EFFECTS OF OPERATING CHARACTERISTICS ON WORK-IN-PROGRESS IN BATCH MANUFACTURING SYSTEMS

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NANAYAKKARA, L.D.J.F.

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Summary

The present state-of-art of the techniques of planning and controlling production in batch shops has been surveyed and the operational characteristic of batch shops have been identified. There is a need in manual shops to introduce methods of systematic capacity planning through balancing of workload by flexible labour assignment, assigning realistic and attainable due dates and processing information to aid management decisions. A methodology is required by which the multiplicity of batch-shop variables can be reduced to a manageable level so that the factors which have a direct effect upon shop performance can be identified and controlled.

A stochastic model based on queueing-network theory is presented which describes the behaviour of wip in batch shops by predicting the mean delay experienced by batches at individual work centres. A batch shop is modelled as a flow network with Markovian transitions between work centres which are determined by the routing probability matrices of a known product mix. A method of solution by decomposition is used, where each work centre is considered as a single-stage queueing system, for estimating the mean delay and wip. The queueing characteristics at a work centre are described by the first two moments of the arrival and processing time distributions. The effect of production uncertainties on

the processing characteristics at work centres is accounted for by forming a composite processing time distribution with which the mean delay at the work centres are computed. The model was validated in two batch shops by predicting mean delays. Subsequently, the measures of wip and the expected flow-times of individual batches were predicted by the model.

Poisson-exponential models were found to be inadequate for representing the operational characteristics of batch shops; the model employing general distributions of processing time which were approximated by the first two moments was found to be adequate. In this model the arrivals at work centres were represented by their first two moments which were not far from those of a Poisson process. The mathematical accuracy of the model, in predicting mean delays, was within ±15 per cent. The mean delays predicted by the model were within ±30 per cent of those observed in the shops; this result was within the random variation due to sampling error.

A substantial proportion of wip which varied from 30 to 60 per cent was due to the planned operator unavailability at the work centres which had not been fully loaded. The interruptions to processing due to non-productive activities caused wip to increase by 40 to 60 per cent at fully-loaded work centres and 20 to 30 per cent at lightly-loaded work centres. Both shops

were observed to carry wip which was nearly twice as large as the wip in the work-centre queues; this excess wip was located at the entry and exit or final assembly stages of the shops. This wip was attributed to the surplus shop time allowed to some batches under the constant shop time rule and it is proposed that the assignment of flow time based due dates and the use of a detailed scheduling system based on these for releasing and progressing batches would help reduce wip in the shops.

The accuracy of the mean-delay formulae employed in the model is sensitive to the shape of the arrival distributions. It is hypothesised that the arrival distributions in batch shops will approach a Poisson process in which case the accuracy of the model would improve. This research has shown that mathematical models of batch shops can be developed and employed to predict wip; the lack of mathematical rigour does not necessarily limit the robustness of the model so long as it is based on empirical assumptions which can be verified. However, the model is expected to yield pessimistic measures of wip in shops where the shceduling system is capable of eliminating a proportion of the random-flow conditions assumed in the model. The validation of the model, in a different production environment, would require minor adjustments of the model.

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