Product-oriented Approach to Productivity Gains - An Experience in Re-engineering

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Abstract

In a fast-paced technology-driven world, manufacturing companies are constantly striving for productivity gains. Pressure to do so comes in response to poor manufacturing processes, reduced government protection, increased wages for a semi-skilled workforce, and sloppy record-keeping and tracking processes.

This paper describes the challenges faced by a mid-sized company that has been manufacturing coated and bonded abrasives, super-refractories, and industrial ceramics for over fifty years in ten different locations in India. Faced with stiff competition from cheaper imports and problems with worker productivity, the company had to experiment with organizational change and develop innovative approaches to stay competitive and retain market share while simultaneously entering the global market. One division -- Bonded Abrasives – was picked to experiment with re-engineering and information technology infusion. With strong backing from senior management, the project was completed successfully with benefits as expected in reduced work-in-process inventory and lead-time to customers. A secondary benefit was a multi-skilled workforce. The company converted threats they faced and their own weaknesses into an opportunity to streamline the manufacturing processes and stay competitive. A nice by-product of this project was a change in the work culture of a large group of employees whose average longevity in the company was thirty-five years.

The project took longer to complete than expected, but the managers are now more knowledgeable and better equipped to carry forward the lessons learned and take on future challenges.

Introduction

It was necessity that proved to be the mother of re-engineering for a mid-sized company in southern India. Stiff competition from cheaper imports and lower worker productivity forced Carborundum Universal Madras, India (CUMI) to come up with an innovative approach to stay competitive. For a company with more than 2,000 employees in a developing country with rigid labor laws, this was quite a challenge. This paper describes how CUMI responded to the external and internal threats and came out ahead through a combination of re-engineering (product vs. process orientation), employee education, and change in workforce culture. Specifically, it details the implementation of a cellular manufacturing process for CUMI's bonded abrasives product line. Although the research on cellular manufacturing and implementation strategies is ample (see [1], [2], [3] for a sample), to understand the full benefits of the technique, one must study a successful implementation [4]. This implementation was especially challenging because of India's stiff labor laws and uncompromising labor unions.

Background

CUMI was founded in 1954 as a tripartite collaboration between the Murugappa Group, The Carborundum Co., USA, and the Universal Grinding Wheel Co. Ltd., U.K. CUMI currently has no foreign equity holders. The company pioneered the manufacture of coated and bonded abrasive in India in addition to the manufacture of super-refractories, electro-minerals, industrial ceramics and ceramic fibers. Today the company manufactures over 20,000 different varieties of abrasives, refractory products and electro-minerals in ten locations across various parts of the country [5].

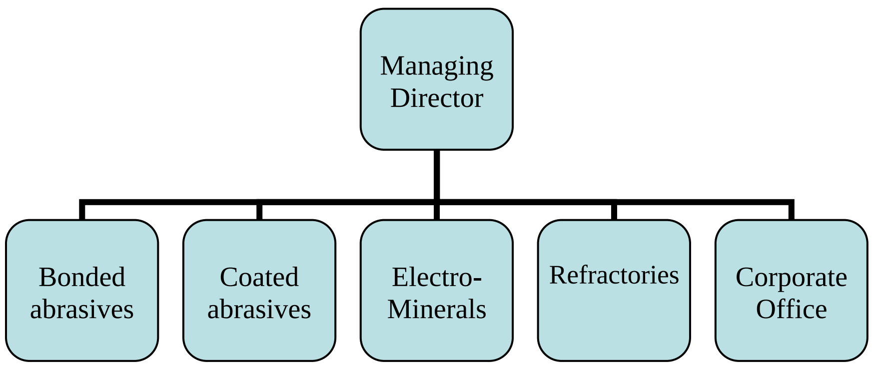

Figure 1: CUMI Strategic Business Units

As shown in Figure 1, CUMI (at the onset of this project) was organized into several strategic business units (SBU): bonded abrasives, coated abrasives, electro-minerals (manufacturing abrasive grains), and refractories. The electro-minerals division provides the raw materials needed for manufacturing abrasive products. Each SBU was headed by a Vice-President. The Vice-Presidents reported to the Managing Director. In all, CUMI employed more than 2000 employees spread across eight manufacturing facilities. CUMI also mines its own bauxite ore to produce one of the two basic raw materials needed, aluminum oxide. The SBUs were supported by a corporate office located in Chennai (formerly, Madras) which consisted of the human resource and finance divisions.

