Lot Streaming in a Flow Shop - Simulation Using Arena® Software

J. Laxmi Lalitha and V. Madhusudanan Pilla

Abstract--- *Lot streaming is one of the technique to achieve reduced Manufacturing Lead Time (MLT) and increased machine utilization. Many of the lot streaming techniques applied in the plant floor are in conjunction with the scheduling. In some practical situations, lot streaming has to be done keeping the schedule constant. This paper emphasize on the effect of the transfer batch size on MLT and machine utilization in both Deterministic and Stochastic 2-Machine flow shop, manufacturing 2 parts with different batch sizes. The effects of different complementary activities such as setup time, transfer time are also applied in conjunction with the batch sizing. A total of 4 models (2-Deterministic, 2-Stochastic) have been simulated using ARENA® 13.0 Software. The simulation results reveals that smaller batch sizes leads to reduction in Manufacturing Lead Time (MLT) and increase in Machine Utilization up to a maximum of 1% depending on the process parameters and complementary activities.*

Keywords--- *Lot Streaming, Transfer Batch Size, Manufacturing Lead Time, Machine Utilization, Simulation*

I. Introduction

INTENSIVE global competition and demand& supply balancing have made the manufacturing companies to seek flexible and better strategies that can compress the manufacturing lead time and increase the machine utilization. Lot streaming is one of the strategies which was introduced by Reiter (1966)[1] and are developed by many researchers[2].Lot streaming is the process of splitting the batch into sub lots and overlapping the consecutive operations to accelerate the progress of the work through a production facility for reduced MLT, WIP and increased Machine utilization[3].There are many factors that can influence a typical multi stage manufacturing system. Johnson[4] has categorized them into eight factors namely setup time, processing time per unit, transfer time, production lot size, transfer batch size, arrival variability and resource utilization and/or resource availability. Most of the researches are on the effect of transfer batch size on MLT for all deterministic situations. However the effects of complimentary activities are neglected in most of the literatures. These complimentary activities, such as setup time, transfer time and inspection, are non-value added activities but still have considerable impact on the performance of the manufacturing system. It is estimated that about 70% to 80% of the MLT is non-value added [5]. This necessitates the need to consider different complimentary activities while determining optimal lot sizes.

Researchers have partly studied the effects of complimentary activities on Lot streaming. Truscott[6] presented a simple model to describe the effect of transfer time and setup time in a multi stage flow shop. Some researchers have developed mathematical models to estimate the optimal transfer batch size in different situations.

In this paper an attempt is made to estimate the effect of deterministic and stochastic transfer batch size on MLT and Machine utilization. Differing from above studies, the emphasis is on the variation of transfer batch size of constant & varying keeping the demand constant.

The paper is organised as follows. Section 2 explains the simulation experiment to analyse the effect of various transfer batch sizes followed by simulation model in Section 3. Finally results are summarized in Section 4 followed by conclusions in Section 5.

II. The Study

This study used the bucketed planned release schedule (i.e. MRP output) as an input to the shopfloor. The MRP output is assumed as 10 units for 2.75 hours. The transfer batches in deterministic model are 5 and 10 respectively and where as in stochastic TRIA (3, 4, 5) and TRIA (8, 9, 10).

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III. MODEL

Arena ® software is used to simulate a flow shop which used two input parts to manufacture two end items. Fig.1 shows the product structure and product sequence for two end items. In fig.1, the notation indicates which process (P_i) at which workstation (W_j) performs machining operation. Table 1 summarizes the run and setup times of each process. The transfer time is considered 3 minutes.

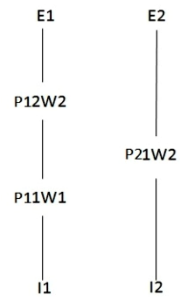

Figure1: Product Structure and Routing

Table 1: Processing and Setup Times in Minutes

Process	Station	Run time	Setup time
$P11$	$W1$	10.0	0
$P12$	$W2$	3.5	20
$P22$	$W2$	7.5	25

Following the initial run-in period of 16,800 minutes (7 weeks; 40 hours/week), each experimental case was ran for 7 weeks. Statistics were collected for every replication, constituting five replications for each case. The simulated shop model is shown in the fig. 2.

