# Tire Industry and Its Manufacturing Configuration

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## Abstract

This paper is intended to propose what manufacturing configuration (manufacturing planning and shop floor control) is suitable for the tire industry.

Basically tire-manufacturing process is mixed-products, parallel-disconnected-flow-shop. Both throughput time and cycle time are very short, the variety of tires is very high, the setup time is long, shop floor data reporting requirements is high, and there are many equipments and people working. And with no exception, tire industry also now confronts increasing requirements of delivery conformance.

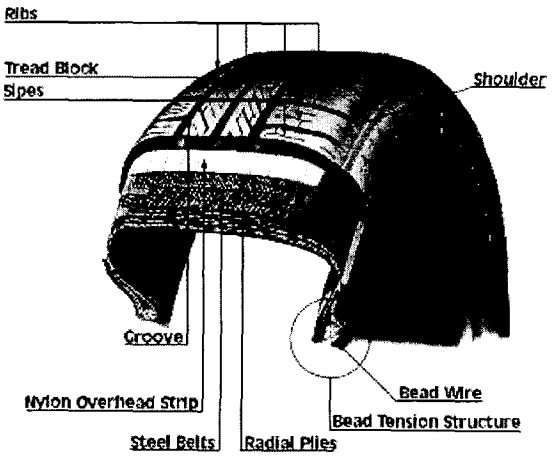
With the above peculiar characteristics of tire manufacturing and changing market environments, this paper suggests, weekly master scheduling with no MRP is desirable and traditional kanban is right selection for shop floor control/scheduling.

This paper describes why this configuration should be, using the manufacturing engineering principles and some new insights like four primitives of parallel flow shop. Generally known that shop with high parallel-product-mix and long setup time isn't good candidate for kanban The four primitives of parallel flow shop explain why kanban is also useful scheduling technique in that environment.

***Key words:*** *Tire, Tire Industry, Manufacturing Environment, Manufacturing Configuration, Manufacturing Strategy, Master Production Scheduling, Manufacturing Planning, Bucket Size, Shop Floor Control, Repetitive Manufacturing, Parallel Repetitive, Disconnected Flow Shop, JIT, Kanban, Push, Pull, Bottleneck Management*

## 1. Tire Manufacturing Process

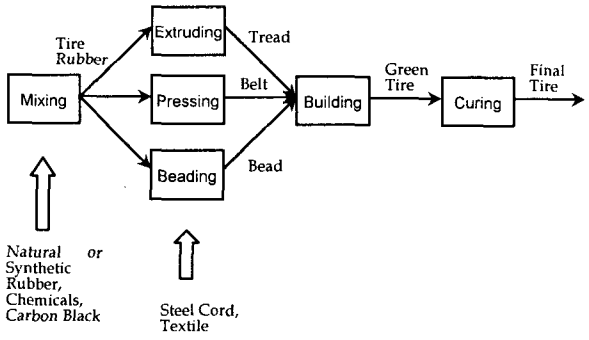
Tire is composed of more components than we usually think. Belt, carcass, tread, inner liner, sidewall, bead and others make a tire. These components are again made of natural




[Pic. 1] Tire Anatomy

rubber, synthetic rubber, steel wire, textile, and etc.

Tire manufacturing starts with the mixing of raw materials like chemicals, synthetic or natural rubber to formulate the tire rubber (usually called as Q-rubber). The tire rubber again with other raw materials like steel wire, and textile are




[Pic. 2] Tire Manufacturing Process

used to make all the components of tires, i.e. belt, carcass, tread, inner liner, sidewall, and bead. The building process assembles these components to make so-called green tire. Green tire become final tire through the curing process. Finally inspection process checks tire quality.

## 2. Product/Process Special Characteristics

**- Routing: Parallel-Repetitive-Shop**

Every all the tires flows same process. They differ just in size, tread-pattern, and belt intensity. Lots of different specifications are processed at the same time at the same process. The processes are disconnected each other. That means material movement depends on the workers. So we can conclude it has *disconnected-parallel-flow-shop or parallel-repetitive-shop.*

**- Short Throughput Time and Cycle Time**

It usually takes only several tens of hours from raw material input to final tire output. Cycle time is about several minutes. Both are relatively short.

