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DESIGNING A SIMPLE U-SHAPED PRODUCTION LINE AND ANALYSIS OF EFFECTIVENESS

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ABSTRACT
U-shaped production lines are special type of cellular manufacturing used in Just-In-Time (JIT) and Lean manufacturing. The U-line arranges machines around a U-shaped line in the order in which production operations are performed. Operators work inside of the U-shaped layout. In this study, first of all, U- shaped assembly lines and the layout options are explained, and then a heuristic technique applied to a Turkish company.
In the company where the application took place, the cells involving the production of axis in two different types (central axis UK, central axis DXE) and dimensions are analyzed. The new system which was designed considering new demand levels is investigated depending on various criteria, viz., cycle time, manpower, number of shifts, overtime durations, security buffers, labor and cell efficiencies, average efficiency and profit. This is followed by the balancing of the new design for various demand levels and evaluation of these alternatives depending on the pre-said criteria.
Keywords: U-shaped production lines, cellular manufacturing, assembly line balancing

1. INTRODUCTION

In recent years, many manufacturers have adopted a Just-in-Time (JIT) approach to manufacturing, finding that it improves their productivity, profits, and product quality. JIT is beneficial for companies engaged in repetitive, job shop, or process manufacturing. One of the important changes resulting from JIT implementation is the replacement of the traditional straight lines with U-shaped production lines [1]. U-shaped production line can be described as a special type of cellular manufacturing used in just-in-time (JIT) and Lean Manufacturing [2]. Machines are arranged around a U-shaped line, in the order in which production operations are performed. Operators work inside the U-line. One operator supervises both the entrance and the exit of the line [3]. In the U-line, tasks are organized into stations that can cross from one side of the line to the other [4]. The assignment of tasks to stations on a U-line exploits the geometry of the line to keep the return and crossover distances as small as possible. Consequently, total travel distance and, hence, travel time is less on a U-line [5].

In this study, as distinct from the traditional production line, designing of u-shaped production lines and u-shaped cells and also the operators in the merged cells are discussed. Application was carried out at sheet metal workshop of a tractor factory. First of all; work flows, task times and current layout are given and then a new u-shaped production line that composed from nested cells, is designed. Production system of the new u-shaped line is compared with the production of the current system.

2. INDUSTRIAL APPLICATION

Application was carried out at a sheet metal workshop that consisting of about twenty cells of a tractor factory. In these cells, axis is produced. Operations in these cells are made by different operators and operators are not allowed to move between cells. The similarity of operations in cells, produced parts and the production processes of these cells have been effective in combining.

2.1 Status quo

In the current situation, cells are balanced within their own. Depending on demand, production is realized by increasing or reducing the number of operators. An operator can control several machine. One piece production and conduction are not in question. System is push-based. Labor and machinery times needed in the system are obtained from the studies that the company already has conducted. Process is given.

Current layout of the cells where two different types and dimensions of axis are produced is shown in Figure 1. Also order of operations and task times are given in Table 1 and 2.

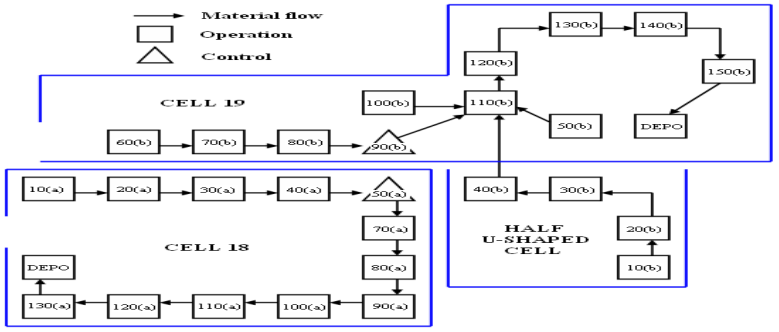

Figure 1. Current layout

Table 1. Task times of Cell 18 (central axis UK)

Task No	Predecessor Tasks	Subsequent tasks	Machinery Time (min.)	Labor Time (min.)
10 (a)	...	30	-	1
20 (a)	...	30	0,2	0,1
30 (a)	10, 20	40	-	2
40 (a)	30	50	-	3,5
50 (a)	40	60	-	1,8
60 (a)	...	70	2,5	2
70 (a)	50	80, 90	-	4,5
80 (a)	70	100	-	7,5
90 (a)	70	100	-	7,5
100 (a)	80, 90	110	5	7
110 (a)	100	120	1,5	2
120 (a)	110	130	-	7
130 (a)	120	...	-	1,8

Table 2. Task times of Cell 19 (central axis UK)

