2006-512: WORKING WITH SMALL COMPANIES IN CAMBODIA TO TEACH LEAN MANUFACTURING PRINCIPLES TO UNDERGRADUATE STUDENTS

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Introduction

Teaching lean manufacturing in the university environment is becoming more common, with many schools in the United States offering "lean" undergraduate courses in various technology and engineering programs. This trend is driven by companies who have implemented or are trying to implement lean as a manufacturing strategy, and who prefer graduates with some level of practical lean knowledge. Our approach to teaching lean has used experiential learning as a method of improving student understanding, as many others have done in various disciplines[1-4]. To this end we have augmented university classroom lectures with industry-based projects, recognizing that lab exercises are useful, but can have limited utility in demonstrating lean principles[5]. We have used this approach for a number of years in two graduate courses. And more recently we used this method in the context of an international internship in Cambodia, during the summer of 2004. The experience gained in that internship is the focus of this paper.

Five junior and senior level students and two professors were involved in a five week project, where the first three weeks were spent gathering information about the challenges and opportunities of running a manufacturing company in Cambodia. A total of 37 companies were surveyed on a variety of topics, including the practical details of operating their businesses, of which most were small, family-run concerns. After completion of the initial three-week phase of studying the practical, social, and historical difficulties they face in this developing country, two small firms were chosen for a more in-depth study of manufacturing performance. The exercises that were carried out at these firms, and the results of evaluations conducted by 5 undergraduate students, will be discussed as a method for teaching lean manufacturing principles. Some background on the companies with whom we worked and a discussion of the business environment in Cambodia will also be provided. The entrepreneurial spirit and determination we found in these companies was a great lesson for us and our students, demonstrating that hard work and creativity can produce good results, even in difficult circumstances.

Evaluation of Manufacturing Performance: Two Small Companies

Two small companies of about 40 to 50 employees were the focus of our efforts during a period of about 8 days of evaluation. This time frame proved to be a little short, because we were just beginning to gain the trust of the owners at the end of our stay. We believe another week or two of effort would have allowed us to implement some of the changes we proposed. We will present a discussion of the efforts of our students to gather and analyze data, which will be followed by a summary of the recommendations for improvement that they provided to these companies.

1. Case #1 - Motorcycle Inner Tube Manufacturing

Background

This family-owned business has been operating for about 6 years and is led by a father and two sons. They produce inner tubes for motorcycles and sell them to wholesale suppliers in Phnom Penh, who then distribute their products to the rest of the country. At one time they did have a local competitor, but they believe that inferior machinery and poor product quality caused it to go out of business. Now their only competition is from tubes imported from Vietnam. They credit their success to producing a quality product at a low cost.

Since 1966 Son Phath, the main owner of the business, was a primary school teacher. His life was spared during the Khmer Rouge regime because he could make fishing nets, an ability that was valued at the time. After the Pol Pot era one of his sons had an idea that the family should move to Phnom Penh, where he had seen a rubber manufacturer and thought they could open their own plant. They started by making bicycle tires, but the quality was poor and their business did not succeed. One of his sons started selling raw rubber to Vietnam and in the process became familiar with an inner tube factory there. Son Phath sent his son to Vietnam to learn their methods and he returned with the knowledge he needed to make higher quality rubber. However, they lacked capital to open a new business by themselves, so the extended family contributed what they had in order to get their current operation off the ground. This family business, which we visited during the summer of 2004, appears to be doing very well. The plant that they built is essentially a copy of the factory where Son Phath's son had spent time in Vietnam. And all of the chemicals that they use in their production processes are imported from Vietnam.

They employ thirty-eight employees at their plant and have an annual employee turnover of about ten percent. One of the challenges that they currently face is competition from low-priced, foreign imports. Corruption of the government was the reason cited for this problem, where foreign imports are sometimes allowed to enter the country without being taxed whereas this company had to pay taxes on raw material as well as excessive "fees" charged by government officials. The untaxed imports drive down prices and result in lower profits. When asked what they needed to succeed as a business, we were told that the government needs to make and uphold laws that keep the playing field level for everybody.

