A TQM Approach for Designing and Building Dedicated Machines and Equipment In-House

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Many industries are responding to the need for major design changes in their manufacturing systems to include flexible and controllable systems that produce superior-quality products on time and at a lower cost. Maintaining flexibility while meeting the functional requirements of a manufacturing system often requires designing a machine that is unique. Consequently, a new trend in manufacturing systems design is to build such machines in-house. This paper describes a systematic implementation of total quality management (TQM) along with continuous improvement concepts to design and build a test-stand in-house. This project also involves creating a prototype for on-going machining design for future needs.

Keywords: Continuous improvement; Cycle time; Machine design; Takt time; Total quality management

1. Introduction

Today’s marketplace is characterised by competition at all levels – local, national, and global. To meet competitive demands, a manufacturing system must be designed to satisfy both the customers’ needs and the market demands. The design strategy (parameters) influencing the functional requirements needed for manufacturing competitiveness can be grouped into two major classes: Process technology and system methodology. Process technology is that which adds true value to the product, whereas system methodology determines how the technologies are coupled within the manufacturing system to produce the customers’ goods. Important measures determining the competitiveness of a manufacturing system are efficiency (productivity), uniqueness, flexibility, and controllability.

Black [1] defines a manufacturing system as a complex arrangement of physical elements which consists of workers, machines, tools, and material handling. Unless all of these physical elements in the manufacturing system are properly maintained, breakdowns will occur and disrupt the flow of products. Therefore, maintainability of equipment should be considered as a significant factor in designing or selecting the equipment. Based on the needs of the manufacturing system, building dedicated in-house equipment is one strategy used to pursue the goal of flexibility and maintainability.

In general, manufacturing engineers are responsible for designing, testing, and implementing the manufacturing equipment. Although many principles have been developed for machine design, it is time-consuming and difficult for one or two manufacturing engineers to design, build, and implement in-house equipment independently [2]. Frequently, designing and building a dedicated machine requires a team approach. This has led the authors to design and implement a dedicated teststand using total quality management (TQM).

Total quality management is a business approach that has gained increasing attention and has been increasingly practised in the USA since the late 1980s. It encompasses many principles including empowerment, internal and external customer awareness, team building, leadership skills, coaching, top leadership commitment, bench marking, trust, respect and continuous improvement [3]. Commitment to TQM principles can sharpen any company’s competitive edge. Colson and Prell stated that, “Conceptually, TQM is an integrated management approach designed to transform customer needs and requirements into customer satisfaction and business success. TQM emphasizes the continual management and improvement of all work and business processes to meet both short-term and long-term customer needs” [4, p. 48].

The concepts and principles of TQM were first articulated in 1951 by Feigenbaum [5] whose work was largely ignored by American management at that time [6]. However, inspired by Deming and Juran, Japanese management embraced these concepts with an almost religious fervour [6]. In the post World War II 1950s era, Japan began using principles taught by Deming, an American statistician, to help deal with long-term competitive and quality control problems [3]. It is believed that the use of these TQM practices helped Japanese products gradually outperform and outsell American-made products over the next 30 years.

The American TQM movement gained widespread attention in the 1980s in an attempt to improve quality related issues such as customer dissatisfaction, rising operating costs,
employee related problems, and other competitive barriers. American companies needed to compete with Japanese products to survive. In 1988, Executive Order (EO)#12637 of the Federal Productivity Improvement Program was issued and the Federal Quality Institute (FQI) was established [7]. The results paved the way for the establishment of total quality management in American industry and the regulation of quality efforts as well.

One specific illustration of the effectiveness of TQM in the auto industry is provided by New United Motor Manufacturing, Inc. (NUMMI), a joint venture between General Motors and Toyota [8]. This approach resulted in the development of the concept of just-in-time in the automobile industry [9]. TQM has been implemented in government and education as well as in industries. Kline [10] reported that 12 state governments in the USA have implemented TQM statewide. Similarly, Iowa State University has implemented TQM in order to retain students as well as using it for several departmental operations and meetings.

In spite of the current popularity of TQM, a great debate is raging. Evidence of the effectiveness of TQM has been provided through an empirical study [11] that focused on a sample of companies which applied for the Baldrige Award prior to 1991. The sample included 30 firms representing 25 industries. Most of the companies had revenues of $100 million or more. By observing the revenues of these companies during the period of 1986 to 1992, the report claims that, “manufacturing revenues in US companies increased 19.3 percent ... The TQM companies nearly doubled that percentage in revenue” (p. 23). Interestingly, the sample companies reported a decrease in employment while US companies, in general, increased employment levels during the same period. On the other hand, not all of the Baldrige winners have continued to be successful. The Wallace Company was a 1990 winner of the Baldrige Award, yet, in 1991, there were indications that the company was facing bankruptcy [12]. This actually did occur before it was acquired by Wilson Industries.

Based on these debates, it is perceived by the authors that the success of TQM depends on how one systematically practises its concepts and principles. It is clear that there are many unanswered questions about the effectiveness of TQM. Several facets should be investigated because TQM refers to a comprehensive, organisation-wide management system. Johnson [13] suggests that, “implementing TQM is like putting a puzzle together” (p. xiv). Each facet of the implementation can be thought of as a piece of the puzzle; none can stand alone, yet all interlock with the other pieces to produce the complete picture. After implementing TQM to design and build a teststand, the authors suggest using a systematic approach to implement TQM in machine design applications. The purpose of this paper is not only to show the success of the in-house machine design but also to present the implementation stages.

2. Overview of the Teststand Design

The transition to a TQM perspective can be a long process that requires uncompromising commitment from upper management. Without this commitment, TQM efforts will surely fail. Employee empowerment, cross-functional work teams, continuous improvement, customer awareness, value-added measures and trust are TQM principles that synergise machine design processes. To be successful, the vision needs to be shared and embraced by everyone, and information should be exchanged freely. Respect and confidence in each member’s abilities and the use of continuous improvement philosophies are essential.

Performance measurement tools must be used to understand the “local” accomplishment level of a TQM process or philosophy. Use of measurement tools indicates that expected results are becoming a reality. The tools that the company applies to gauge internal and external customer satisfaction are the most important part of performance measurement.

A design project focused on evaluating a new combined application is generally known as a teststand. Figure 1 shows a teststand that has been used in the field for more than 15 years. The purpose of the teststand designed in this study was to test functionality hydrostatic transmissions (pumps) in a post-assembly operation. This functional test not only flushes the assembled unit, but also carries out a performance test of the response and efficiency of an automised (i.e. automated with a human touch) test. A value-added feature was also included in the assembled unit during the test in the form of customer-specific pressure settings or other adjustments. Finally, the testing intelligence installed on this machine was given a customer model number by a bar code. This model number is cross-referenced to the customer order code and the hydrostatic pump is tested to ensure compliance to all customer explicit and product engineering specifications.

In the past, test machines were contracted and built outside the company. As a result, many problems surfaced over time such as reliability, replaceability and maintainability. The sophistication of the outsourced test machine design indicated a lack of understanding of what the machine needed to do, and the documentation was hard to understand and even harder to keep up to date. As production requirements increased over time, the operators realised that the current design was inhibiting the assembly/test process. Fatigue resulted from a poor ergonomic design and cycle times were lengthy as a result. Significant machine downtime began to affect critical production requirements which resulted in the delay of delivery to the customers.

Fig. 1. The old teststand in use prior to the project.