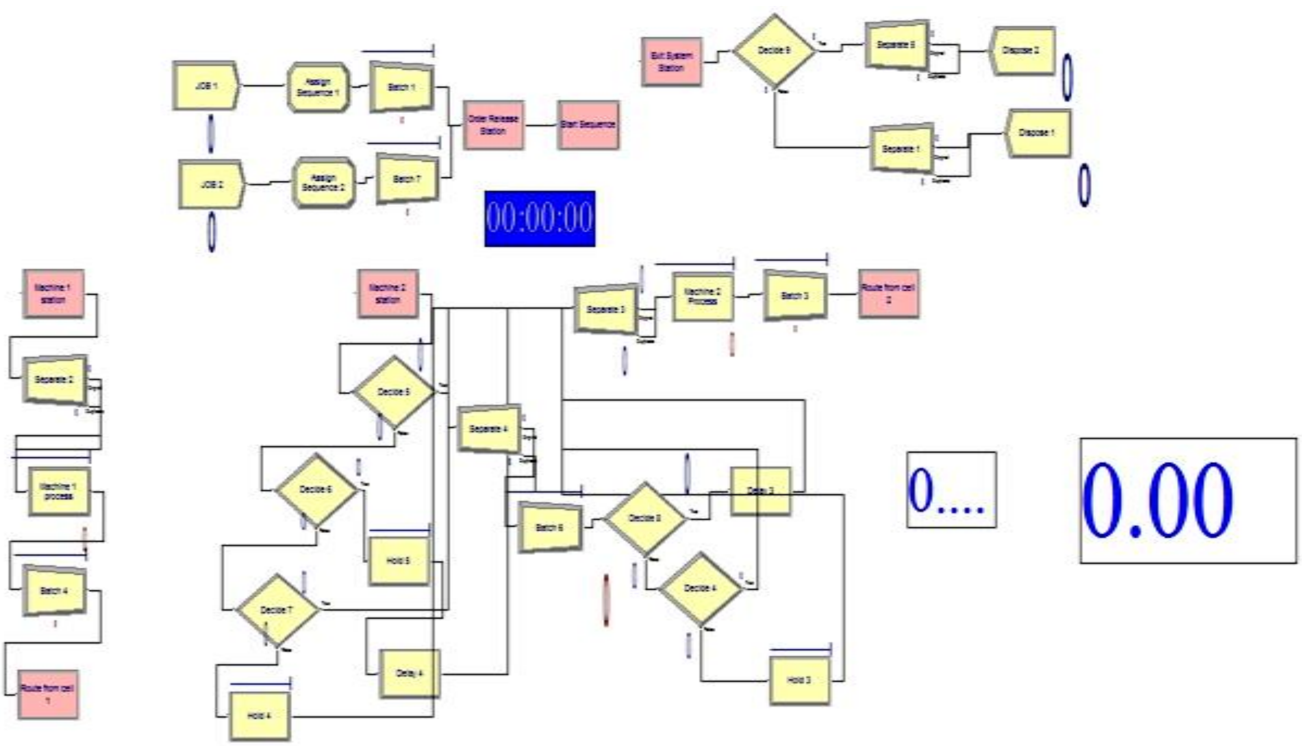

Figure 2: Simulated Model in Arena

IV. RESULTS AND DISCUSSIONS

Results of the batching decisions are depicted based on three performance measures: (1) Machine Utilization, (2) MLT, (3) Number Out. In Fig 3-5, the performance is plotted comparing all the four models for the above three performance measures for the average of 5 replications.