Another interesting thing we observed was the strong relationship of trust these entrepreneurs developed with their suppliers and customers. We were told that sometimes their wholesale customers do not have enough money to pay them for the inner tubes they take. A customer once wrote them an I.O.U. for $2,000 USD; however, they did not worry, because their customers have never failed to pay them. In similar fashion, their suppliers will send them raw material without immediate payment. Thus, even though corruption and dishonesty is a serious problem, a high level of trust seems to exist between companies in the industrial sector.

Inner Tube Manufacturing Plant

The manufacturing process begins with raw rubber, which is placed in a rolling machine, shown in Figure 1.

Figure 1. Processing raw rubber at the beginning of the process.

Chemicals are added, including carbon, and the rubber is kneaded several times and then extruded through a die. The extruded product is further worked in a different machine, where sulfur is added, and then it is rolled into sheets. The sheets are cut into strips approximately 6 inches wide and then each strip is put through a machine which extrudes the material into a tube, as seen in Figure 2.

Figure 2. Rubber sheet is extruded into tubes. One of the students is seen feeding the machine.

The tube ends are then welded together and inspected for defects, as seen in Figure 3.

Figure 3. Inspection of welded inner tube and preparation for stem insertion.

Then the stem is inserted and the tubes are inflated and cured in steam-heated presses. Finally, the guts of the valve are inserted and the finished product is packaged into boxes.

Analysis and Recommendations by Students

Students computed average cycle times for each process in order to analyze the line balance and to determine the bottleneck operation. Based on their observations the valve stem insertion was the bottleneck, with a cycle time of about 12 seconds, which corresponds to a daily capacity of about 2400 tubes. This estimate was reasonable when compared to the owners' claim that their average daily production was about 2000 tubes, or 83% of theoretical capacity. We recognized that this level of performance is actually quite good. It should be noted that the students thought this factory was one of the best organized operations they visited in Cambodia. However, they still found some areas for improvement. For example, the distance between individual processes was significant, causing wasted motion and lost time in moving parts between stations. The students proposed moving the equipment between the extrusion machines and the curing processes closer together, so that batch sizes could be reduced and wasted motion could be eliminated. They proposed a revised factory layout showing new locations of equipment and a slightly different path for material flow. When the father/owner was presented with these ideas he accepted them readily and was willing to implement the proposed changes. In fact, the students and faculty assisted him in moving equipment one morning near the end of the project so that a trial could be done with the new layout. However, one of his sons intervened before the trial began and we had to move the equipment back to the original locations. The students were a little discouraged that we were not able to put their suggestions into action. However, this was a reasonable lesson in the difficulty of getting ideas implemented, which is something they will face when they graduate and start their careers. A detailed report was given to the owners with clear drawings of the new factory layout, as well as some other suggestions, which we hope they may find useful at some point. They seemed to be grateful for our efforts.

2. Case #2 - Fabrication of Metal Tables and Racks

Background

Mam Putheavy started her manufacturing company in 1994. Her plant was one of the first in Phnom Penh to manufacture metal products such as tables, clothing racks, and cabinets. She orders raw material from Thailand, which is where she learned how to manufacture these products. She would like to increase the size of her plant; however, competition in Phnom Penh has made expansion risky. From the time that Putheavy's company began to manufacture tables it took about one year for other companies to begin to copy her products. The copycat mentality has made it difficult to find a market that enables her to gain a competitive advantage. While the demand for her product is reasonably good, there are two main things she sees as roadblocks to her success. The first one is that many Cambodian people feel that foreign products are made with better quality. She claims this is especially frustrating because her product has the same quality, or in some cases better, while costing less than the foreign product. The second is the competition she faces in the market. The impetus for innovation is lost when products can be copied so quickly, and when there is essentially no legal protection or patent rights. In addition, she also is faced with occasional visits from government officials that request "fees" for her to remain in business. While she claimed she often did not pay these fees, as she knows many of the requests are bribe demands, the real and potential impact on her company is real. While she remains optimistic and willing to improve her company the market seems to have reached equilibrium for now.

Metal Table Fabrication Plant

Table fabrication starts with cutting of metal tubing to various sizes. This is done in batch mode, as shown in Figure 4.