Task No	Predecessor Tasks	Subsequent Tasks	Machinery Time (min.)	Labor Time (min.)
10 (b)	...	20	11,5	2
20 (b)	10	30	3,5	0,25
30 (b)	20	40	8	4
40 (b)	30	90	6	2
50 (b)	...	110	4	8
60 (b)	...	60	-	0,8
70 (b)	50	70	-	3
80 (b)	60	80	4	1,45
90 (b)	70	100	-	0,95
100 (b)	...	110	0,1	0,2
110 (b)	40	100	-	3,35
120 (b)	80	90	-	10,25
130 (b)	100	120	-	42,7
140 (b)	110	130	-	3,25
150 (b)	120	...	-	4

2.2 Designed system

In the new system, the three cells in the current situation are designed as nested u-shaped cell. (Figure 2). The goal of placement in a U-shaped design; to facilitate and accelerate the transmission of major component, produced in half u-shaped cell, from half u-shaped cell to 19th cell, to reduce work-in-process, to provide one-piece flow, to obtain maximum benefit from workforce, to minimize transportation costs, to avoid overproduction, to minimize inventory holding costs, to provide a flexible structure.

2.3 Assumptions

The following assumptions are accepted for line balancing and new layout designing; walking times are very small compared to process times. For that reason walking times are neglected, except huge assembly part (pivot), all assembly parts that come from other workshops and other cells are assumed to be ready in processing zones, for the welding process ongoing 42 minutes in 19th cell, accepted that stocks are made by additional shifts and overtime, parts may enter the system when they are needed, operators are qualified personnel, and they can take part in each operation, There is enough space to stock, the demands of both parts are the same, the data for the last two years are taken into consideration, the monthly average demand of both part are 400 units, respectively. The variation of ± 25% of the demand is also examined. According to these assumptions, new cell design, and heuristic line balancing with different levels of demand are made, and stations are created. The results of the current situation and new cell design is summarized in Table 3 are compared. Figure 3, 4 and 5, for demand level 300, 400 and 500; show the layout and the workstations of the new system, respectively.

3. CONCLUSION

In this study, the cells are balanced in themselves, but they re-designed as u-shaped cell to increase production efficiency and effectiveness. Line balancing with different levels of demand is made. The current situation and new designed system are compared with the obtained data, and the results are summarized.

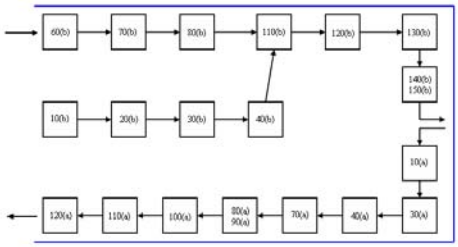

Figure 2. Designed new layout

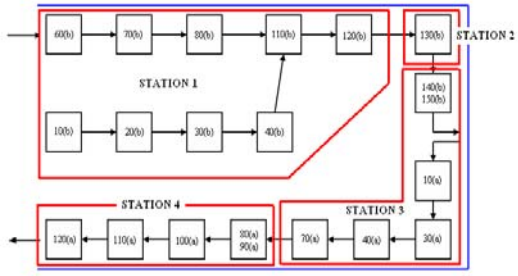

Figure 3. CASE 1; demand: 300 units, cycle time: 32 min., 4 workstations

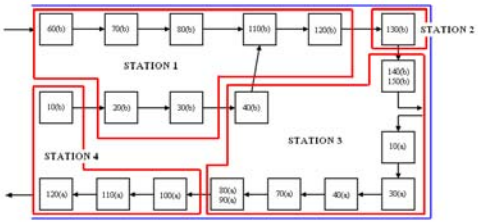

Figure 4. CASE 2; demand: 400 units, cycle time: 24 min., 4 workstations

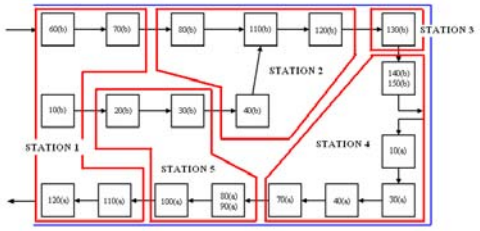

Figure 5. CASE 3; demand: 500 units, cycle time: 19,2 min., 5 workstations

Table 3. Due to the variations in demand; labor productivity, number of operator, number of station, profits

		CASE 1	CASE 2	CASE 3
Monthly Demand (units)		300	400	500
Monthly working days (day)		20	20	20
Cycle time (minutes)		32	24	19,2
Number of stations (Number of operator)		4	4	5
Labor productivity (%)		0,788	0,967	0,87
Current State Efficiency (%)	**Cell 18**	0,905	0,696	0,787
	Cell 19	0,539	0,719	0,899
	Half u-shaped cell	0,258	0,344	0,43
	Average efficiency (%)	0,629	0,645	0,765
Profit	**Labor (%)**	0,159	0,322	0,105
	The number of stations	1	2	1

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