**- High Product Variety**

There are plenty of specifications of tires. It reaches about thousands specifications. The productivity problem due to specification exchange is very critical.

**- No Crib Inventory Item**

Product structure of tire has no crib inventory items in it. This point makes sense in the point that the total manufacturing lead-time is very short. No crib implies there is no need for MRP.

**- Equipment Intensive but Less Automation**

Tire manufacturing is high fixed capital business. But the degree of automation is not enough to acquire the shop data automatically. Therefore data acquisition usually relies on worker's key in. The fact that cycle time of tire is very short means so frequent data acquisition is needed. Non-automatic data acquisition corrupts the data accuracy and real time rescheduling.

**- Long Setup Time**

In the curing process, it takes about a few hours to exchange die. There is much opportunity for SMED (Single Minute Exchange of Die) but that is out of scope of this paper. With high variety the long setup reduces the productivity.

**- Production Environment: MTS**

Tire is commodity. In other words, it has MTS (Make-to-Stock) production environment. MTS always brings low price competition.

**- Changing Customer Requirements: High Delivery Reliability**

Customers are more concerned about delivery reliability and delivery speed than before. Delivery competition doesn't pass by with tire industry untouched.

## 3. Manufacturing Configuration Principles

**- Manufacturing Style and MPC Configuration**

The manufacturing style and its implication on MPC (Manufacturing Planning and Control) system have well known to everyone. This principle can be summarized as following table.

[Table. 1] Manufacturing Style and MPC configuration

| | Job Shop | Repetitive | Process |
|---|---|---|---|
| Shop Floor Control | PUSH<br>- Detailed Scheduling<br>- CRP | PULL<br>- JIT<br>- Kanban (Electronic or Traditional) | Input Sequencing Optimization |
| Manufacturing Planning | MRP | | |
| | MPS | MPS | MPS |

**- Lead Time Length and Time Bucket Size**

Manufacturing lead-time determines the planning horizon and bucket size of MPS/MRP. Component manufacturing lead-time determines the bucket size of MRP and total accumulated manufacturing lead-time determines the planning horizon. The next principle says that lead-time and bucket size tend to have same time scale. For example, if lead-time is several weeks then the bucket size is week and planning horizon is several weeks.

## 4. Manufacturing Planning Configuration

From the facts that tire-making process is repetitive and the lead-time is about several tens of hours, and the basic manufacturing principles, we can derive manufacturing planning configuration about tire industry. [Table. 1] indicate repetitive process usually doesn't require MRP. The fact that lead-time is short and there is no crib inventory item except WIP support it again. In short, tire industry needs MPS only.

Next, what about the time bucket of MPS? According to the principle, the bucket size would be day because the lead-time of tire is several tens of hours. But we should consider the fact that the degree of tire variety and the specification exchange time. The number of tire specs reaches several thousands and the set up time takes about a few hours. On the other hand, MTS require low cost manufacturing. What

all of them means is the productivity is very important. If we set the bucket size as day, it would cause more exchange. The long set up time never allow such frequent set up change. So, week is more desirable than day as the bucket size of MPS. Productivity and quick response find them happy medium at the day as time bucket. The shorter the time bucket the quicker the customer response and lower inventory. Week scale time bucket makes it possible that the salespeople promise delivery due date on the scale of weeks.

In summary as manufacturing planning strategy for tire industry the MPS with week time bucket and no MRP is recommended.

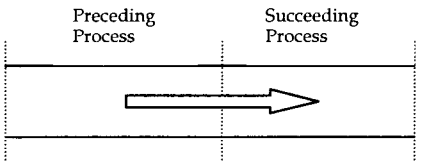
## 5. Shop Floor Control Configuration

[Table 1] states pull type shop floor control is more suitable to repetitive process rather than push type detailed scheduling. The only (maybe as I know) effective pull control mechanism verified until now is using kanban. Nowadays automation became so popular and data acquisition technology has developed that the electronic kanban (e-kanban) might be used instead of traditional paper card kanban. But high reporting detail or high manual reporting impede to using e-kanban. As said before, tire industry stays in that situation until now. So at tire industry traditional kanban is more desirable as a shop floor control mechanism than e-kanban.

