Proceedings of the 2015 Winter Simulation Conference
M. Eyal and I. Tirkel.

THROUGHPUT AND FLOW-TIME IN A PRODUCTION LINE WITH PARTIAL MACHINE AVAILABILITY AND IMPERFECT QUALITY PROCESSING

Maayan Eyal

Industrial Engineering and Management Department Ben-Gurion University of the Negev Beer-Sheva, ISRAEL

Israel Tirkel

Industrial Engineering and Management Department Ben-Gurion University of the Negev Beer-Sheva, ISRAEL

ABSTRACT

Machine availability and quality performance can significantly constraint the operation of production systems. This work investigates the throughput and flow-time of a serial production line, considering partial availability and imperfect quality processing. The study develops analytical models of a production system based on Markov Chains and the Queuing Theory. The analytical model's results are verified using discrete event simulation. Preliminary results exhibit the most throughput-constrained station and the impact of the model's parameters on selected performance measurements.

1 INTRODUCTION

Machine availability and quality performance can significantly constraint the operation of production systems. This work investigates the throughput and flow-time of a serial production line, considering partial availability and imperfect quality processing. In practice, the throughput of a station is always higher than or equal to the throughput of the following station. The throughput loss along in a production line has a significant effect on the system's performance. Most models do not take into account imperfect quality outcomes in production lines nor do they analyze the effect of those results.

2 METHOD

The study develops analytical models of the serial production line based on Markov Chains and the Queuing Theory. The analytical model's results are verified using discrete event simulation. The work investigates the production line throughput, the processed items flow-time and the buffers occupancy. It also determines the most throughput-constrained station and prioritizes the improvement of the corresponding throughput-limiting factors.

3 MODEL

The work assumes a line with two or more stations, each with a single machine, and a buffer between every two consequent stations. Each processed item is inspected for its quality post processing, resulting in either: good item continuing to the consequent station, defected item requiring rework in the current station, or bad item which is scrapped. It is assumed that the demand is unlimited (i.e. system's arrivals), the station's process times are deterministic, and the station availability follows a known probability. The probabilities for good, defected or bad item are also known and their sum equals unity. The machine availability and quality performance probabilities are considered throughput limiting factors. Two main cases are investigated in the steady state:
Case I – production line with a finite and known number of stations and unlimited buffers size, and
Case II – production line with two stations and a single buffer with a limited size.

4 RESULTS

The steady state requirement is developed for Case I and II illustrating interesting analogy to the traffic intensity requirement in the Queuing Theory. It is also shown that the stations throughput-limiting factors are bounded by the steady state requirement.

Preliminary results of Case I exhibit that the most throughput-constrained station is the first one in the production line. Also, that increasing the "traffic intensity equivalent" drives larger buffers

978-1-4673-9743-8/15/$31.00 ©2015 IEEE

occupancy on average, and reduces the probability of an idle station. The flow time increases when the availability of the first station increases but decreases when the availability of the other stations increase. Preliminary results of Case II illustrate that it is always preferred to improve the throughput-limiting factors of stations closer to beginning of the line than closer to its end. Buffer size limit determines the convergence condition where increasing buffer size grows the throughput at slower pace. In addition, buffer size limit has significant impact on flow time especially for small values.

Furthermore, in Case I it is shown that changing the parameters of Station i affect the throughput of the current station and the downstream stations. However, in Case II it is shown that changing the parameters of Station i, when the buffer is limited, affect the throughput of the downstream and upstream stations.

5 FUTURE RESEARCH

Future research will investigate additional cases of a production line of three or more stations with limited buffers size and their throughput-limiting factors' prioritization for improvement.

AUTHOR BIOGRAPHIES

MAAYAN EYAL is completing his thesis in Industrial Engineering and Management at Ben-Gurion University of the Negev. He received his B.Sc. at 2007 and M.Sc. degrees at 2013 in Industrial Engineering and Management from Technion-Israel Institute of Technology and Tel-Aviv University, respectively. He has been working for a large organization for the past 8 years as an Operation Manager and Lean Management consultant.
maayaneyal@gmail.com

ISRAEL TIRKEL is a faculty researcher-lecturer in the department of Industrial Engineering and Management at Ben-Gurion University of the Negev, Israel. He has worked for Intel Corporation, in Israel and the USA, for twenty-three years in senior management positions of Fab Operations and Program Management. He received his B.Sc. with distinction at 1983, M.Sc. with distinction at 2009, and Ph.D. at 2011 in Industrial Engineering and Management, from Ben-Gurion University of the Negev. His areas of specialization are production and operations analysis and management, and project management, which he formerly practiced and is now investigating and lecturing. His prior research include work in cooperation with companies such as Intel, Micron and KLA. He is an Associate Editor in IEEE Transactions on Semiconductor Manufacturing.
tirkel@bgu.ac.il