Scheduling Of Mixed Model Assembly Line Using Pom Software

Dr.K.ArulSelvan\textsuperscript{1}, Dr.J.David Rathnaraj\textsuperscript{2}
\textsuperscript{1} Professor, Department of Marine Engineering, Coimbatore Marine College Coimbatore
\textsuperscript{2} Professor & Head, Department of Manufacturing Engineering, Sri Ramakrishna Engginering College, Coimbatore

ABSTRACT : This paper mainly concerned with actual problems faced in mixed model assembly lines. For this the cycle time, takt time and production line balancing are mainly considered. Cycle time means the period required to complete one cycle of an operation; or to complete a function, job, or task from start to finish. And takt time is a adjustable time units in lean production to synchronize the rate of production with the rate of demand. Line balancing is the problem of assigning operations to workstations along the assembly line. These problems are take an account while considering the scheduling of any process. In mixed model assembly lines layout designing is a critical one, and also scheduling problem will occur. The scheduling problem occurs due to same layout is followed for all the products. In mixed model the products produced are having some similarities but the size and shape of the products are varied in many cases. Due to these variations the overall machining time for each product is differed from other products. To decrease the machining time and for the scheduling problems software’s are used.

The products taken in account here is the fan pulley for air compressors and HP motors. 15 different types of products are taken here, but the process sequence is same for all the products. In this paper POM (Principles Of Operation Management) software is used for scheduling. Mainly this software is used for changing the current schedule, by making some changes in the current scheduling; the machining time of the product is decreased.

The 15 products are selected according to the demand rate from the customers. These products are splitted into 3 batches for machining process in lathe. By using the POM software the current sequence is changed and the machining time also decreased up to 5mins. And for drilling the products is splitted into 5 batches and the machining time is decreased up to 1min. The jobs are assigned to the right machine for machining process, due to the correct assigning of job the production rate is increased. For this the POM software is used in this paper.

KEYWORDS : Process scheduling, Production scheduling, Line balancing, JIT, Mixed model assembly

1. INTRODUCTION

In the last years industrial competition has been primarily based on model variety increase, time to market and cost reduction. In the final assembly line operations, mixed-model lines allow to reach different objectives as the minimization of the line stop time, a productivity goal, and the components fluctuation, a JIT goal. The above mentioned objectives are strictly connected with the “lean production” philosophy which was developed by the Toyota Motor Company. One of the key issues in the lean production success is surely production flexibility. Flexibility allows to match the costumer changing demand through both product variety and production volumes. In final assembly line operations, production flexibility is achieved through the adoption of mixed model assembly lines which allow small batches of products to be manufactured without keeping significant and often
unnecessary stock levels. Within such production environment, a relevant management problem is the item sequencing through the line.

For managing the sequencing of line problem and reducing the time statistical simulation softwares are used. Here the software used is POM (Principle Of Operation Management) for reducing the total time of the product. The products taken in account here is the fan pulley for air compressors and HP motors. 15 different types of products are taken here, but the process sequence is same for all the products. To increase the production rate time management is an important one, for that the process and the time activities for all the processes are simulated by using the statistical simulation softwares.

**LINE BALANCING**

Assembly Line Balancing, or simply Line Balancing (SALB), is the problem of assigning operations to workstations along an industrial importance: the efficiency difference between an optimal and a sub-optimal assignment can yield economies (or waste) reaching millions of dollars per year.

LB is a classic Operations Research (OR) optimization problem, having been tackled by OR over many years, algorithm has been proposed for the problem and the OR efforts that have been made to tackle it, little commercially available software is available to help industry in optimizing their lines. Recent survey by Becker and Scholl (2004), there appear to be currently just two commercially available packages featuring both a state of the art optimization algorithm and a user-friendly interface for data management. One of those packages appears to handle only the “clean” formulation of the problem (Simple Assembly Line Balancing Problem, or SALBP), which leaves only one package available for industries such as automotive. This situation appears to be paradoxical, or at least unexpected: given the huge economies LB can generate, one would expect several software packages vying to grab a part of those economies.

