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Assembly Line Balancing of Watch Movement Assembly

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ABSTRACT

The assembly line of watches at titan industry (calibre 5000 auto line) contains larger inventory and non value added activities leading to increased cycle time and cost of operation. Thus assembly line balancing is done by using lean tools heijunka and redesign in line layouts . Assembly Line Balancing, or simply Line Balancing (LB), is the problem of assigning operations to workstations along an assembly line, in such a way that the assignment be optimal in some sense. Thus the project deals with studying the existing manufacturing configuration at the movement assembly and implementation of lean system resulting in shortening of cycle time, set up time, production quantity and overall equipment efficiency.

Key words: **line balancing, line layouts, cycle time.**

I. INTRODUCTION

Customisation demands variants with unique characteristics. Producing a range of variants often means that the time to complete a task at a work station differs between variants, resulting in difficulty keeping a high and constant utilisation. Different cycle times means that certain stations requires more time then is available, *"peaks"*, and it leads to operators having to work faster on oncoming models to compensate for this. Therefore, one should avoid sequencing "peakmodels" after one another. Work load distribution is referred to as line balancing or the Japanese term heijunka . Balancing and sequencing activities attempt to evenly divide time over stations to achieve high utilisation and using available cycle time as efficiently as possible.

II. METHODOLOGY

A comprehensive literature review was completed and current theories studied to gain an in-depth understanding.

A. Heijunka

The production needed to be increased in order to meet demand. A shortage of parts meant nothing was obtained in correct quantity or on time. Two weeks of the month was spent gathering materials arriving in no particular order and assembly took place during the next two weeks, which would not work if production levels increased. Hence, like many other components of the Toyota Production System (TPS) heijunka was born out of necessity. *"The simple definition of heijunka is production leveling"* (Toyota imports forum, 2008). Heijunka is one of the cornerstones of Toyota's production.It is a vital part enabling Toyota to achieve highest quality, lowest cost and shortest lead time. It evens out workload over available production time both by product mix and volume. Heijunka sequence production uniformly, involving both workload leveling and line balancing (Liker, 2004) and consequently carries dual intentions (Coleman and Vaghefi, 1994):

• Reduction in inventories due to very small batches, mixed production.
• The associated ability to equate work loads in each production process to each
other and capacity.

Associated with heijunka are the three M's (Figure 2);
• Muda – non value added.
• Muri – overburdening people or machines.
• Mura – unevenness.

. Effects of heijunka (Coleman and Vagehefi, 1994):
• Reduction in overall inventories.
• Reduction of required productive capacity.
• Reduction of lead times to the customer.
• Heijunka's line-balancing aspect implies that employees are not encouraged by dissimilar work loads to migrate toward easier tasks and away from those jobs which need most improvement.

B. Line layouts

Different line design layouts are all associated with an assembly line balancing (ALB) problem. Balancing distributes tasks to work stations and work content per station and variant. Line balancing is divided in areas depending on layout ofthe assembly line. To minimise work overload sequencing is carried out (Boysenet al., 2008). The sequence determines spreading of material demand and labourutilisation at workstations. Two objectives are central (Boysen et al., 2007):

• Work overload: Work overload can be avoided if a sequence is found, where variants causing high station times alternate with less work-intensive ones.
• Just in time objectives: Different models are composed of different options and thus require different parts, so that the model sequence influences the progression of material demands over time. The two objectives are done through mixed-model sequencing .

III. MANUFACTURE AND PRODUCT DESCRIPTION

The product is a electronic watch. This paper deals with the movement assembly process of the hand setting assembly. The major process steps in manufacturing are sketched in Fig. 1. Finally, 11 stations with a continuous materials flow compose the assembly line.

