Economic Investigation in Variable Transfer Batch Size, in CONWIP Controlled Transfer Line

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ECONOMIC INVESTIGATION IN VARIABLE TRANSFER BATCH SIZE, IN CONWIP CONTROLLED TRANSFER LINE

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Abstract:

Production shop is a complex task that impacts the ability of an organization to integrate between economic and production performance measurements. The CONWIP (CONstant Work In Process) approach is the simplest pull system to implement. Two-machine transfer line with the exponentially distributed duration of process, break and repair were formulated and solved as a Markovian-chain. Decomposition was used to iteratively employ this solution in solving K-machine transfer line. These models assume that batch size is fixed. In this study we extend the existing transfer line solution, to deal with 1 unit process batch and t units transfer batch along the line.

Keywords:

Financial and Economic Modelling/Aspects of Logistics, Inventory Management, Logistics Modelling and Simulation

1. INTRODUCTION:

To survive in an environment where customers require prompt deliveries, a company needs sufficient flexibility to react promptly to changes in demand. However, since manpower is one of the most expensive assets of many companies, additional staff cannot, in general attain this flexibility. Moreover, additional inventory (which is the common solution in many industries), will not be the right solution for the customer because it can cause longer lead-time (according to Little's law [3]), and less flexibility. For a fixed level of capacity, prompt reaction to changes can only be achieved when cycle times are short. Moreover, short cycle time entails low inventory and timely reaction to customers' needs.

In the literature, there are models that deal with k-machine transfer lines (KTL)[2]. Most of these models assume equal transfer batch size (TBS) and work batch size. In this study, we propose tools that deal with KTL with a difference between TBS and work batch size, under constant work in process (CONWIP) [9]. Dealing with this type of KTL is a new area, which can be useful in many practical scenarios.

Investigating the TBS is essential for several reasons:

(1) The TBS might not, and many times should not be equal to the process batch [4], [5]. The TBS is the number of units transported from one work center to another, and the process batch is the size of production or process run. When setup costs for processing and transporting are significantly different, batch sizes should be different. The idea here is to encourage LOT splitting, which in some circumstances may increase throughput.

(2) Schedules should be established by looking at all constraints simultaneously. Lead times are the result of a schedule and cannot be predetermined. Bottleneck scheduling recognizes that lead times are not

necessarily fixed quantities and may vary as a function of the schedule. Note that MRP assumes that lead times between levels are fixed and known in advance [9]. Hence, the potential reduction of cycle time by decreasing TBS is negligible.

The focus of our study is to extend the existing KTL solution to permit different processing and transfer batches. Yet, we restrict the analysis to same process batch in all machines and same TBS from all machines. The policy assumes that throughput is limited by the bottleneck machine and that there should be just enough inventories to avoid starving in the bottleneck machine. To keep inventory levels low, the material is released as late as possible to arrive at the bottleneck machine just in time to prevent bottleneck starvation [2].

2. LITERATURE REVIEW

In our work we decided to focus on transfer lines for two main reasons: (1) They are of economic importance [8], they are used in high volume manufacturing, particularly automobile production, and (2) they represent the simplest form of an important phenomenon: the interactions of manufacturing stages, and their decoupling by means of buffers [1], [2].

A transfer line is a manufacturing system with a very special structure. It is a linear network of service stations or machines (M1, M2, . . . Mk) separated by buffer storage (B1, B2... Bk-1). Material flows from outside to M1, then to B1, then to M2, and so forth until it reaches Mk, after which it leaves the system. Figure 1 depicts a transfer line. The squares represent machines and the circles represent buffers.

Each machine has its own parameters:

μ_i = process rate

p_i = failures rate

r_i = resumption rate

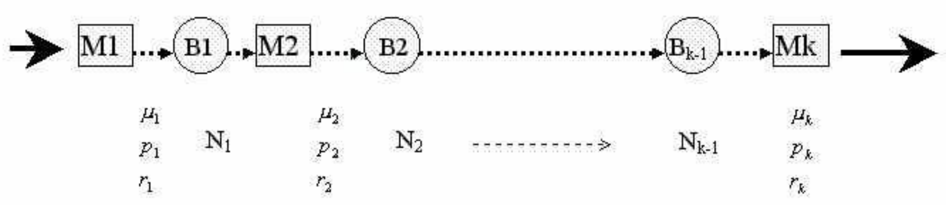

Figure 1- Structure of transfer line.

If a machine’s behavior was perfectly predictable and regular, there would be no need for buffers. However, all machines eventually fail, and some stations require an unpredictable, or predictable but not constant, amount of time to complete their operations. This unpredictability or irregularity has the potential for disrupting the operations of adjacent machines, or even machines further away, and buffers are used to reduce this potential. We want to assess the effects of this uncertainty on the performance of our system.

There is a lot of literature describing approaches for approximating multistage manufacturing systems. Some of them derive the performance measures of a multistage system by decomposing it into a series of two-machine line [2].

The main performance measures that are commonly used in problems that deal with manufacturing systems are: (1) Throughput: A manufacturing system’s throughput is the number of parts that it produces per time unit [6]. This may be a vector if the system can make more than one-part type. It is also called production rate, (2) Work in process (WIP): WIP is the average amount of material in a manufacturing system. It is composed of the parts in the machines, in the storage areas (buffers), in the transportation subsystems and the inspection systems, (3) Cycle Time: Cycle Time is the average amount of time that a part (of a given type) spends in the manufacturing system. There is a linear link between cycle time and inventory, so, reducing one of them will reduce the other one accordingly. Cycle time is also called throughput time or lead-time. The relationship between production, or arrival, rate (λ), WIP (L), and cycle time (W) is given by Little's law [3]: L = λ *W.