**CYCLE TIME**

The cycle time required to process a customer order might start with the customer phone call and end with the order being shipped in this example.

Cycle Time Reduction is identifying and implementing more efficient ways to do things. activity, which is defined as any activity that does not add value to the product.

**TAKT TIME**

Takt Time is one of the key principles in a Lean Enterprise. Takt Time sets the ‘beat’ of the organization in synch with customer demand. As one of the three elements of Just In Time (along with one-piece flow and downstream pull) Takt Time balances the workload of various resources and identifies bottlenecks.

**Limitations of takt time**

Takt time is useful for simple cells These are typical of the workcells at Toyota and what most people think of when they picture a cell. Such cells have:
- Minimal setups
- A single routing
- Identical work times for all products

**NEED OF SCHEDULING**

Process planning and scheduling are two of the most important sub-systems in a manufacturing system. Both of them are used to link product design and manufacturing. A process plan specifies what manufacturing resources and technical operations / routes are needed to produce a product (a job). Although there is a close relationship between process planning and scheduling, the collaboration between them is still a challenge in both research and applications. Without Collaborative Process Planning and Scheduling (CPPS), a true Computer Integrated Manufacturing System (CIMS), which strives to integrate the various phases of manufacturing in a single comprehensive system, may not be effectively realized.

Manufacturing facilities are complex, dynamic, stochastic systems Many manufacturing organizations generate and update production schedules, which are plans that state when certain controllable activities
(e.g., processing of jobs by resources) should take place.

The two key problems in production scheduling are “priorities” and “capacity” (Wight, 1984). In other words, “What should be done first?” and “Who should do it?” Wight defines scheduling as “establishing the timing for performing a task” and observes that, in manufacturing firms. Cox et al. (1992) define detailed scheduling as “the actual assignment of starting and/or completion dates to operations or groups of operations to show when these must be done if the manufacturing order is to be completed on time.”

2.0 MIXED MODEL ASSEMBLY

Mixed-model production is the manufacture of similar products on a single assembly line. This assembly technique is gaining popularity in a multitude of production environments. For some world class manufacturers, mixed-model production also causes increased commonality amongst products on each assembly line thus leading to reduced inventory levels and number of stock-keeping units (SKU).

However, a systematic approach is lacking in most companies leading to an increase in human assembly errors due to the increase in process complexity. In response, many companies focus on automation, lean-manufacturing, and JIT parts delivery along with other forms of technology and error proofing devices.

Unfortunately, there are two problems with this approach. First, how does a company with low production volume justify the investment in automation, technology, and error-proofing devices to alleviate these types of errors? Second, employing these fixes after the problems exist leads to sub-optimal designs. With product life-cycles shrinking and development times shortening even more severely.

An example for mixed model assembly

An assembly line is a flow-oriented production system where the productive units performing the operations, referred to as stations, are aligned in a serial manner.

Formally, a mixed model assembly line balancing problem can be stated as follows: given M models, the set of operations associated with each model, the processing time of each operation (operation time), and the set of precedence relations which specify the permissible orderings of the operations for each model, the problem is to assign the operations to an ordered sequence of stations such that precedence relations of each model are satisfied and some performance measures are optimized. Unlike the case of a single model line, different models of a product are assembled on a mixed model assembly line. The models are launched to the line one after another. Essentially, this problem is a sequencing problem with constraints: different sequences of operations being processed correspond to different allocation plans.

To assess the desirability of the proposed algorithms, we give some numerical examples that are performed on a personal computer. We choose five combined precedence relation matrices from the stand ALBP lib (Scholl 2007); operation times are assumed to be describing by TFNs, whose parameters are randomly generated. All problems have 3 models; total numbers of work pieces to be assembled are all 50 and every sequence is randomly generated. The conveyor speed is set as \( V=0.01 \text{m/s} \), cycle time is \( C=380 \text{s} \), drifting distance is \( l=1 \text{m} \) for all problems, and station quantities are determined by the number of operations.