CUMI's employees are all salaried. About 1700 are unionized. New wage structures with automatic wage increases are negotiated every four years with the labor union. Thanks to good management practices and strong industrial relations, CUMI hasn't seen a strike for the past 15 years. The employees are paid well. It is not unusual for people to start and end their careers at CUMI. Employees at the factory work for an average of 35 years.

Challenges to the Bonded Abrasives division

The early 1990s brought several new challenges to the management. A careful analysis of their strengths, weaknesses, opportunities and threats (SWOT) revealed several weaknesses and threats that had to be addressed. The strengths included a strong dealer network, highly rated products, and a strong management team. The weaknesses were in the area of customer satisfaction and production operations that often resulted in large work-in-process inventories and scrap. Opportunities existed in new revenues from exports, but these were offset by threats from cheaper imports and competition from numerous small businesses. The status quo was not acceptable as CUMI had no interest in “flirting with extinction” [6]. The management decided to focus on increasing domestic market share, improving profits and entering new markets -- two of these were threats and one a new opportunity:

- **Domestic market share**. There was steady erosion in CUMI’s domestic market share. There were two main reasons for this: (1) India's new liberalized economic policy brought down tariffs and eliminated regulations that were designed to protect domestic industry. This opened the door to competition from other Asian manufacturers. (2) The rapid growth of small-scale industries that were vying for the same business. Together, these threats forced CUMI to either compete or withdraw.
- **Profits**. A second significant threat was weakening profits. For reasons mentioned above, CUMI could no longer pass on cost increases to the customer. They simply had to absorb any cost increases (material, wages etc) if they were to match the competition in price and quality.
- **New markets.** CUMI had made some initial forays into the global market (mainly the United States) and had found conditions favorable. However, there were certain obstacles that had to be overcome. The international customers expected high quality products and prompt order fulfillment. CUMI had to devise means for maintaining high quality while reducing manufacturing costs. Low worker productivity was tolerated in India, but would not be acceptable in the newly competitive arena. This required a change in the entire workforce culture. Customer satisfaction needed to be of high priority. This was measured primarily through "on-time-delivery" (OTD) of orders. Current OTD values were at a dismal 50 to 60%. In order to tap into new markets and be assured of a healthy profit margin, CUMI had to ensure both high quality products and on-time delivery of orders while lowering manufacturing costs.

Strategy for change

These challenges demanded innovative solutions. Experienced management consultants were brought in to analyze the situation. Their report coupled with several high-level corporate strategic planning meetings helped lay the foundation for CUMI's new strategy: (1) re-engineer the current production process to reduce manufacturing costs; (2) implement an integrated Enterprise Resource Planning (ERP) System to track information accurately; (3) develop and apply the Total Quality Management (TQM) approach to all aspects of the business; and (4) increase exports. Of these, the first and fourth had a direct bearing on the immediate challenges faced by CUMI. The second and third were critical for sustaining the benefits accrued from implementing the other two.

In order to implement this solution successfully, CUMI attempted a test implementation in Bonded Abrasives based on the recommendations of the consulting firm.

CUMI - Bonded Abrasives

The abrasives manufactured by CUMI are used widely in automobile, bearings, automobile accessories, engineering and other manufacturing industries. About 35% of finished goods are custom-built and shipped directly to customers. The rest are sold through a 250-member distribution network, primarily in India. CUMI had a 40% share of the Indian bonded abrasives market with major competition from one other multi-national company (also 40%). In addition, there were more than 25 small-scale industries competing for the same business. The Indian market was estimated at US $63 million with CUMI's share at US $25 million at the time.

The Bonded Abrasives division manufactures grinding wheels of varying shapes and sizes. These wheels range in diameter from 1/4" to 48". On any given day, two separate factories produce grinding wheels in all sizes and shapes as per customer orders. The Chennai factory produces a large variety of custom-built wheels in small batches, while the Hosur factory uses automated machinery to produce a smaller variety in large batches, for the retail industry. CUMI manufactures close to 20,000 different products (see figure 2).

Figure 2: Sampling of Products Manufactured by CUMI

To appreciate the value of the re-engineering process, the current production process needs to be properly understood (see Figure 3).

