Mixed Model Production

By
Quarterman Lee, P.E.
Strategos, Inc.
Mixed Model Production

What Is Mixed Model Production?

Mixed Model Production is the practice of assembling several distinct models of a product on the same assembly line without changeovers and then sequencing those models in a way that smooths the demand for upstream components. The objective is to smooth demand on upstream workcenters or suppliers and thereby reduce inventory, eliminate changeovers, improve kanban operation. It also eliminates difficult assembly line changeovers.

Toyota developed the concept in the 1960's in response to the problems created by line changeovers. It originally applied to long assembly lines such as those used in automotive.

However, Mixed Model Production is adaptable to other situations. There are also alternatives, such as assembly cells, that accomplish the same purpose, often with better results. This topic also relates to Focused Factories in because it addresses the same issues at a more detailed level.

The Underlying Principle

Henry Ford demonstrated that steady, repetitive production dramatically reduces cost. This is true for both assembly operations and for upstream fabrication. However, when final assembly models proliferate and the issue is addressed by changeovers and long runs on the assembly line, it creates highly variable demand in upstream fabrication and subassembly.

The ideal production system would be like a smoothly flowing stream with many tributaries and no pools, dams or other accumulations.

...like a marching band with everyone in step, spaced at a fixed distance, all in time to the music beat and smoothly flowing from one figure to another throughout the performance. This is the origin of “Takt Time.”
Demand Pattern With Batch & Line Changeover

Assume a scenario where an assembly line builds three major variations of the similar end-product in figure 3. Assume also that the upper component comes from three separate sources (vendors or workcenters). The graph of figure 4 shows average demand for each product.

On large assembly line, setup is often problematic. Parts are brought in for a new job and remaining parts taken away for the just-completed job. Such lines often need re-balancing with different stations and task assignments. Then, there is the initial startup as everyone gets accustomed to the new configuration. If parts do not fit, or cannot be found, there is more disturbance. When, at last, the line is humming, nobody wants to disturb it with another changeover.

Such is the case with our hypothetical assembly line. And so, once setup, it runs for at least a week on the first product, 1-GRN. At the end of a week, 40 units are complete. After another frenetic changeover to product 2-YEL, the line runs for 2.0 weeks since the demand for this part is higher. Another changeover and, for another week, the line runs 3-RED. Figure 5 illustrates.
Figure 5 Demand Patterns With Conventional Batch Assembly

The three suppliers for the upper covers of, respectively, 1-GRN, 2-YEL and 3-RED, see high demand for one or two weeks and then no demand for 2-3 weeks. One way to deal with this intermittent upstream demand is to size upstream production for the overall average demand for each part and then build inventory between production runs. This, however, creates a host of inventory control, scheduling and quality problems. Mixed Model Assembly lines address this situation.

Demand Patterns With Mixed Model Lines

A Mixed Model Assembly line is configured to produce several models without changeover. The mixed Model Line, as pioneered by Toyota, is shown in figure 6. A schedule specifies the proportion of each model required for customer demand. In this example, the proportions are 25%, 25% and 50%.

Figure 6 Conversion To Mixed Model Line
Proper sequencing of products smoothes the demand on upstream suppliers even further. In this example, the sequence is:

**RYGY--RYGY--RYGY--RYGY**

- Red- 1.0 Unit Every 2.0 Hours
- Yellow- 1.0 Unit Every Hour
- Green- 1.0 Unit Every 2.0 Hours

A mixed model line may complicate *line operations* to some extent. However, it streamlines and simplifies *upstream operations* as well as the inventory, scheduling and transport system that connect the line with upstream operations. Among the benefits are:

- Upstream Demand Is Steady
- Machines Sized For Customer Demand
- Simplified Scheduling Such As Kanban
- Stable Labor Requirements
- Simpler Transport

**Dedicated Assembly Cells**

Toyota probably used Mixed Model Assembly lines because their large Detroit-style lines were already in place. It may have seemed like a natural and easy solution to the problem of upstream demand smoothing.

