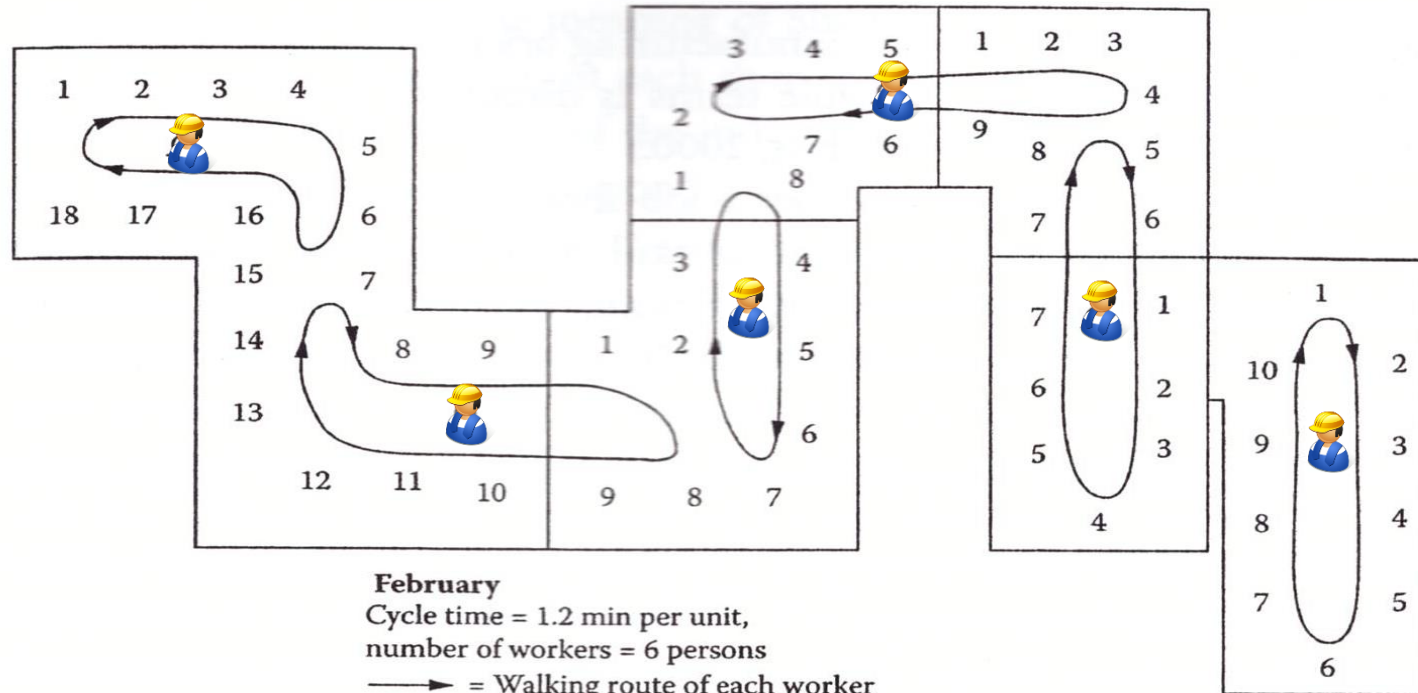


FIGURE 8.8
 Allocation of operations among workers in February.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Each individual U-turn process is a kind of cell, where either one or two workers are working.
- ❖ It is easy to increase or decrease the number of workers.
- ❖ This phenomenon is a key merit of the *cellular manufacturing system*.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

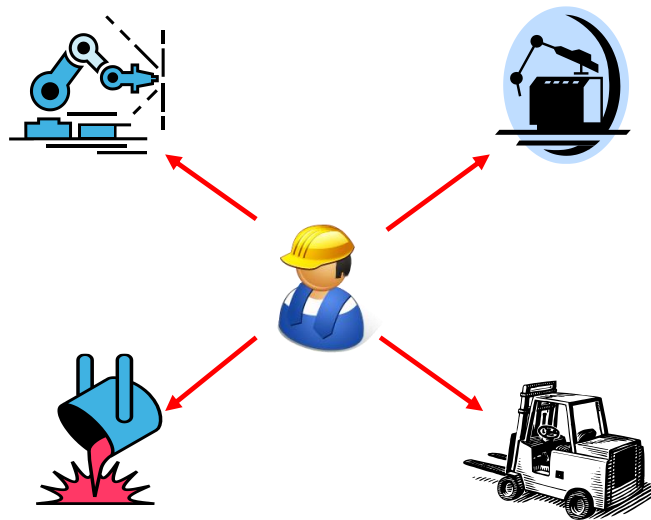
- ❖ The cellular manufacturing system belongs to the process design based on a product-flow type machine layout.
- ❖ It assumes that similar products are flowing through the process.