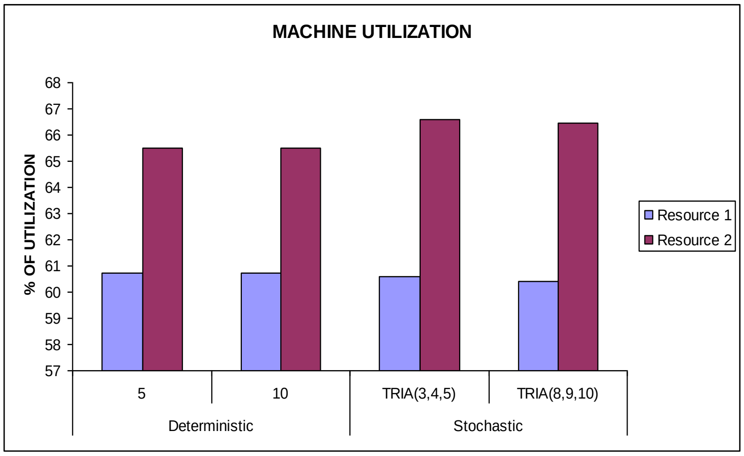

Figure 3: Machine Utilization

As can seen from Fig.3, the machine utilization for the resource 1 is constant in all the four cases as the resource 1 is used only for part 1 and it does not require setup time. But the utilization of the resource 2 is varying as the batch size is affecting the set uptime. It can be seen that for varying transfer batch size, the machine utilization is more compared to the constant transfer batch size. The variation is more than 1% in both cases.

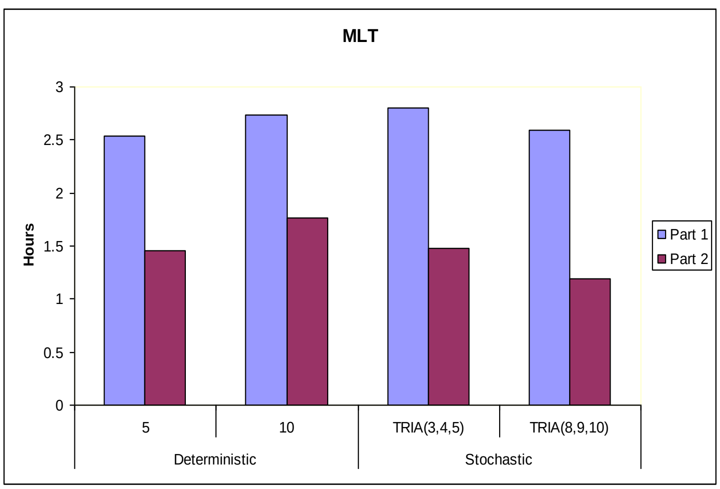

Figure 4: MLT

From the Fig.4, the average MLT for the constant transfer batch size of 5 is less compared to the constant transfer batch size of 10 as the smaller batch size reduces the MLT. But for varying transfer batch size , the MLT for TRIA(3,4,5) is more than TRIA(8,9,10). The reason is only 10 entities are sent in to the system at an interval of 2.75 hours and the batch is sent for machining until a batch of the respective number is formed. This sometimes leads to the waiting of the entities for the next arrival for come up with a batch. This increases the MLT. As there are less number of left over entities in the latter case, MLT again decreases.

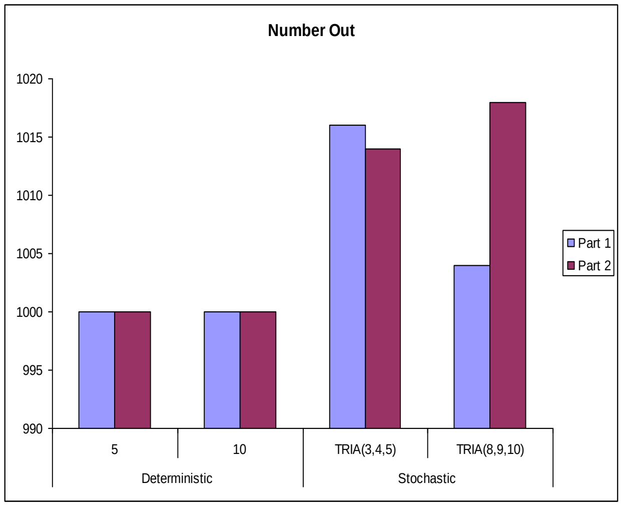

Figure 5: Number Out

From the Fig. 5, it is observed that there is a good increase in the number of parts leaving the system in varying transfer batch cases compared to constant transfer batch. It can also be noted that there is no change in the number out from the system with constant transfer batch sizes 5 and 10. The reason is the arrival of the entities is constant and the entities are divided into 2 and 1 batches respectively throughout the system. In the varying transfer batch size case, TRIA(3,4,5) gives more output compared to TRIA(8,9,10). Lesser the transfer batch size more will be the mobility of the parts.

The results also varied from the replication to the replication. The graphs are plotted for MLT and Number Out for all the five replications and are shown in the Fig 6-9.

