Production Planning and Control Systems - State of the Art and New Directions

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Abstract: This chapter begins with a description of the role of production planning and control (PPC) within the manufacturing function. After discussing the impact of the operating environment on the choice a system for PPC, we describe some recent empirical evidence regarding the use and performance results of various PPC systems. This is followed by a brief overview of the two most widely used systems for production planning and control. We then describe a recent development in the area of short-term detailed scheduling exploiting the latest developments in computing technology. The chapter concludes with a discussion of an emerging paradigm for exploiting the advancements in computing technology for developing sophisticated state-of-the-art PPC systems capable of satisfying the needs of tomorrow's market place.

1. Introduction

The Production Planning and Control system is a major component of the infrastructure which supports the manufacturing process selected for the specific environment faced by the firm [27]. Production planning and control (PPC) is a major function essential for the successful operation of every manufacturing company. It is a complex task because of the large data volume involved [18]. Villa [26] characterizes it as a control optimization problem for a large-scale dynamic system. He argues that the evolution of a PPC system is influenced largely by two types of events: (1) events to be planned and (2) events to be controlled.

A PPC system is mainly concerned with ensuring efficient and effective use of capacity for satisfying anticipated demand. Four major tasks comprise production planning and control: Aggregate Capacity Planning, Material Planning, Production Activity Planning, and Production Activity Control. Aggregate Capacity Planning focuses on matching demand and supply (i.e., capacity) over the short or medium horizon. Material Planning deals with making sure that the needed material is available at the right time. Production Activity Planning generates detailed plans ensuring that the available capacity is consumed in an effective and efficient fashion. Production activity control is concerned with execution of the plans.

Successful companies plan and control their operations using a formal system. Systems designed to support companies in planning and controlling their operations are called Production Planning and Control Systems. Many PPC systems are being used by companies around the world. Earlier this century firms often used what has come to be known as Reorder Point Systems (ROP). With the advent of computers,

during the early sixties, the use of Material Requirements Planning Systems became widespread. Beginning in the 1960's, many traditional reorder point systems were replaced by what are known as Manufacturing Resource Planning (MRP) systems. According to some estimates, more than 20,000 companies in various parts of the world deploy MRP systems to plan and control their operations. In the early 1980's the "MRP Crusade" ran up against the "JIT Crusade" built around the Kanban system. In the last decade, largely due to some Japanese firms operating under the Just-In-Time philosophy, Kanban-based systems became popular. At about the same time, another new system called Optimized Production Technology based upon the "drum-buffer-rope" approach [5] was introduced and is used by some companies. Thus, the four most common PPC systems used in practice and discussed in the literature are the following: MRP-based push systems (MRP), Kanban-based pull systems (Kanban), constraint theory based systems that identify and schedule according to bottleneck resources (OPT), and traditional reorder point based systems (ROP).

Computer integrated manufacturing (CIM) links all vital functions of a manufacturing organization through an integrated computer system thus providing the capability to consistently produce the desired products at a low cost and high quality, and in a timely fashion. The CIM concept spans the entire firm. For the purposes of this chapter we limit attention to only the planning and control function. Within CIM, the PPC system is computerized. CIM requires that the PPC system be tightly integrated and be capable of speed and sophistication. This is so because of the increased product variety typically associated with a CIM environment. Furthermore, the enhanced capability to supply products at short notice (reduced customer leadtimes), the need for accurate planning of capacity and materials, and tighter control of the shop floor activities in greatly increased. In short, under CIM the PPC system plays a more central and important role in ensuring effectiveness and efficiency.

2. Manufacturing Environment and PPC Systems

Recent market-trends indicate that manufacturing firms are being required to excel in a variety of dimensions [6]. Low cost manufacturing, quicker product development, faster delivery, wider variety of products, wider range of efficient production volumes, and steadily increasing quality standards have all become important. Demand for capabilities that would have been impossible to meet under the more dichotomous strategies of the not too distant past have become the norm for competition in today's manufacturing environment [2, 25, 28].

The environmental conditions faced by the manufacturing function can be characterized by (1) product volume and variety, (2) competitive priorities, and (3) process technologies and infrastructure available within the firm. The volatility of demand, the level of product design changes, and the rate of new product introduction define the product volume and variety mix. In terms of competitive priorities, firms are faced with the need for holding the line on costs while meeting demand for more frequent and smaller lot deliveries of an increasing variety of products. The process technology available within the firm (e.g., Numerically Controlled Machines, Flexible