A special type of assembly line balancing problem with station lengths longer than the distance conveyor moved within one cycle time is investigated in fuzzy environments. Based on explicit formulation of this problem, we proposed a fuzzy total work overload time minimization model. In order to solve this model efficiently, a fuzzy simulation is designed and embedded into genetic algorithm to produce a hybrid intelligent algorithm. Finally some computational experiments are given to show the effectiveness of the proposed algorithm.

3.0 TOOLS OF LINE BALANCING
3.1 PROCESS PLANNING AND SCHEDULING

Q.F. Sun [4] found that because of the complementarily of process planning and scheduling and the multi objectives requirement from the real-world production, the research of this paper focuses on the multi-objective collaborative process planning and scheduling problem. The game theory is used to deal with the multi objectives. And a genetic algorithm is used to identify optimal solutions efficiently from the vast search space. Considering the complementarily of process planning and scheduling [5], the research on the collaborative process planning and scheduling problem is very important. And because of the multi objectives requirement from the real-world production, this paper proposed a game theory based genetic algorithm to do the research on the MOCPPS problem. Three game theory strategies have been used to deal with the multi objectives. And a genetic algorithm was used to identify optimal solutions. Experimental results have shown the strategies and algorithms have obtained the good results.

3.2 PRODUCTION SCHEDULING

Jeffrey W. Herrmann [19] has reviewed many manufacturing organizations generate and update production schedules. Production schedules coordinate activities to increase productivity and minimize operating costs. Unfortunately, many manufacturers have ineffective production scheduling systems. Production scheduling systems rely on human decision makers. This will help production schedulers, engineers, and researchers understand the history of production scheduling, will show them that this history provides useful suggestions.

VALUE STREAM MAPPING

Petter solding found that [12] traditionally Value Stream Mapping (VSM) is used for quick analyses of product flows through a manufacturing system. Discrete Event Simulation (DES) is often used for analyses of complex manufacturing systems with several products and a complex planning. The value stream map is presented in an spread sheet that can be altered in the way the team wants. It was described earlier that there are some weaknesses with using VSM and simulation alone. Many of these can be avoided by integrating VSM analysis in a simulation model. However most of the time simulation models are much more detailed than corresponding VSM maps.

ONE PIECE FLOW AND MASS PRODUCTION

The research is developed into a specific case study by CI Tie-jun Li Sha [8] focusing on a selected sample manufacturing plant that is derived from a supply chain model. Model is conducted using simulation software via PRO-MODEL to represent a model of a manufacturing system through two production method. From the simulation software, the good production method of a manufacturing system can be determined using quantitative method. The comparison between lean and mass production can be analyzed using simulation and statistical method. It is proven that the properties of production such as cost per unit and production time differ between lean and mass production. With this finding, lean has lower cost comparison against the mass production.

3.3 LEAN PRODUCTION THEORY

The core idea of lean production was observed by CI Tie-jun Li Sha [9] analyses the need of the Pacific company adopting lean production. Xu Xuejun [14] found that lean production method is an effective way to improve management, enhance the international competitiveness of manufacturing enterprises. We should make clear that in order to maximize effectiveness of lean production can not be satisfied with the learning and use of several lean production “techniques” or “tool”, must understand the kernel concept of lean production.

3.4 MULTI-TYPE AND SMALL-BATCH PRODUCTION

The development of economy globalization and customer requirements increasingly changing make the market competitive. The quality of the products for the lean production has an important
influence. Based on the Q control chart approach we are proposing more comprehensive quality control methods. This research proposes a of Lean Production continual improvement mechanism based on multi-type small-batch production. Regarding the fast requirement and the dramatic changes, the multi-types small batch production and the high-tech development degree of uncertainty environment still shows certain inadaptability.