8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Item or parts with similar physical forms or similar engineering procedures must be grouped into *item families* or *part families*.
- ❖ Various machines are identified by the group of machining operations necessary to process sets of similar items (or part) families.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

- ❖ The ability to widen or narrow the range of jobs performed by each worker is a key ingredient in achieving Shojinka.
- ❖ The workers must be multi-functional, i.e., trained to be a skilled worker for any type of job and at any process.



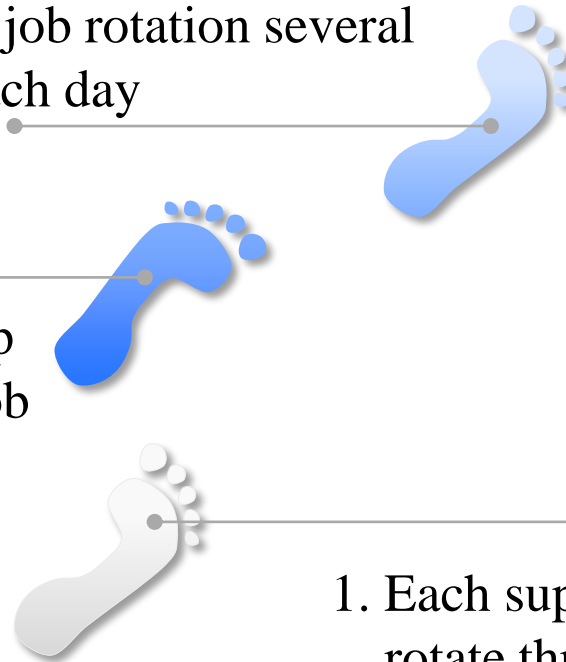
8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

❖ Toyota cultivates their workers using a job rotation system that consists three steps.

3. Schedule the workers through job rotation several times each day

2. Each worker within the shop is trained to perform each job in the shop

1. Each supervisor must rotate through every job



8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

- ❖ A job rotation plan in Toyota was first implemented at the Tsutsumi Factory.