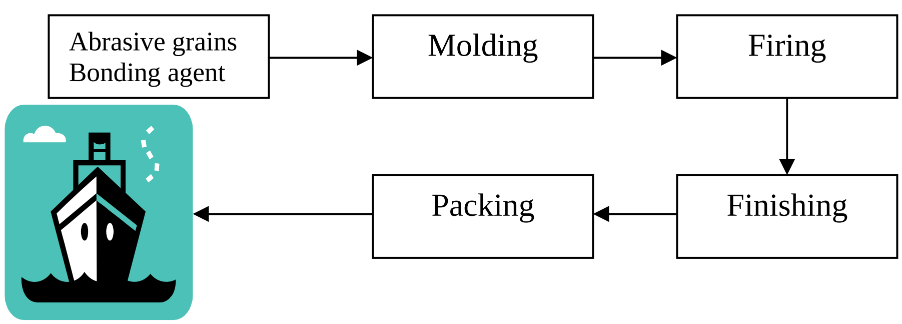

Figure 3: Original Process-oriented Approach

Aluminum Oxide and Silicon Carbide are the two major raw materials used in this industry. These are combined in varying proportions with bonding agents and then molded or pressed in hydraulic presses whose capacity is anywhere from 5 to 3000 tons.

CUMI manufactures three types of products classified on the basis of bonding materials used - vitrified, rubber and resinoid. Vitrified products are fired in kilns at 1240^{o}C. Resinoid wheels are cured in ovens at 220^{o} C while rubber bonded wheels are vulcanized. These products are then finished to the size and shape desired by the customer. The final step is labeling, packing, and shipping as ordered.

The entire operation is neatly categorized into distinct processes – hence *process-oriented.*

Weaknesses of the process-oriented approach

This approach was utilized with great success in the past. However, this system resulted in unbalanced production lines, inefficient utilization of labor, large work-in-process inventories, scrap and long manufacturing cycle time.

<u>Unbalanced production lines</u>: The major processes involved in production consist of mixing, molding, drying (for vitrified products), firing (vitrified) /curing (resinoid), finishing, packing, and shipping (see figure 3). Of these processes, mixing and molding, drying and firing, finishing, packing, and shipping were each managed by a department manager. Each department operated like an independent company with its own task-based production targets without any regard to customer needs/satisfaction. This often resulted in an unbalanced production line and poor customer service.

<u>Single skill specialists:</u> Workers were assigned to individual production departments. Their knowledge and training were limited to what was required within their departments. That is, a worker in "molding" could not be deployed in "finishing" because he was not trained in that area. There was clear demarcation of duties and responsibilities. They were single-skill specialists.

<u>Work-in-process (WIP) inventory:</u> Workers would complete their part of the process without regard to the need of the next person in the process. Supervisors set targets for finished *tasks*. The accumulation of WIP inventory did not bother the worker because productivity-linked bonuses were tied to the individual's completed task and not the finished product. The result was an accumulation of WIP inventory all along the production line. Employees had no incentive to minimize the size of the WIP inventory.

<u>Product traceability:</u> Workers had no tie whatsoever to the finished product. If a product was defective, there was no easy way of accurately identifying the source of the problem.

All of these had a direct impact on the cost of the final product. It was imperative that CUMI follow through on its strategy to stay competitive.

Implementation

The re-engineering of the current production process in Bonded Abrasives began with the following well-defined objectives: reduce WIP inventories, reduce manufacturing cycle time, balance the production line, improve product traceability, utilize labor efficiently, and increase the on-time delivery performance.

The stage was set by getting senior management behind the project. The Division Head for Bonded Abrasives was sold entirely on the project and was made the chief sponsor. It was important to have a senior manager in this position because he understood the long-term implications of the project and also had the authority to make necessary resources available, often at very short notice.

Re-engineering the production process

Although much has been written about cell (or cellular) manufacturing in the research literature [7], it is a relatively new concept in the developing world. It involves the grouping of machines, processes, and people into cells ("modules" for CUMI) responsible for manufacturing or assembly of similar parts or products, in order to build a variety of products with as little waste as possible. The technique cuts out costly transport and delay, shortening production lead time, and saving factory space that can be used for other value-adding purposes. It emphasizes production flexibility and reduces production cycles. [6] [8] [9].

The re-engineering team embraced this concept and customized it to suit their specific needs. Managers and supervisors from all levels were brought together to freely discuss ways of improving the production process. The group came up with a lot of interesting ways to reduce costs. These ideas were compiled into a novel adaptation of cellular manufacturing which was called Cellular Autonomous Production System (CAPS).

