Modeling Manufacturing Systems. A Simulation Study.

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ABSTRACT

The goal of this paper is to establish a framework for using in an easy way the system dynamics manufacturing models. We do this by taking a simplified view of a manufacturing system and designing a user-friendly interface. The production systems - push and pull- are modeled for a serial production line. The behavior of the models is evaluated, by using global operational measurements, for different scenarios regarding most frequent situations found in real production systems.

1. INTRODUCTION

A good number of techniques (Hopp et al, 1996) have been proposed to face the problems found in modern manufacturing systems. There are quite a few production approaches depending on the way used to authorize production or assembly. These approaches can be classified in pull, push and hybrid systems. However, to manage the real system in an appropriate manner we have to define the criteria needed in order to see the behavior of the system in different working scenarios. In such way we have built up a comprehensive framework of models, scenarios and measurements using the system dynamics methodology for each one. Thus, we can work with any of the manufacturing system dynamics models in a chosen scenario and using some of the desired criteria, already modeled, to carry out a comparative study as depicted in table 1.

The problem to be studied, the manufacturing techniques, and the scenarios and measurements that are used in the simulation study are described below.

2. MODELS, MEASUREMENTS AND SCENARIOS.

The problem to be studied is a serial production line consisting of three stations. Raw materials, work in process and finished products. The raw materials are supplied in the needed amount. The first station processes the materials and the work in process is going through the second and third stations to obtain the finished products to be sent to the customers to satisfy the existing demand. The materials are processed in a continuous manner taking in every station the corresponding lead time.

2.1.Manufacturing Models.

To manage this serial production line several approaches/models can be used:

2.1.1. Push Techniques.

The most popular push technique is the well known Material Requirements Planning, M.R.P., (Orlicky, 1975) launched by the American Production and Inventory Control Society (A.P.I.C.S.) in the so called the MRP Crusade during the 70´s. After the official appearance of the initial MRP some refined techniques followed the way initiated by MRP (MRP II, Close Loop MRP...). As a matter of fact the MRP technique can be considered as a pure push technique.

2.1.2. Pull Techniques.

In spite of several techniques that have been modeled in our study we might refer to the well known Just time/Kanban (Ohno, 1988; Monden, 1983) as a pure pull technique and the most representative of them. Since the official appearance of the JIT in the Toyota Manufacturing Plant in Japan this technique has been applied to many western manufacturing plants. Although JIT is often seen as a global management philosophy which takes into account principles such as: avoiding waste, to eliminate non value added activities, personnel involvement, reduction of setup times, enhancing quality and maintenance and so on. However we will focus on the pull effects originated on the production line by these techniques: Reorder Point, Base Stock and JIT. For all of them a system dynamics model has been constructed.

2.2. Measurements.

To evaluate the behavior of the models, two kind of measurements can be used. The first one refers to the so called financial measures such as: Throughput, Net Profit and Turnover Ratio. For the second type of measurement, non financial, we consider the following: Adjust Time of the Production Rate to the Demand, Average Inventory Units, Unit Mean Flow Time.

2.3. Scenarios.

Several scenarios have been selected in order to study the model behavior regarding demand fluctuations, station breakdowns, bottlenecks in one station and capacity production constraints for all the work stations.

2.3.1. Demand Variations.

The detailed proposed scenarios are as follows: (in all cases initial value of demand = 100 units/time unit)

- Increasing step of the demand of 10% starting at period 2.
- Increasing step of the demand of 20% starting at period 2.
- Increasing demand pulse of 10% during 10 time units, starting at period 2.
- Decreasing demand pulse of 10% during 10 time units, starting at period 2.

2.3.2. Station breakdowns.

The effect originated in the production line when a machine breakdown occurs it is contemplated within this scenario. The scenarios considered are mainly related with the duration of the breakdown time in every station. Therefore, some standard scenarios could be to stop the first, second or third station for one and five time units.