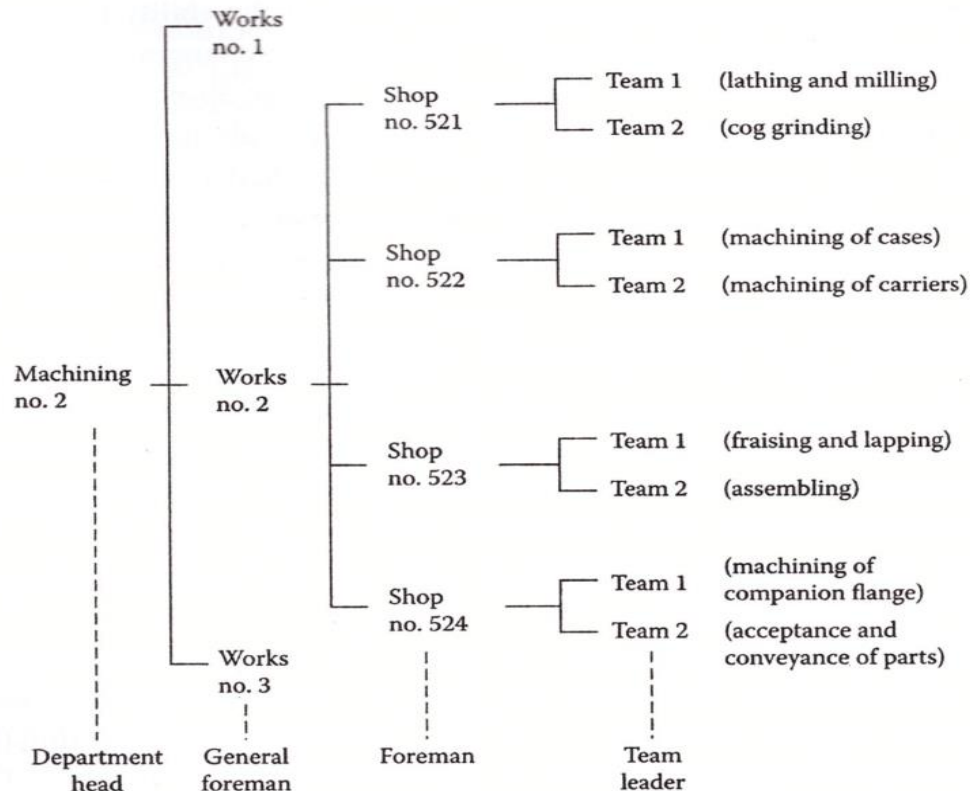


FIGURE 8.9
Organization of machining plant no. 2.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

- ❖ The managers and supervisors must first display themselves as examples of the multi-functional worker.
- ❖ The general foremen, foremen, and line chiefs were rotated among each work's shop and line in Toyota's Tsutsumi Plant.
- ❖ This job rotation plan was a part of a long-range planning program.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS





- ❖ For the rotation of each worker, a job-training plan must be scheduled.
- ❖ A multi-functional worker rate for each shop must be formulated (n is the number of workers at the shop).

$$\frac{\sum_{i=1}^n \text{number of processes that worker } i \text{ has mastered}}{\text{total number of processes within the shop} \times n}$$





































































What does the rate equal to 1 mean?

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

Job Training Plan Sheet
(shop no. 523)

 = Planned to train this year
 = In training
  = Trained already

Line name: 160 mm differential carrier assembly line

Workers \ Processes	Processes							
	1	2	3	4	5	6	7	8
A								
B								
C								
D								
E								
F								
G								
H								
Foreman								

What is the rate in this plant?

FIGURE 8.10
Job training plan sheet.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

- ❖ When the multi-functional worker rate is high, job rotation could be made every week, or in many cases every day.
- ❖ All workers could be rotated among all processes in two- or four-hour intervals.
- ❖ Suppose that 160 mm differential carriers are assembled by 8 workers within the cycle time of 26 seconds.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

