**The impact of production interruptions on kitting, an analytical study**

1. Introduction

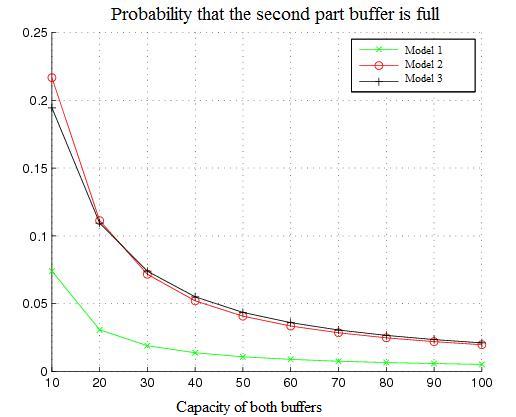
Nowadays customers put a lot of pressure on the market to afford custom-made products, leading to an increased amount of units on the shop floor. Hence, efficient transport of input materials between the different stages of the production process is a key issue for overall production cost minimization. In this viewpoint, the kitting process was introduced. Instead of delivering parts at the assembly line in containers of equal parts, in kitting prior to arriving at an assembly unit the necessary parts are collected into a specific container, referred to as “kit” [Bozer and McGinnis, 1992].

Although kitting is a non-value adding activity, its application can reduce the overall materials handling time [Ramakrishnan and Krishnamurthy, 2008]. However, the introduction of a kitting operation involves a major investment. Therefore it is important to analyze the performance of kitting in a production environment prior to the actual introduction of this operation.

This article studies the kitting process as a two-queue model in an stochastic assembly system. The parts arrive at the part buffers and “wait” there till they are collected into a kit. The impact of temporary interruptions in the production of one and/or both parts on kitting is analyzed.

1. Methodology

We model the kitting process as a (Continuous Time) Markov Chain with a multidimensional state space. The state of the Markov Chain roughly corresponding to the number of distinct parts in the two different inventories, the state space includes all possible inventory levels. While the state space of the transition matrix is very large, the number of possible state transitions from any specific state is limited. This means that most of the entries in the transition matrix are zero, i.e. a sparse matrix. Techniques to define and solve sparse matrices (e.g. the generalized minimal residual method) are applied. The input parameters of the process defined as though it enables a significant outcome, numerical examples such as figure 1 are generated.



The figure above illustrates a numerical example of the probability that the second part buffer full is for the three models. The first one models a process without temporary interruptions in the production. The parts arrive according to a Poisson Process. In the second model, part one is subject to temporary interruptions and his arrival is modeled according to an Interrupted Poisson Process. Finally in the last model part one as well as part two are experiencing inefficiency. Both arrival processes, modeled according to an Interrupted Poisson Process, are identical and independent. We assume a finite-buffer-capacity for both buffers showed on the x-axis.

We can observe that temporary interruptions in the production of one part have a significant impact on the buffer of the other part. When part one experiences interruptions, buffer two will be significantly more often full than without production interruptions. If we “add” a production interruption component at part two, this doesn’t have a significant impact on this probability.

1. Conclusion

Queuing models that have been studied in the literature cannot accurately capture the performance of kitting processes. Therefore, models aimed to assess the performance of kitting operations, taking possible inefficiencies in the production of parts into account should be further developed. The sparse matrix techniques are in the meantime a valuable queuing theoretic/ numerical approach in terms of solution speed and accuracy for the performance estimation of the kitting process.