Goldratt [5] said that the goal of a factory is to make money. He identify the three important measures: throughput, inventory, and operating expenses, in monetary terms rather than physical units. We will demonstrate some of our results from a financial aspect.

3. RESULTS

We will describe the result of our study from a financial analyzing point of view.

Our Objective function is:

Minimum: $T\prod = TP * \prod_i - WIP * C_{WIP} - NTIH * TRANC$

S.T:

a) The quantity of parts to be released in the releasing parts point depends on the level of the parts in the buffer in front of the bottleneck and the size of the batch.

b) The machine's processing time will be sampled from the machine's specific distribution time (deterministic, normal, and exponential).

c) The machine can be in one of four states: busy, starved, failed or blocked.

Where:

T $\prod$ = Total revenue

TP = Hourly Throughput

$\mathbf{\Pi_i}$ = unit profit

WIP = Hourly work in process

$\mathbf{C_{wip}}$ = WIP cost

NTIH= Number of transferring in hour (on average)

TRANC= Transfer Cost (each).

We can see that TP will be driven from the machine's production rate, availability and the percent of the time that it is blocked or starved. In the Cwip we put regular costs (material, storage, lead time, etc.). The Πi includes the selling price minus the unit working cost (manpower, machine, etc.), under the assumption that the parts that will be produced, will be sold. We chose that target function to see the difference in the costs when we change the TBS and the total level of inventory (in the first step of the analyzing we didn't take in account the transferring cost).

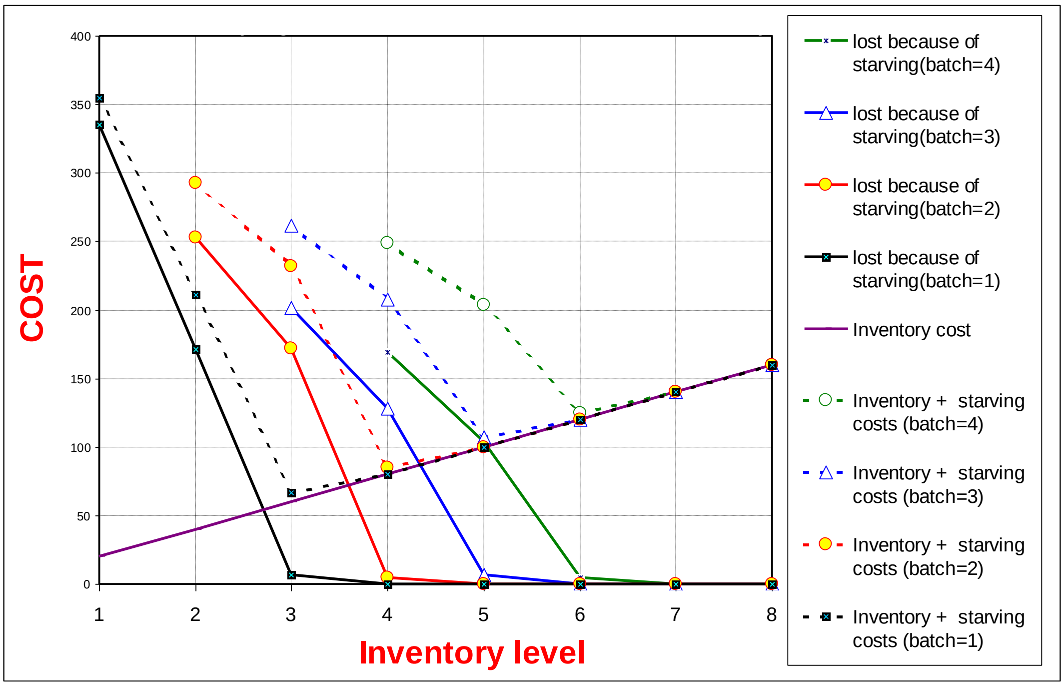

Figure 2- Starvation and inventory costs versus TBS

In figure 2, we made our financial analyzing by checking the link between the TBS and inventory level, and the cost. We marked two kinds of costs: the linear cost that depends on the size of the inventory and cost that we defined as lost because of starving i.e., the alternative profit that we lost. We summed these costs and found some results. First, if we will start to analyze from the biggest inventory level (eight parts) to the smallest inventory level (one part), we can see that up to inventory =six parts we have only the inventory cost because we reach the maximum throughput in batch = 1,2,3, or 4. Second, when the inventory becomes smaller we can see that the cost because of starving becomes crucial, especially if we use a big TBS. For example when the inventory equals to four parts the worst choice is batch = four parts and the best choice is batch = one parts or two parts. In our experiments the best choice is inventory = three parts and the TBS equals to one part. We can notice that the minimum cost decreases if the inventory decreases.

4. SUMMARY:

We began this work by emphasizing the importance of production management in new production environments. We reviewed the literature concerning production control techniques and decided to study first the Drum Buffer Rope technique, in which the focus is on the bottleneck machine. We studied the relations between the decision variables and the performance variables and the financial implications. The results of our study can support research in managing the integration of production and economic aspects in an organization. Specifically, in job shop operations, our contributing might be in analyzing both common manufacturing performance measurements as throughput, WIP, production rate and cycle time, and economical performance measurements as revenue, profit, WIP cost, and Transfer cost. The integrated perspective could be used to analyze case studies in job shop operations.

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