Chapter XLIII
Worker Performance Modeling in Manufacturing Systems Simulation

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ABSTRACT

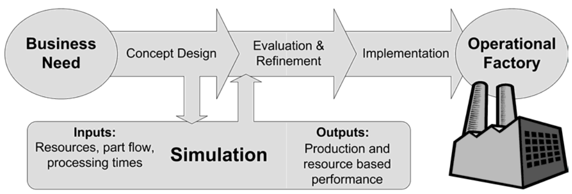
Discrete event simulation is generally recognized as a valuable aid to the strategic and tactical decision making that is required in the evaluation stage of the manufacturing systems design and redesign processes. It is common practice to represent workers within these simulation models as simple resources, often using deterministic performance values derived from time studies. This form of representing the factory worker ignores the potentially large effect that human performance variation can have on system performance, and it particularly affects the predictive capability of simulation models with a high proportion of manual tasks. The intentions of the chapter are twofold: firstly, to raise awareness of the importance of considering human performance variation in such simulation models; and secondly, to present some conceptual ideas for developing a worker agent for representing worker performance in manufacturing systems simulation models.

INTRODUCTION

Manufacturing systems are most often highly complex constructs and their behavior is of a dynamic and stochastic nature. They consist of extensive interactions between people, information, materials, and machines. Systems like assembly lines may look quite simple because their tasks are mainly done in a sequential order. In reality, these systems are quite complex constructs due to breakdowns of various types and natural variation in processing times, which makes them non-deterministic. The breakdowns can be machine failures, but in systems like manual assembly lines where humans play a key role, they can also be unusually long task completion times or the unavailability of workers.

When it comes to the design or redesign of manufacturing systems, it is common to use a methodological approach. Discrete event simulation (DES) is generally recognized as a valu-

Figure 1. Steps in manufacturing systems design



able aid to the strategic and tactical decision making that is required in the evaluation stage of the design process. Figure 1 depicts the way in which DES integrates into the manufacturing system design process. A major advantage of simulation models, compared to the analytical ones that are also in use, is their ability to model random events based on standard and non-standard distributions and to predict the complex interactions between these events. This allows the system designer to obtain a system-wide view of the effect of local changes to the performance of the overall system and enables him or her to predict system performance, to compare alternative system designs, and to determine the effect of alternative policies on system performance.

Among other things, DES models are used to determine the amount of machines, buffers, and operators that are needed to produce a certain target output. Companies that have groups which specialize in studying multi-million-dollar systems using DES include Honda, Ford, General Motors, Harley-Davidson, and Renault (Baudin, 2002). The simulation experts within these groups have a high degree of responsibility to ensure the accuracy of the results. Inaccuracy can prove very costly, as it may lead to poor system performance and failure to meet the production demand.

Due to the complexity of the real world, a system model can only be a restricted copy of a real system. Therefore, abstraction and simplification have to be used in order to cope with this complexity. Abstraction comprises or concentrates in itself the essential qualities or behaviors of a thing, but not necessarily in the same form or detail as in the original, while simplification entails stripping away unimportant details and assuming simpler relationships (Shannon, 1975).

It is commonly observed that a gap exists between the performance predictions of a manufacturing system simulation model and the performance of the real system. As a consequence of abstraction and simplification, system models tend to model the real world too optimistically compared to real systems. Another common observation is that performance predictions of systems involving a high proportion of manual tasks are notably less accurate than those of highly automated systems. This is attributed to the way in which the human element is represented within the system simulation model. It is common practice within DES models to represent workers as simple resources, often using deterministic performance values derived from time and motion studies. This is an extreme simplification as the work measurement literature indicates clearly that workers' task performance varies. This variation occurs between different workers carrying out the same task, and moreover for the same worker when repeating a task (e.g., Dudley, 1968). It has also been shown that workers' task performance varies as a consequence of its dependence on past events and the current state of the system. The current approach of representing workers within DES models ignores the potentially large effect that human performance variation (HPV) can have on the system performance of the labor-intensive manufacturing system.

This chapter has been written with two objectives in mind: firstly, to raise awareness of the importance of considering HPV in human-oriented DES models; and secondly, to offer some conceptual ideas for developing a more

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