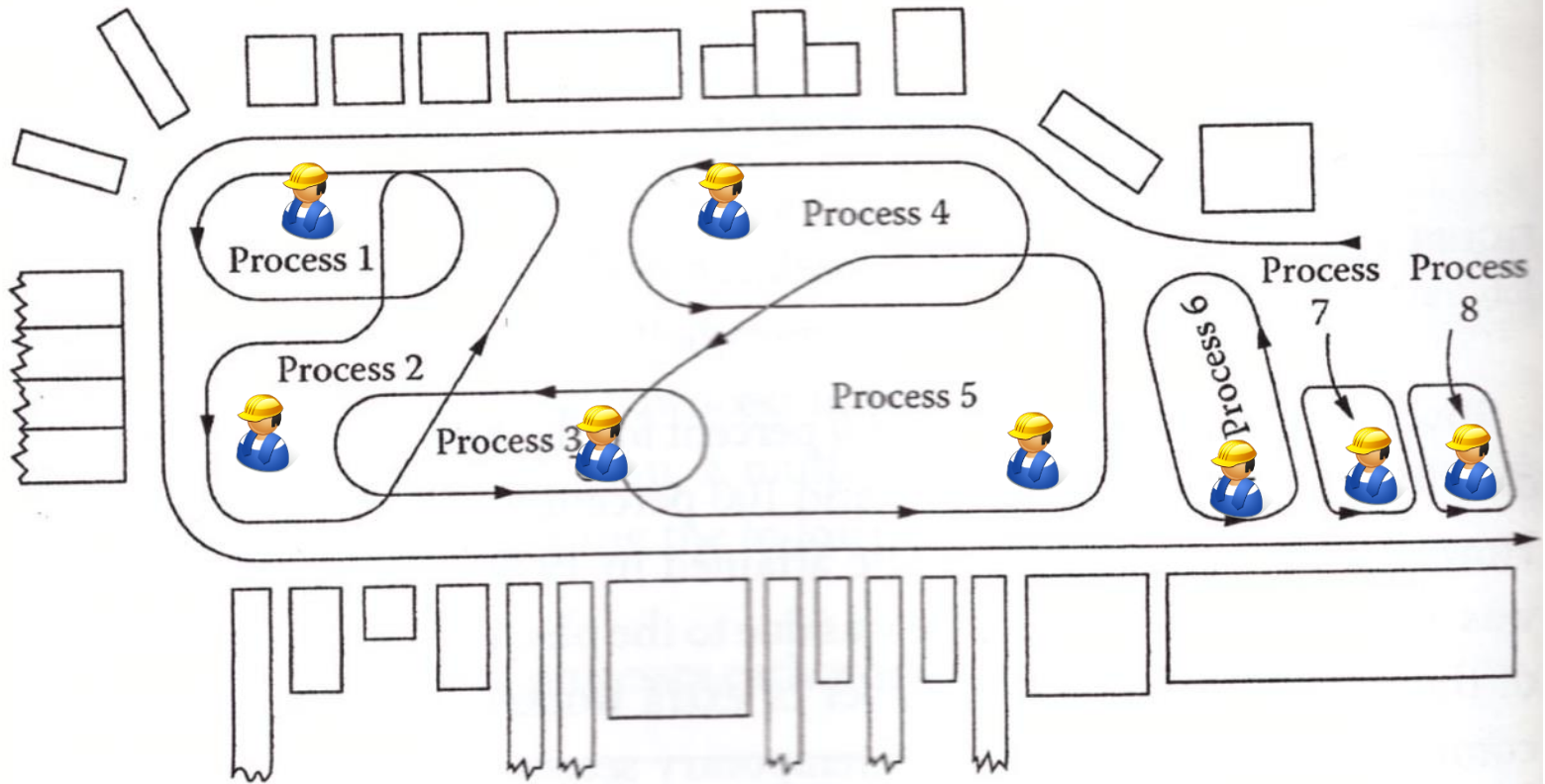


FIGURE 8.11
Layout and standard operation routines.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

Process No.	Contents of the job at each process	Characteristic of operations	Manual operations time	Fatigue rank
1	Differential case	Skill of finger work is required	26"	4
2	Cover assembly	Skill and knowledge of quality check are required	26"	5
3	Can adjust	Long walking distance	26"	3
4	Ring gear assembly	Finger work, and heavy work by right arm	26"	1
5	Pre-load adjustment	Long walking distance with heavy material	26"	2
6	Bearing assembly	Sensitivity of hand and finger is required	26"	6
7	Back-rush holding	Skilled work, and heavy work by waist and arms	26"	7
8	Rock-bolt assembly	Waiting time of 2 sec. exists	24"	8

FIGURE 8.12

Job characteristics and fatigue rank of each process.



8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

- ❖ Job rotation in this example is accomplished in intervals of 2 hours.
- ❖ A job rotation schedule must be planned for the five days of the following week.
- ❖ A fair allocation and the training program for the newcomer should be considered.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

Job-Rotation Schedule

(shop no. 523)

Times of rotation	Line name		160 mm differential carrier assembly line							
	Time interval	Process no.	1	2	3	4	5	6	7	8
1	8AM-10AM		A	B	C	D	E	F	G	H
2	10AM-12AM		G	A	B	C	D	H	E	F
3	1PM-3PM		E	G	C	A	B	F	D	H
4	3PM-5PM		D	C	G	B	A	H	F	E
5	5PM-7PM		B	D	C	E	E	A	G	H

FIGURE 8.13

Job rotation schedule for workers (A-H).