IV. INITIAL LAYOUT

A single-model assembly line of watch calibre 5000 is used that is limited to producing one variant and is mainly used for mass production of one homogeneous product. In unpaced lines, workpieces are transferred whenever the required operations are

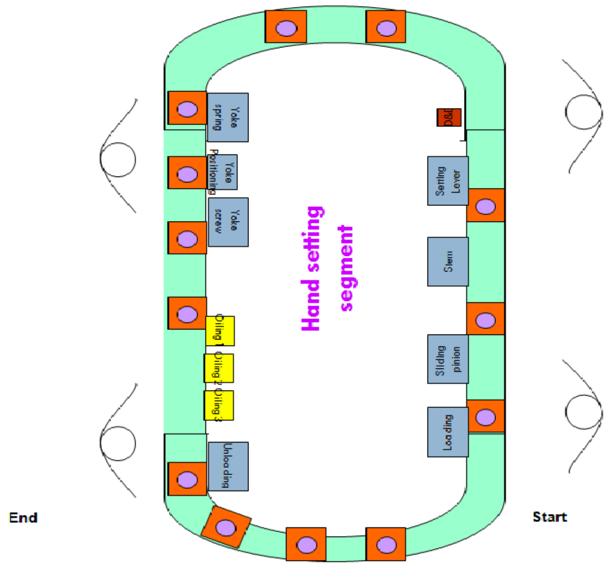

Fig 1 Initial layout

completed, rather than being bound to a given time span (β1=unpac). Further distinguish as to whether all stations pass on their work pieces simultaneously (synchronous) or whether each station decides on transference individually (asynchronous). Under asynchronous movement, a work piece is always moved as soon as all required operations at a station are completed and the successive station is not blocked anymore by another work piece. After transference the station continues to work on a new work piece, unless the preceding station is unable to deliver (starving). In order to minimize waiting times, buffers are installed in-between stations, which can temporarily store work pieces (β6=buffer). Thereby, a trade-off between work-in-progress, which can be reduced by using few buffers, and throughput, which is increased by installing more and larger buffers, has to be observed. Buffers can only be used to compensate for temporary deviations in task times.

Sliding pinion and yoke positioning stations are faster than loading and yoke spring stations respectively, the buffer storage will soon be filled to capacity and lose its function. In addition unnecessary travelling time at setting lever, detect and eject, sp oiling, final inspection adds up to the increase in cycle time.

Stochastic task times (α3=tsto) are caused by (i) deviations in manual labour, (ii) default of machinery and/or (iii) by a model-mix (α1=mix), which cannot be anticipated upfront. Thus in this line, the production rate is no longer given by a fixed cycle time, but is rather dependent on the realised task times. These can be estimated as long as the distribution functions are known which are, however, considerably influenced by buffer allocation. Thus, the configuration planning of assembly system needs to: (1) determine a line balance, (2) allocate buffer storages, (3) estimate throughput (and/or further measures of efficiency).

Fig 2 Existing layout

V. MODIFICATIONS AND LAYOUT PROPOSAL

Slight changes in the work content at a station might lead to a more efficient buffer allocation and improve the system's overall performance. Optimal buffer allocations could thus be determined repetitively for varying line balances or both problems might be solved simultaneously.

Once resources are allotted to stations, heavy machinery might not be reallocated. In this case, alltasks which require this resource need to remain at their previous station, which can be enforced by assignment restrictions (α5=fix). Often, the movement of a machine is, however, not technically impossible, but rather associated with movement costs. In this case, movement costs might need to be considered explicitly Additionally, space constraints need to be observed whenever a machine is moved .The space at a station might be limited, so that two tasks each of which requires a large machine cannot be assigned to the same station (α5=inc).

TABEL 1 PROPOSED LAYOUT CHANGES

Station	Existing distance cm	Proposed distance cm	Reasons
Loading to Sliding pinion	135	135	
Sliding pinion to Stem	76	96	Changeover from 2.19s t0 2.64s, small distance to accommodate pallets will lead to ideal time of machines in previous stations
Stem to Setting lever	37	25	2.64s to 1.94s thus the station will process quickly no pallets are to be accommodated
Setting lever to D&E	51	35	1.97s to 1.98s thus they will be processed in same

			speed
D&E to Yoke spring	144	144	Circular path of conveyor
Yoke spring to Yoke positioning	18	18	2.23s to 1.4s thus speed of processing is higher
Yoke Positioning to Yoke Screw	57	110	1.4s to 2.96s hence more distance to accommodate will reduce ideal time of previous stations
Yoke screw to SP Oiling	53	32	2.96s t0 2.95s thus both stations will process in same speed
SP Oiling to Yoke oiling	31	31	2.95s to 2.96s same processing time
Yoke Oiling to SL Oiling	18	18	2.96s to 1.58s thus it be processed quickly
SL Oiling to Final inspection	50	18	1.58 to 0.88 thus processed quickly

VI. ANALYSIS AND DISCUSSION

The analysis of asynchronous lines revealed an interesting attribute, generally referred to as „bowl phenomenon" according to which the throughput of a line can be improved by assigning smaller station loads to central stations than to those located at the beginning or end of the line. This effect is the stronger, the higher the stochastic deviations of processing times . The same concept applies to buffer allocation, if buffer storages in the centre (or at bottle-neck stations) are increased in size . In this context, the use of a global cycle time seems inappropriate, and should thus be replaced by station-specific local cycle times to account for this phenomenon, which assign a lower work content to central stations or alternatively enforce a higher probability of regarding the cycle time in case of a stochastic model.