Cellular Autonomous Production System (CAPS)

During the re-engineering process CUMI determined that the product range was too broad for the current production system to handle efficiently. Regardless of the size and complexity in the manufacturing process, these products were combined into groups ("modules") based on the similarities in the manufacturing facilities needed. Products requiring similar manufacturing equipment were grouped into a module. An analysis of all 20,000 products resulted in three specific product modules. Each module had its own dedicated machines for mixing, molding, and finishing. However, as shown in Figure 4, products requiring firing were combined into a single step because building dedicated kilns for each module was not feasible.

The workers were now assigned to individual modules. They were trained to operate all the machines in their module; that is, a worker was trained to operate the mixing, molding, and finishing machines. CUMI was changing its workers from "single-skill specialists" to "multi-skilled operators". This gave the operators better control over the entire production line and a sense of ownership over the finished product.

Balancing: With the new *product orientation*, CUMI could now accomplish a more balanced production schedule [8]. Line supervisors set targets for finished *products* instead of finished *tasks*. Workers are given daily schedules that show how much production was to be expected from each machine. Scheduling is designed in such a way that there is very little work-in-process inventory at any of the machines.

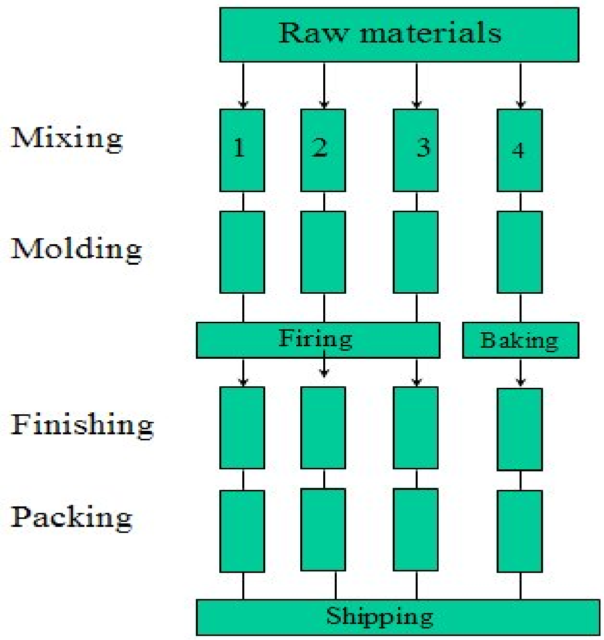

Figure 4: Product-oriented Approach Based on Cellular Manufacturing

Work-flow redesign: All machines were re-arranged to minimize the movement of work-in-process between stages. No new machines were needed. This allowed CUMI to reduce the average distance traveled by each product by roughly 30%.

Elimination of Non-value-adding activities: A work study was completed by management to eliminate non-value-adding activities. This was done either by low-cost automation or total elimination of that activity. For example, if an employee had to physically carry raw materials to the machine, a conveyor belt was added to automate the step. Under the old system, the "shaving" process was done twice, once before and once after drying. It was determined that shaving before drying was not adding any value to the finished product. The shaving after drying served the purpose adequately with no loss in quality. This was yet another factor that helped reduce the manufacturing cycle time.

Management under CAPS: The product-oriented CAPS approach is significantly different from the previous process-oriented approach. It needed a different management structure. Under the old method, there was a manager for the finishing department with several assistant managers and supervisors under him. This was also true of the mixing, molding, and packing departments.