2.3.3. Capacity constraints.

The scenarios devised under this heading are set to a maximum production capacity, in all the stations, of 20% over the smoothed demand and introducing a demand step of 15 or 20% starting at the second time period.

2.3.4. Bottlenecks.

The difference with the last scenario is that we consider bottleneck, every time, in only one of the stations of the production line. The figures are quite similar to those considered in the capacity constrains scenarios.

3. THE SIMULATION LINK.

To be able to carry out a cross simulation study, that means: it should be possible to use any of the techniques/models, push or pull, quoted above in any of the scenarios measuring the behavior of the system with the desired measurement, financial or non financial.

To achieve this, a simulation program, using the VENSIM capabilities, called LINK has been designed. In such way the user can access very easily the different models and results simplifying many of the routine work to be done. The reader can consult the VENSIM Manual (VENAPP: Vensim Applications) for a deeper insight. In table 1 the simulation framework is depicted.

THE SIMULATION FRAMEWORK: LINK				
Techniques/Models		***Measurements***		***Scenarios***
Push	**Pull**	**Financial**	**Non Financial**	**Demand Variations**
MRP	**JIT-Kanban**	**Sales**	**Inventory**	**Stations Breakdowns**
	Order Point	**Throughput**	**Flow Time**	**Capacity Constraints**
	Base Stock	**Net Profit**	**Adjust Time**	**Bottleneck**

Table 1. The simulation framework

To manage our serial production line, the user can select any of the above techniques/models, measure the behavior of the system with the desired measurement in any of the scenarios shown. In such way a cross simulation study (techniques/measurements/scenarios) can be conducted in order to improve the management of our manufacturing line.

4. SIMULATION OUTPUTS.

Some of the outputs generated are shown in the following figures. For the original management parameters a model comparative study has been carried out. The user can select one or more techniques/models to be used, the scenarios and the measurements. At any time the management parameters can be modified according to the scenario to be analyzed.

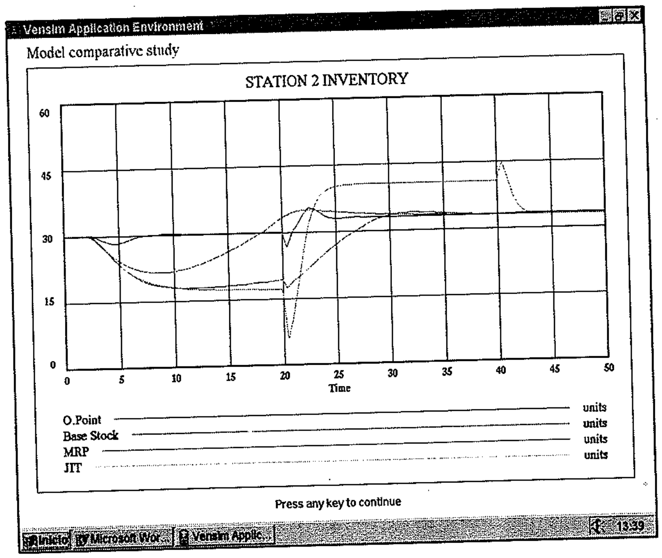

Figure 1. Comparative study

	JIT	MRP	Base Stock	Order Point
Sales	32.801	32.801	32.801	32.801
Turnover	1.06	1.07	1.10	1.07
Average inventory	253.80	251.59	246.90	251.78
Process time	2.39	2.37	2.32	2.37
Inventory value	602.17	593.64	579.77	595
Profit	10.327	10.334	10.361	10.332

Figure 2. Measurements results

5. REFERENCES.

HOPP, W.J., and SPEARMAN, M.L., *Factory Physics*, Irwin, 1996.

MONDEN, Y., *Toyota production system*, Norcross, 1983.

OHNO, T., *Toyota production system (English translation)*, Productivity press, 1988.

ORLICKY, J., *Material Requirements Planning*, McGraw-Hill, 1975.