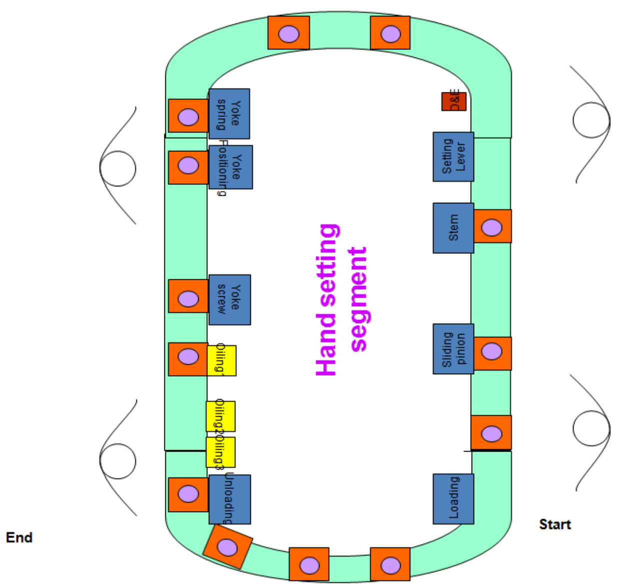

Fig 3 Proposed Layout

TABEL 2 BENIFITS OF THE PROPOSED LAYOUT

	Envisaged	Existing
Production quantity	**9700**	**7000**
Production rate	**2.69**	**3.72**

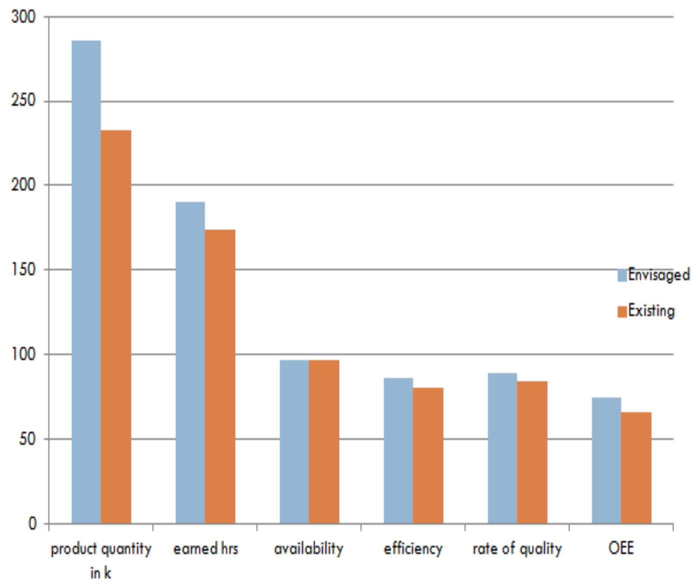

Fig 2 Result of proposed layout

VII. CONCLUSION

This paper provides a case study of the titan wathch industry movement assembly layout by means of assembly line balancing and heijunka, which connects manufacturing system design objectives to operational objectives. It focuses the assembly line balancing of operations by eliminating nonvalue-added time and decreasing the intermediate stocks and eliminate inefficiencies. Results explain that the design of layout without buffer space and unnecessary transportation reduces the waste in terms of unnecessary inventories, excessive transportation, and idle times applicable to every production and layout designs. the application of these skills of production help to enhance the materials flow in the assembly line in a short time and under particular conditions of small storage space and requirements of flexibility. The empirical results drawn from the case implementation serve to demonstrate that an operative decision has helped to improve the metrics lean, in particular to reduce the production time and increase overall equipment efficiency shows the transformation of a former line manufacturing organization into a better lean organization that has set a lowest cycle time.

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