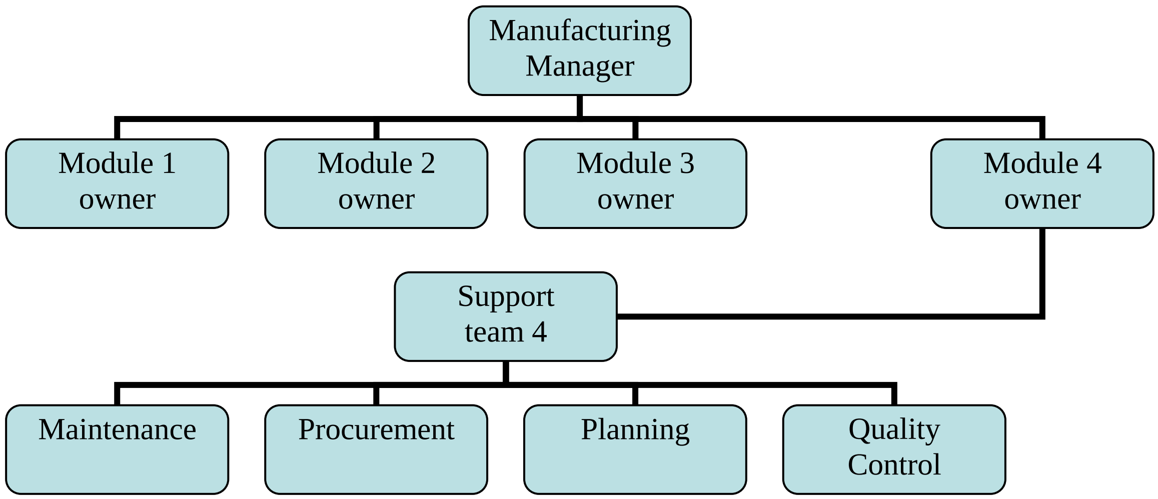

Figure 5 New Management Structure for CAPS

Under CAPS, each module has its own production facilities (except for the firing part) and a "module-owner" (see Figure 5). The owner was responsible for products from his/her group from start to finish. Each module also had a support team that consisted of specialists from procurement, maintenance, planning, and quality control. This resulted in quick response times for breakdowns and procurement needs. To eliminate conflict of interest, the quality control specialist did not report to the manufacturing manager; he reported directly to the quality control manager.

Due to the slight difference in the production process, the Resinoid product line was treated as a separate module. All modules were fully functional in three years.

Results

CUMI's experience with re-engineering was both challenging and rewarding. A series of tangible measures were used to assess the impact of the shift to a product-orientation. These include WIP inventory, scrap, delivery schedule, timeliness of order fulfillment, manufacturing cycle time and average distance travelled by each product. Table 1 summarizes the specific improvements from this project. Given that the strategic thrust was to reduce cost and improve quality, CUMI can confidently say that the effort was immensely successful.

Discussion of results

These numbers are consistent with, if not better than, the averages reported in the literature for companies in the United States [10]. The new product-orientation (CAPS) was successful in (1) creating a highly trained workforce equipped with multiple skills, (2) inculcating a sense of ownership among the employees who now take pride in their work, and (3) shifting employees from solo players to team players.

Table 1: Benefits Accrued Due to Changes in the Production Process

Measure	**Before**	**After**
Work-in-process inventory	14 to 18 days	10-11 days
Scrap	5%	2%
Delivery time promised to customer	12 to 20 weeks	8 to 10 weeks
On time delivery	50 – 60%	Exceeded 90%
Manufacturing cycle time	Dropped 50%	
Average distance travelled by each product	Dropped 30%	

A key success factor for this project was "senior management buy-in." The senior managers were all very supportive. A Vice President was designated to oversee the whole project. This individual was responsible for dealing with conflicts, making sure teams were motivated and on-task and releasing/finding resources as needed.

Besides strong leadership, the gains from CAPS came from reduction and/or elimination of several unproductive tasks, automation of simple tasks (use of conveyor belts, for example), redesign of workflow, and better utilization of the existing workforce. All of these led to lower costs of manufacturing and higher productivity levels. They did not come from increased physical effort or reduced workforce or even new machinery.

The whole exercise was not without its pitfalls. The re-engineering process was only one of several changes attempted by CUMI. Other activities included a focus on Total Quality Management, a shift to an Enterprise Resource Planning system (to facilitate better traceability), and several work-force culture changing tactics. These impacted employees across the board with many requiring training in keyboarding and computer literacy.. The consequence was a delay in the implementation schedule – the project took twice as long as expected to complete.

Conclusion

CUMI's Bonded Abrasives division successfully completed a re-engineering project that resulted in the refocus of the manufacturing operation from a process to a product orientation. The company converted the threats and weaknesses it faced into an opportunity to streamline the manufacturing processes and now is better prepared to face future threats without major investments in new machinery. A by-product of this project was a change in the work culture of a large group of employees. In spite of the shortcomings alluded to above, the whole project brought valuable change to CUMI.

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Biography

VICTOR RAJ is an Associate Professor in the Department of Computer Science and Information Systems at Murray State University. His research and teaching interests are in the area of database design, software design, project management, optimization and the open source movement. He has published in the area of Knowledge acquisition, Decision Support, Business Expert Systems and more recently in the area of Social Networking.