### 4.0 PROCESS LAYOUT MMALB PROBLEM:

It involves grouping together like machines in one department based upon their operational characteristics. Machines performing casting operations are grouped in casting dept. Machines in each dept attend to any product that is taken to them. These machines are therefore called as ‘General purpose machines’. Work has to be allotted in each department in such a way that no machines in any dept should be ideal. In a batch production layout machines are chosen to do as many different as jobs possible

#### 4.1 Principles of process layout

The following are some of the principles of process layout to be followed while grouping the machines.

- The distance between departments must be shorter so as to avoid long distance movement of materials.
- The departments should be located in accordance with the serious of operations.
- Convenience for inspection.
- Convenience for supervision.

The products that manufacturing here is the fan pulleys for air compressors and HP motors. More than 250 products are being manufactured here in that 250 products, we are considering only the 15 types of pulleys which are in the high rate of demand. These 15 products are manufactured in a high demand rate according to the customers requirement.

#### 4.2 BATCH ALLOCATION

Batch production scheduling is the practice of planning and scheduling of batch manufacturing processes.

The allocation of batch is scheduled according to the number of lathes and the number of drilling machines which are takes place in the machining processes. Here the total 15 products are split into 3 batches for machining operation in lathe. And for drilling operation the 15 products are split into 5 batches for drilling process. Due to this batch allocation the production is increased due to the decrease of non value added times which is job movement from one station to other station, tool setup time, etc.

#### 4.3 SCHEDULING USING SOFTWARE

The software used here is the POM software (Principles Of Operation Management) which is used to rectify the assigning problems. Here the main problem is assigning the job to the correct machine for

<table>
<thead>
<tr>
<th>SL.NO</th>
<th>PRODUCT TYPE</th>
<th>TOTAL QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AF740</td>
<td>367</td>
</tr>
<tr>
<td>2</td>
<td>AF739</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>AF596</td>
<td>172</td>
</tr>
<tr>
<td>4</td>
<td>AF603</td>
<td>156</td>
</tr>
<tr>
<td>5</td>
<td>AF719</td>
<td>208</td>
</tr>
<tr>
<td>6</td>
<td>AF1298</td>
<td>297</td>
</tr>
<tr>
<td>7</td>
<td>AF983</td>
<td>217</td>
</tr>
<tr>
<td>8</td>
<td>AF986</td>
<td>170</td>
</tr>
<tr>
<td>9</td>
<td>AF987</td>
<td>83</td>
</tr>
<tr>
<td>10</td>
<td>AF420</td>
<td>415</td>
</tr>
<tr>
<td>11</td>
<td>AF647</td>
<td>198</td>
</tr>
<tr>
<td>12</td>
<td>AF736</td>
<td>140</td>
</tr>
<tr>
<td>13</td>
<td>AF2277</td>
<td>151</td>
</tr>
<tr>
<td>14</td>
<td>AF2622</td>
<td>18</td>
</tr>
<tr>
<td>15</td>
<td>AF2627</td>
<td>106</td>
</tr>
</tbody>
</table>
making the process as more effective. To make the changes in the current assigning status the POM software is used.

5.0 ASSIGNMENT IN THE POM SOFTWARE
5.1 STEPS FOLLOWED IN THE POM SOFTWARE
Step 1:
To open the POM software’s screen double click the particular shortcut of the software.

Fig. 5.1 Home page of the POM software
Step 2:
In the home page we have to select module that we are going to work, here the module used is assignment. For assigning the job to the correct machine this module is used, this module is mainly used for assigning the job to the correct machine to decrease the machining time of the current status.

Fig. 5.2 Module selection
Step 3:
The figure 5.3 shown below is the module which is used to rectify the assignment problem for decreasing the time.

Fig. 5.3 Assignment problem module page
Step 4:
In the assignment module page have to give the batch no going to assign, no of jobs going to assign to the machines, type of the problem. Here the problem is time reduction so we are selecting the minimize problem option.

Fig. 5.4 Selecting type of problem & no jobs
Step 5:
Because of using different types of products have to give the name or model number of the product. For example the first product is a fan pulley and the model number is AF740.
Fig. 5.5 Naming the product name in the work sheet

Step 6:

After giving the product name, the next step is to give the type of machine used for the process. Here the machine used for the machining process is a lathe, the name given to the lathe is L01.