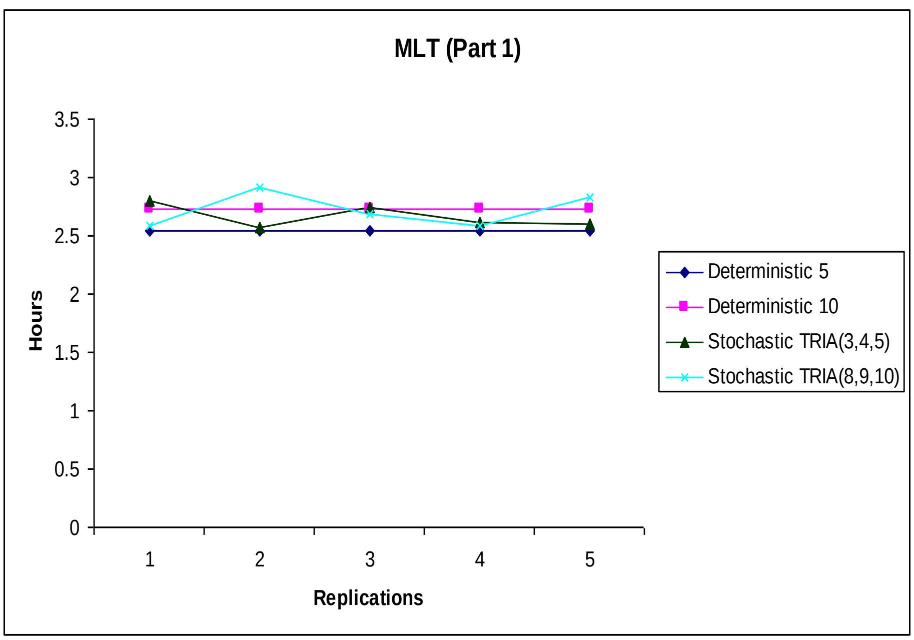

Figure 6: MLT (Part 1)

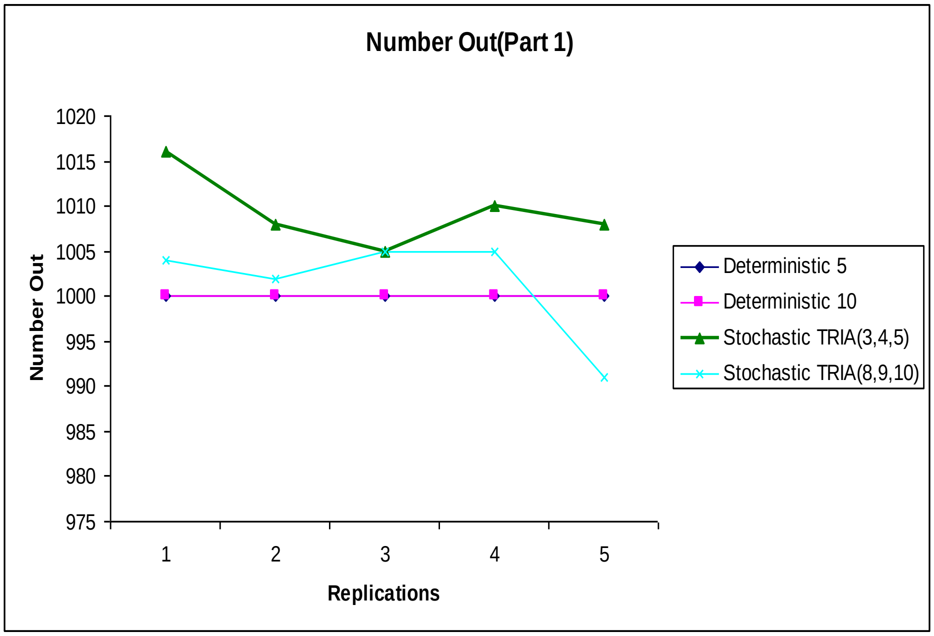

Figure 8: Number Out (Part 1)

It is observed from the Fig.6-9, in the case of constant transfer batch size, there is no change in the MLT as well as the Number Out in all the 5 replications. The results vary only in the case of varying transfer batch sizes only.