This paper said before the tire process is kind of parallel repetitive shop. Although [table 1] doesn't comment about parallel repetitive, I concluded the kanban is required. In short all the concepts of repetitive also applies to parallel repetitive. The reasons follow.

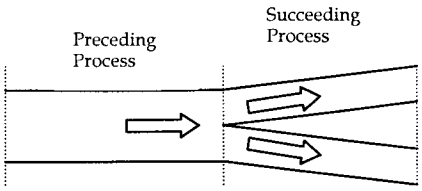
### - Four Primitives of Parallel Flow Shop

In most books or articles about JIT or Kanban, they assume serial flow shop, in other words only one product are processed at specific time point. No two or more products flow at the same time at the same process. But if that situation is possible, we call it parallel flow shop.



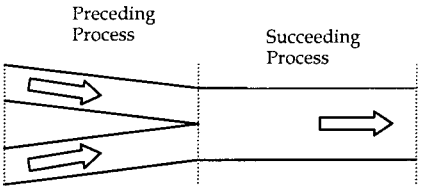

[Primitive 1] Serial Flow

In conclusion all the concepts related serial flow shop applies equally. We can prove it with four primitives

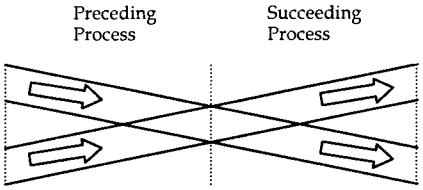



[Primitive 2] Branch Off

consisting flow shop. They are serial, branch-off, combine,

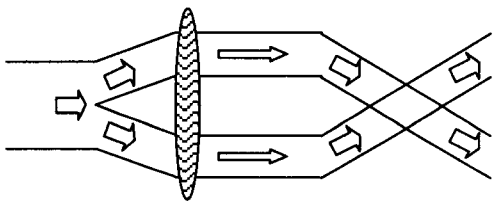



[Primitive 3] Combine




[Primitive 4] Crossing

and crossing. The important point is that no matter how they are mixed up through the manufacturing process the aggregate pipe is just serial, in other words primitive 1 serial flow. We can see it as just single big pipeline unless there are severe external inputs from out of big pipe or U-turn in it. In fact this situation exactly means job-shop. This is the proof. Of course there are so many delicate issues on synchronizing the parallel flow depending on the difference of thickness and flow speed of each branch pipe. This issue is beyond this paper's scope.



[Aggregate Pipe] The Cross Sectional Area is Same Throughout the Whole Pipe

### - Setup Time and Kanban

Another misconception about shop floor control is about interrelationship between setup time and push mechanism.

Most people believe that if setup time is high then we cannot apply push style control mechanism. In one word, there is no relationship between setup time and kanban. Shop floor control is up to only where the manufacturing process is located in the horizontal line from job-shop to continuous flow. Of course short setup time helps floor control because it lead stable and level production. But it doesn't determine push or pull. Therefore though the setup time takes a few hours at certain process during tire manufacturing, push style floor control must be selected.

## 6. Conclusion

The paper addressed what the best MPC (Manufacturing Planning and Control) system for tire manufacturing. For this purpose, first the special feature of tire manufacturing process has been reviewed. Tire-manufacturing process is mixed-products, parallel-repetitive-shop. Both throughput time and cycle time are very short, the variety of tires is very high, the setup time is long, shop floor data reporting requirements is high, and both lots of equipments and people working. From these facts and known manufacturing configuration principle, the paper suggests week scale time bucket MPS (Master Production Scheduling) without MRP is recommended for planning strategy. And in the area of shop floor control, traditional kanban would be effective control mechanism. In addition some misconception about shop floor control, that is in the environment where complex parallel repetitiveness or long setup time exist we cannot apply kanban as shop floor control, has been cleared.

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