But there is another method for providing smooth demand: Final Assembly Cells. In this approach, the assembly line is broken down into multiple, smaller workcells. Each workcell produces a single model or, perhaps, several models with a high degree of part commonality.
**Integrated Assembly-Fabrication Cells**

A further evolution of assembly cells is to incorporate some (or all) upstream fabrication into the cells. The figure below shows how the fabrication equipment for each model joins with respective assembly operations in a cell or sub-cell. It provides even closer coordination and corresponding improvements in quality and inventory.

**Enabling Mixed Model Lines & Dedicated Cells**

The principle of Mixed Model Production is simple enough. Designing the process and system is often more difficult. When people are enmeshed in an existing system they have difficulty envisioning how mixed model, smoothly flowing production is possible. It helps to ask two key questions:

1. **What must be true for this to work?**
2. **How could we make it true?**

Thoroughness and tenacity can often make various conditions true and achieve (or come close to) the ideal model of a smoothly flowing stream. The following tables summarize some of the design problems related to mixed model lines, dedicated assembly cells and integrated cells. They also suggest possible solutions.
# Mixed Model Assembly Lines

<table>
<thead>
<tr>
<th>Problem</th>
<th>Description</th>
<th>Solutions</th>
</tr>
</thead>
</table>
| **Work Balance**         | When different models have different work content, operations must be flexible enough to deal with the product mix. | § A constantly moving line does only lends itself to mixed model production when work content is nearly identical for each station. See Balancing Workcells.  
§ Small Queues between stations accommodate short-term variation.  
§ Adjacent workers share tasks and help each other.  
§ Fewer stations and longer task times. |
| **Part Availability**    | For a mixed model assembly line to function, every part for every product must be immediately available. | § Small quantity of every part replenished by Kanban.                      |
| **Tool Availability**    | Tools and special fixtures must be readily available. (This is seldom a problem when the product is small. It may be a problem with large products such as refrigerators or vehicles.) | § Multi-purpose fixtures & Tools  
§ Setup Reduction  
§ Dedicated cells with a permanent setup of fixtures & tools. |
| **Fabrication Setup Reduction** | Dedicated fabrication equipment is not always available. Long, expensive and/or inconsistent changeovers force large batches and high inventory between fabrication and the mixed model line. | § Setup Reduction In Fabrication with small lots.  
§ Redesign fabrication processes with more dedicated equipment, even (if necessary) at the cost of decreased labor efficiency.  
§ Investigate alternate processes. |

## Dedicated Assembly Cells

<table>
<thead>
<tr>
<th>Problem</th>
<th>Description</th>
<th>Solutions</th>
</tr>
</thead>
</table>
| **Demand Variability**    | Variation in demand for each dedicated cell may be larger than the variation for a single line. (Peaks and valleys of demand often cancel when combined.) | § Design assembly cells for multiple levels of staffing.  
§ Move people between cells to balance output & demand.  
§ Provide excess equipment capacity to handle peak demands. |
| **Cell Design**           | Workcells appear simple and this is especially true for assembly cells. In reality they are complex and sometimes sensitive socio-bio-technical systems. | § Design cells from fundamental principles. |

## Integrated Cells

<table>
<thead>
<tr>
<th>Problem</th>
<th>Description</th>
<th>Solutions</th>
</tr>
</thead>
</table>
| **Process Incompatibility** | This usually involves processes that must be isolated for environmental reasons (Dust, Dirt, Chemicals or Noise). | § Address the environmental problem with dust control, noise control, etc.  
§ Investigate alternate processes. |
| **Process Scale**         | Large-scale fabrication processes have too much capacity for a single assembly cell. | § Investigate alternate equipment and methods. (e.g. small, manual paint booth replacing large paint line) |
| **Special Skills**        | Certain tasks require extensive skills, experience and/or training but do not require a full-time operator for each cell. | § Tools, fixtures or gages that require less skill  
§ Train or cross train  
§ Train cell workers in basics with consultant for difficult problems. The daily tasks often do not require high skills or knowledge. |