Fig. 5.6 Naming the machine in the work sheet

Step 7:

The products are split into 3 batches and the figure 5.7 given below is an example for “Batch-1” the product names are given in the row and the machine names are given in the column. The machining time for each job in the machine is entered in the work sheet for assigning the job to the correct machine for decreasing the machining time.

Fig. 5.7 Entering the “Batch 1” machining times in the work sheet

Step 8:

The figure 6.8 shown below is the assigning order of job to machine. For example the job “AF740” is assigned to the lathe “L05” by assigning in this order the time decreased is 5mins.

- Total machining time for this batch according to the current assigning order is 389mins.
- After using the simulation software the assigning order is changed and machining time is decreased to 384mins, 5mins decreased for this “Batch-1”.

Fig. 5.8 Assigning order output for “Batch 1”

Step 9:

Datas for the second batch is entered in the work sheet.

Fig. 5.9 Entering the “Batch 2” machining times in the work sheet

Step 10:

The figure 5.10 shown below is the assigning order of “Batch-2”, in this order the time decreased is 5mins.

- Total machining time for this batch according to the current assigning order is 389mins.
• After using the simulation software the assigning order is changed and machining time is decreased to 384mins, 5mins decreased for this “Batch-2”.

**Fig. 5.10 Assigning order output for “Batch 2”**

Step 11:
Datas for the third batch is entered in the work sheet.

**Fig. 5.11 Entering the “Batch 3” machining times in the work sheet**

Step 12:
The figure 5.12 shown below is the assigning order of “Batch-3”, in this order the time decreased is 5mins.
- Total machining time for this batch according to the current assigning order is 386mins.
- After using the simulation software the assigning order is changed and machining time is decreased to 381mins, 5mins decreased for this “Batch-3”.

**Fig. 5.12 Assigning order output for “Batch 3”**

Step 13:
For drilling operation the products are splitted into 5 batches the figure 5.13 given below is an example for “Drilling-Batch-1” the product names are given in the row and the machine names are given in the column. The machining time for the each job in the machine is entered in the work sheet for assigning the job to the correct machine for decreasing the machining time.

**Fig. 5.13 Entering the “Drilling Batch 1” machining times in the work sheet**

Step 14:
The figure 5.14 shown below is the assigning order of “Drilling-Batch-1”, in this order the time decreased is 1min.
- Total machining time for this batch according to the current assigning order is 10mins 5secs.
- After using the simulation software the assigning order is changed and machining time is decreased to 9mins 5secs, 1min is decreased for this “Drilling-Batch-1”.

**Fig. 5.14 Assigning order output for “Drilling-Batch-1”**
Fig. 5.14 Assigning order output for “Drilling Batch 1”

Step 15:
Datas for the second batch is entered in the work sheet.

Fig. 5.15 Entering the “Drilling Batch 2” machining times in the work sheet

Step 16:
The figure 5.16 shown below is the assigning order of “Drilling-Batch-2”, in this order the time decreased is 1min.

- Total machining time for this batch according to the current assigning order is 10mins 10secs.
- After using the simulation software the assigning order is changed and machining time is decreased to 9mins 10secs, 1min is decreased for this “Drilling-Batch-2”.

Fig. 5.16 Assigning order output for “Drilling Batch 2”

Step 17:
Datas for the third batch is entered in the work sheet.

Fig. 5.17 Entering the “Drilling Batch 3” machining times in the work sheet

Step 18:
The figure 5.18 shown below is the assigning order of “Drilling Batch 3”, in this order the time decreased is 1min.

- Total machining time for this batch according to the current assigning order is 10mins 5secs.
- After using the simulation software the assigning order is changed and machining time is decreased to 9mins 5secs, 1min is decreased for this “Drilling Batch 3”.