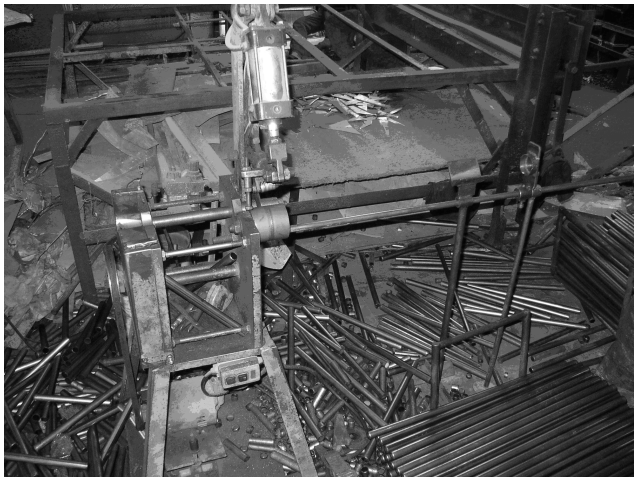

Figure 4. Cutting of metal tubing used for table fabrication.

In parallel, pre-cut blanks are loaded into a manual hydraulic press where the table top is formed into circular or rectangular shapes. The press is shown in Figure 5.

Figure 5. Manual hydraulic press used for forming metal table tops.

The metal tubes are then bent and welded into a frame (Figure 6), using fixtures made for each style of table, of which there are four: circular and rectangular tables in small and large sizes.

Figure 6. Welding tubes into table frames using fixtures.

The frames and tabletops are treated chemically, then powder-coated, assembled, and packaged.

Analysis and Recommendations by Students

In order to better understand the movement of materials through the production line, cycle times were taken at each of the individual processes on the shop floor. The bottleneck process proved to be the table top forming, which cycled at about 8 minutes. This equates to a capacity of about 60 tables per day, which is higher than average demand of around 40 tables per day. So rather than focus on decreasing the cycle time of the bottleneck, the students focused on the factory layout. The poorly organized material flow made it impossible to implement single piece flow, or small batch production, because consecutive processes which were often far apart. Therefore, the students proposed a new layout, where material flow was clearly more organized amenable to small batch processing. Another recommendation by the students was to implement 5S (sort, set

in place, shine, standardize, sustain). The haphazard storage of raw material and the clutter of unused parts and equipment made the shop floor an unpleasant and potentially dangerous place to work. A report was given to the owner with a detailed explanation of their suggestions. They had a discussion with her prior to our departure and she appreciated our work. However, she felt she needed to find a larger building before she would consider changing the layout. We thought this missed the point and we would have liked to stay a little longer, to educate the owner more on some basic principles of lean manufacturing. However, we believe that some of the things we discussed may have planted the seeds for future improvement. Though the owner was quite a strong-minded woman, she was reasonably open to at least having a discussion about the changes that could be implemented to improve her plant operation.

Discussion and Future Plans

The project we carried out in Cambodia was beneficial in several ways. It gave us experience in planning and doing an internship in a developing country. And it provided the students with a multi-cultural experience, in addition to the opportunities they had to study manufacturing operations of various small companies and to propose improvements in the context of lean manufacturing. The cost of this type of internship is relatively high, making it difficult to sustain without some form of permanent funding.

However, we think there are some important benefits to this kind of learning experience. The students are able to see a variety of operations and products during the course of the project, which is usually not the case in a company-paid internship. They are also more likely to see problems that are not directly related to their discipline, such as those involving infrastructure, government policy, culture, and traditions, all of which impact company performance. This kind of an experience can also provide some benefit to the companies themselves. Small manufacturing firms are especially important to the success of the economy of a developing country, and any help that can be given to these firms will be beneficial to the growth of the country and its economy. Therefore, despite the cost and the large time commitment by faculty, we plan to pursue country-focused internships, like the one we did in Cambodia, from time to time. The experience we had there was educational, inspirational, and memorable.

We would also like to develop an international internship program that is sustainable over time. As a result, we have begun to implement a model of company-paid internships in more developed countries like China and the Philippines. These types of internships are more easily sustainable, because companies that want our students for their expertise will pay for their travel and lodging, and provide them with a modest salary during a stay of 3-6 months. In addition, faculty do not have to be on-site when the internships are carried out, although we are involved in finding companies and locations where our students will have good experiences and will be safe during their stay.

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