Chapter 7
Stochastic Optimization of Manufacture Systems by Using Markov Decision Processes

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ABSTRACT

In real-world most of manufacturing systems are large, complex, and subject to uncertainty. This is mainly due to events as random demands, breakdowns, repairs of production machines, setup and cycle times, inventory fluctuations and more. If items move too quickly, workers may work too hard. If items move too slowly, workers may have great leisure times. However, must make decisions here and now regarding the operation of the system optimally and quickly. In practice, these decisions are based on recent statistics of the system behavior, in the experience of the analyst and the urgency of the solution. In this chapter, we present a real problem associated with the production of individual parts in metalworking industry for the refrigerators production. We develop a model based on the Markov Decision Process to study the dynamics of the trajectory of end products in a manufacturing line that works by process. Then, we propose a measure of the average production rate of the line by using the Monte Carlo method. We illustrate our proposal using a numerical example with real data obtained in situ.

1 INTRODUCTION

Manufacturing is the process of converting raw materials, components, or parts into finished goods that meet a customer's expectations or specifications. Manufacturing commonly employs a man-machine setup with division of labor in a large scale production to make a good with tools and/or machines by effecting chemical, mechanical, or physical transformation of materials, substances, or components, or by simulating natural processes, usually repeatedly and on a large scale with a division of labor. Manufacturing flow

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line systems consist of material work and storage areas. Material flows from work area to storage area to work area visiting each station exactly once in a fixed sequence. At the beginning of the production line there is an entity named raw material warehouse, and at the end there is another warehouse named of finished product. The time that parts spend in work areas can be random; this randomness may be due to random processing times, random failures and repair events or both. Storage areas can hold only a finite amount of material and the machines are always working. The work areas are called the shop floor and the storage areas are called buffers. Thus, a manufacturing system is a method of organizing production and it involves flow lines, job shops, transfer lines, flexible manufacturing systems, flexible assembly systems, cellular systems and more (Buzacot & Shatikumar, 1993).

Stochastic manufacturing is the analysis of the manufacturing systems from a randomly approach. Models for production planning which do not recognize the uncertainty can be expected to generate inferior planning decisions as compared to models that explicitly account for the uncertainty. In practice, there are many forms of uncertainty that affects the production line: a) The environmental uncertainty and b) System uncertainty. The first concept includes the uncertainty of customer demands and the uncertainty of suppliers, the second is related with the uncertainties within the production process such as operation yield uncertainty, production lead time uncertainty, quality uncertainty, failure machines and changes to product structure see (Mula, García Sabater, & Lario, 2006).

A manufacturing system therefore may be looked upon as an independent group of sub-systems, each sub-system performing a distinct function. Different sub-systems may perform different functions, yet they are inter-related and require to be unified to achieve overall objectives of the organization.

The manufacturing systems can be classified in intermittent and continuous systems (Balduzi, Giua, & Seatzu, 2001). Intermittent production systems are those where the production facilities are flexible enough to handle a wide variety of products and sizes. In the intermittent system the goods are manufactured specially to fulfill orders made by customers rather than for stock. Here, the flow of material is intermittent. These can be used to manufacture those products where the basic nature of inputs changes with the change in the design of the product and the production process requires continuous adjustments. Considerable storage between operations is required, so that individual operations can be carried out independently for further utilization of men and machines. In continuous systems the items are produced for the stocks and not for specific orders. Before planning manufacturing to stock, a sales forecast is made to estimate likely demand of the product and a master schedule is prepared to adjust the sales forecast according to past orders and level of inventory. In this systems the inputs are standardized and a standard set of processes and sequence of processes can be adopted. After setting of master production schedule, a detailed planning is carried on. Basic manufacturing information and bills of material are recorded. Information for machine load charts, equipment, personnel and material needs is tabulated.

In order to model these systems, many conventional techniques and intuitive approaches used for years have become satisfactory (Vitanov, Julkaa, Bainesb, Tjahjonob, & Lendermanna, 2007). Mathematical model and methods together with other methodologies such as simulation (Mula, García Sabater, & Lario, 2006), (Smith, 2003), (Liu & Song, 2012), (Fowler & Rose, 2015), (Anglania, Griecoa, Pacellaa, & Toliob, 1996), (Metropolis, Rosenbluth, Teller, & Teller, 1953), Petri nets (Jonsson P, 2003), (Popescu, Soto, & Lastra, 2012), (Hsieh & Lin, 2014), (Liu & Song, 2012), (Leitao, Mendez, Bepperling, Cachapa, Colombo, & Reestivo, 2012), and more have been used to study, analyze and to control these systems. Production planning problems have been formulated and solved as optimization problems since the early 1950's, and an extensive literature has been developed. The widespread use of Enterprise Resource Planning (ERP) systems and developments in information technology and scientific computing have opened the