Fig. 5.18 Assigning order output for “Drilling Batch 3”

Step 19:
Datas for the fourth batch is entered in the work sheet.
Fig. 5.19 Entering the “Drilling Batch 4” machining times in the work sheet

Step 20:
The figure 5.20 shown below is the assigning order of “Drilling Batch 4”, in this order the time decreased is 60secs.

- Total machining time for this batch according to the current assigning order is 9mins 55secs.
- After using the simulation software the assigning order is changed and machining time is decreased to 8mins 55secs, 60secs is decreased for this “Drilling Batch 4”.

Fig. 5.20 Assigning order output for “Drilling Batch 4”

Step 21:
Datas for the fifth batch is entered in the work sheet.

Fig. 5.21 Entering the “Drilling Batch 5” machining times in the work sheet

Step 22:
The figure 5.22 shown below is the assigning order of “Drilling Batch 5”,

- Total machining time for this batch according to the current assigning order is 10mins 5secs.
- After using the simulation software the assigning order is changed and machining time is decreased to 9mins5secs, 1min is decreased for this “Drilling Batch 5”.

Fig. 5.22 Assigning order output for “Drilling Batch 5”

6.0 CONCLUSION
In mixed model assembly lines different types of products are produced in a single production layout, the products are different but the machining processes are same for all the products. Due to this, scheduling problem is occurred during layout designing. The setup time, machining time for the products are varied, to decrease the machining time and for scheduling problems softwares are used. Here the software used is POM (Principles Of Operation Management) to solve those problems that we are discussed.
above. By using this software the scheduling is done and the machining time is decreased for all the batches. More than 5mins is decreased for all the batches and the previous scheduled order is changed for effective production rate.

Table 6.1 Changed schedule time in lathe

<table>
<thead>
<tr>
<th>SL.No</th>
<th>Batch No</th>
<th>Name of the Product</th>
<th>Current schedule time</th>
<th>Changed schedule time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Batch – 1</td>
<td>AF740, AF739, AF596, AF603, AF719</td>
<td>389mins</td>
<td>384mins</td>
</tr>
<tr>
<td>2</td>
<td>Batch – 2</td>
<td>AF1298, AF983, AF986, AF987, AF420</td>
<td>389mins</td>
<td>384mins</td>
</tr>
<tr>
<td>3</td>
<td>Batch – 3</td>
<td>AF647, AF736, AF2277, AF2622, AF2627</td>
<td>386mins</td>
<td>381mins</td>
</tr>
</tbody>
</table>

Table 6.2 Changed schedule time in drilling machine

<table>
<thead>
<tr>
<th>SL.No</th>
<th>Batch No</th>
<th>Name of the Product</th>
<th>Current schedule time</th>
<th>Changed schedule time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Batch – 1</td>
<td>AF740, AF739, AF596</td>
<td>10mins 5secs</td>
<td>9mins 5secs</td>
</tr>
<tr>
<td>2</td>
<td>Batch – 2</td>
<td>AF603, AF719, AF1298</td>
<td>10mins 10secs</td>
<td>9mins 10secs</td>
</tr>
<tr>
<td>3</td>
<td>Batch – 3</td>
<td>AF983, AF986, AF987</td>
<td>10mins 5secs</td>
<td>9mins 5secs</td>
</tr>
<tr>
<td>4</td>
<td>Batch – 4</td>
<td>AF420, AF647, AF736</td>
<td>9mins 55secs</td>
<td>8mins 55secs</td>
</tr>
</tbody>
</table>

SCOPE FOR FUTURE WORK
- The obtained line can be scheduled for getting optimized production schedule by using statistical simulation softwares like Witness, Arena softwares.
- By using those softwares, the total sequence of the processes for the products are analysed and the changes are done by simulating in these softwares.
- To increase the production rate the total machining time is reduced by implementing the altered assigning order for the jobs and the machines.
- We can increase overall equipment effectiveness of the entire layout.

REFERENCES


16. He Zhen, ‘The continuous improvement model of Lean Production based on Multi-type and small-batch production’, 2009