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

Additional advantages of job rotation

- ❖ Workers' attitudes are refreshed and muscle fatigue can be prevented.
- ❖ The feeling of unfairness that veterans must have heavy work will disappear.
- ❖ The skills and know-how are dispersed throughout the shop.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

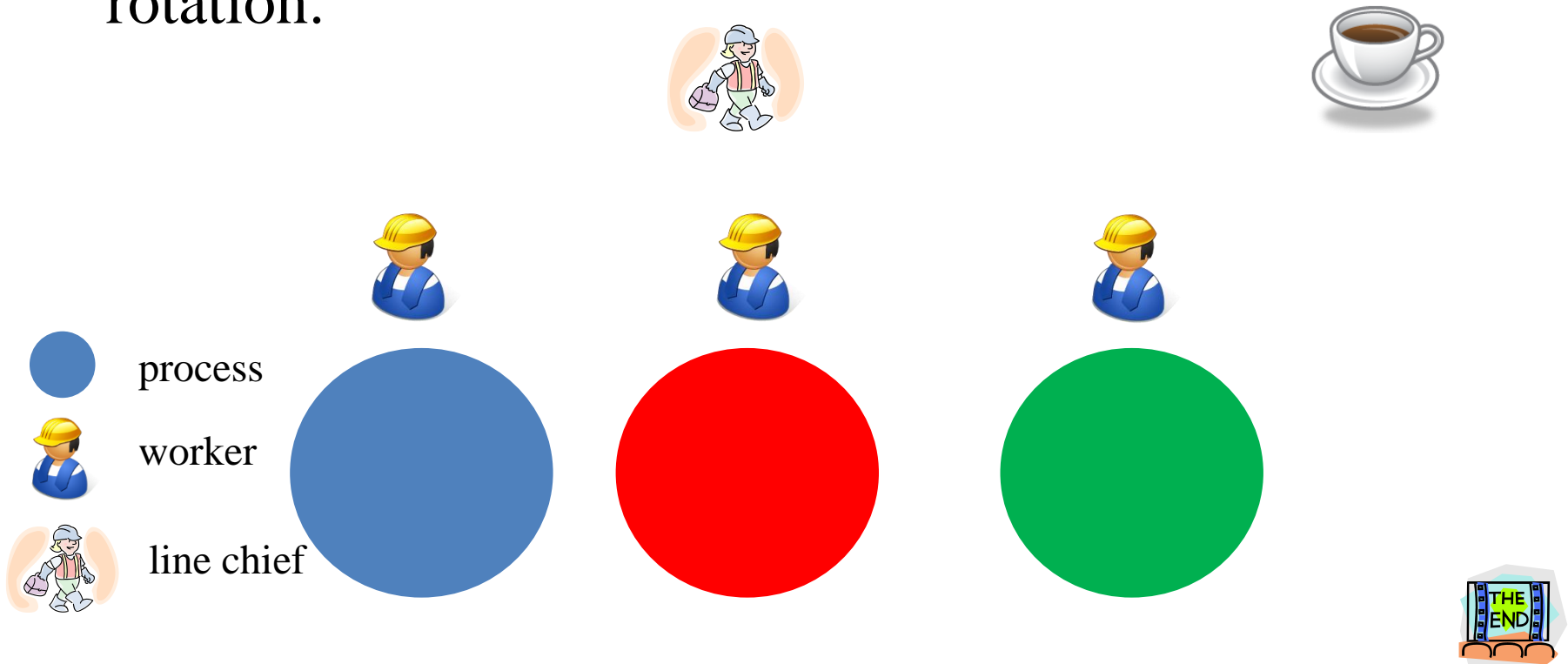
Additional advantages of job rotation (continued)

- ❖ Each worker feels responsible for all goals of the shop.
- ❖ At new shops and processes, ideas and suggestions will increase remarkably.
- ❖ These benefits can be summarized with *respect for humans*.

8.3 ATTAINING SHOJINKA THROUGH MULTI-FUNCTIONAL WORKERS

Importance of the line chief

- ❖ Allows workers to take a rest while still permitting job rotation.



8.2 LAYOUT DESIGN: THE U-TURN LAYOUT

- ❖ Suppose that one unit has been produced in a 2-minute cycle time by only one worker.
- ❖ Assume that the cycle time was reduced to 1.5 minutes due to increased demand.
- ❖ An additional worker should be introduced and the two workers totally have 1 minute of idle time in each cycle.