V. Conclusions

From the above results, we can conclude that it is possible to increase the performance of the flow shop by just varying the transfer batch size without changing the schedule of the system. One important conclusion is varying the transfer batch size rather than constant transfer batch size increases the Machine utilization, MLT and Number Out. The effect of complimentary activities also accounts for the variation in the transfer batch sizes. The above results also justify that the smaller the transfer batch size, the more will be the production output but does not guarantee it when the amount complimentary activities is more and when the fixed capacity transporters are used between the machines.

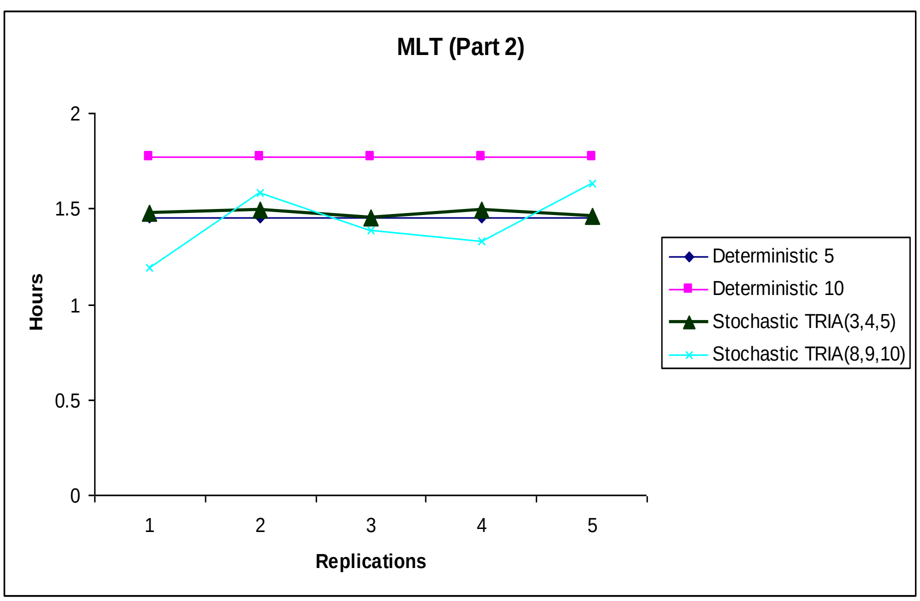

Figure 7: MLT (Part 2)

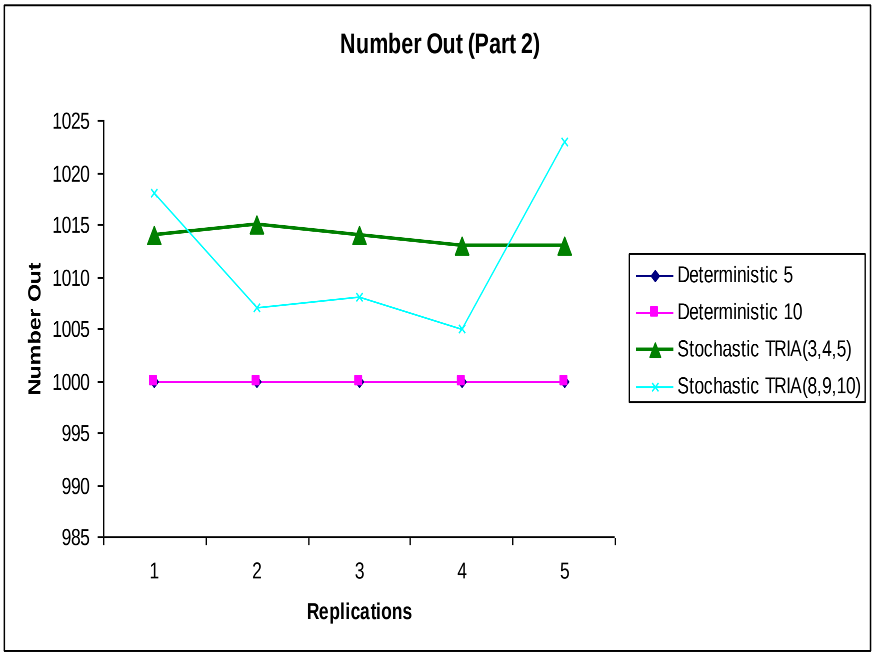

Figure 9: Number Out (Part 2)

The results in the simulation study are limited to the two machine flow shop. This work can be extended to find the optimal batch size by increasing the number of machines in the flow shop and considering the stochastic demand.

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