PERGAMON

Computers & Industrial Engineering 44 (2003) 673–693

computers & industrial engineering

www.elsevier.com/locate/dsw

An integrated multidimensional process improvement methodology for manufacturing systems

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Accepted 12 December 2002

Abstract

In this paper, an integrated multidimensional process improvement methodology (IMPIM) is formulated to address the yield management, process control and cost management problems of a manufacturing system. Simulation is used as a platform to implement the integrated multidimensional process methodology by incorporating the productivity, quality and cost dimension in a unified, systematic and holistic manner. Total Quality Management (TQM) addresses the quality parameters and Activity-Based Costing is used to manage the cost dimension of the system. Discrete event simulation is then used as a platform to perform process reengineering (Business Process Reengineering) and process improvement (TQM). The general implementation framework of the IMPIM is given with a step-by-step explanation. A conceptual discussion is also provided for the integrated methodology. The generic IMPIM is then formulated and the detailed implementation procedures for two case studies are compared with the generic methodology.

Keywords: Activity-based costing; Control chart; Discrete event simulation; Neural networks; Statistical process control

1. Overview

The explosive production power of the Pacific Rim has led to worldwide over-resourcing and a competitive global marketplace. With the inclusion of China and India, the pressure is on for businesses in the West to improve management processes in order to secure a trading place in the 21st century (Hutchins, 1998). However, global competition and the recent recession have exposed a serious

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0360-8352/03/$ - see front matter
doi:10.1016/S0360-8352(03)00002-0

weakness in Asian organisations; namely many organisations had become over-staffed, cumbersome, slow and inefficient. These factors only underscore the importance of organisations properly redesigning their processes and structures, so that they will become more efficient with higher yield, better quality and lower cost.

Sometime during the early 1970s, a quality-based approach to doing business began to emerge from Japan (Burnstein, 1995). Competition, changing customers' needs, changing product mix, increasing product complexity and higher customer expectation are the changing set of business conditions that are embedded with the quality parameters (Juran & Gryna, 1993). This changing set of business conditions can be characterised by dynamic structural change of the system (Spedding & Chan, 2000). Shorter product life cycle, better quality and competitive pricing has caused the development of several key philosophies such as Total Quality Management (TQM), Just-In-Time (JIT), Total Productive Maintenance (TPM), production cells, the Ss of housekeeping, Kaizen, set-up time reduction, Kanban and Poke-Yoke. Another philosophy is the concept of near-perfection introduced by Philip B. Crosby (Crosby, 1979). Later, Motorola adapted this concept as the six-sigma quality concept which is not only used to manufacture defect-free products, but also to eliminate defects throughout the organisation's processes (Fontenot, Behara, & Gresham, 1994).

In practice, productivity, cost and quality of a manufacturing system are normally optimised individually. This is evident in most of the manufacturing companies in Singapore. Discrete event simulation is a tool used to optimise productivity but it fails to address the quality process control issues. However, discrete event simulation can be used as a planning tool for implementing Business Process Re-engineering (BPR) projects in order to avoid potential problems (see (Hammer & Champy, 1993; Hammer & Stanton, 1995a,b) for theoretical details). In TQM, the emphasis is usually placed on improving individual components or processes rather than integrating the results (Dettmer, 1995). Goldratt reiterates what has been known in system dynamics for three decades that if the performance of each process of a system is individually optimised, the overall system performance might not be optimum (Goldratt, 1992). Propagation of errors through the system also cannot be identified if the components of the system are investigated individually. Most of the undesired effects within a system are caused by a few interconnected components or subsystems.

Most manufacturing companies in Singapore have yield problems due to the very competitive environment. Singapore faces stringent competition from neighbouring countries, like Malaysia and Indonesia. The neighbouring countries have cheaper labour, better natural resources and an improving standard of quality. Hence, manufacturing companies in Singapore must approach the yield problem in a holistic way. This is because the yield problem involves multidimensional factors. Traditional tools, such as discrete event simulation software, Design of Experiments (DoE) and traditional accounting techniques, can only solve the productivity, quality and cost problems separately. Improving productivity in the conventional way (upgrade the technology and modifying the existing system) is normally more expensive. However, improving the yield by introducing statistical quality control charts such as the Fractional Non-conformance (Montgomery, 1997), the Exponential Weighted Moving Average (EWMA) (Hunter, 1986; Robert, 1959) and the Control Run Length (CRL) chart (Xie, Xie, & Goh, 1995) can be more effective and cheaper for attribute data (Woodall, 1997). Unfortunately, there is no integrated methodology to combine the productivity optimisation, cost minimisation and quality control consideration together in a systemic way (see Fig. 1). The flatter the triangle, the better the system.

While many theories such as BPR, TQM and ABC have been proposed to solve the manufacturing problems in a disparate manner, there is a scarcity of methodology that are capable of improving yield,