LEAN PRODUCTION: FINAL ASSEMBLY PLANT (THE MACHINE THAT CHANGED THE WORLD – 55-58)

Ohno's rethinking of final assembly shows just how this new approach to human resources paid enormous dividends for Toyota. Remember that Ford's system assumed that assembly-line workers would perform one or two simple tasks, repetitively and, Ford hoped, without complaint. The foreman did not perform assembly tasks himself but instead ensured that the line workers followed orders. These orders or instructions were devised by the industrial engineer, who was also responsible for coming up with ways to improve the process.

Special repairmen repaired tools. Housekeepers periodically cleaned the work area. Special inspectors checked quality, and defective work, once discovered, was rectified in a rework area after the end of the line. A final category of worker, the utility man, completed the division of labor. Since even high wages were unable to prevent double-digit absenteeism in most mass-production assembly plants, companies needed a large group of utility workers on hand to fill in for those employees who didn't show up each morning.

Managers at headquarters generally graded factory management on two criteria—yield and quality. *Yield* was the number of cars actually produced in relation to the scheduled number, and *quality* was out-the-door quality, after vehicles had defective parts repaired. Factory managers knew that falling below the assigned production target spelled big trouble, and that mistakes could, if necessary, be fixed in the rework area, after the end of the line but before the cars reached the quality checker from headquarters stationed at the shipping dock. Therefore, it was crucial not to stop the line unless absolutely necessary. Letting cars go on down the line with a misaligned part was perfectly okay, because this type of defect could be rectified in the rework area, but minutes and cars lost to a line stoppage could only be made up with expensive overtime at the end of the shift. Thus was born

the "move the metal" mentality of the mass-production auto industry.

Ohno, who visited Detroit repeatedly just after the war, thought this whole system was rife with *muda*, the Japanese term for waste that encompasses wasted effort, materials, and time. He reasoned that none of the specialists beyond the assembly worker was actually adding any value to the car. What's more, Ohno thought that assembly workers could probably do most of the functions of the specialists and do them much better because of their direct acquaintance with conditions on the line. (Indeed, he had just confirmed this observation in the press shop.) Yet, the role of the assembly worker had the lowest status in the factory. In some Western plants, management actually told assembly workers that they were needed only because automation could not yet replace them.

Back at Toyota City, Ohno began to experiment. The first step was to group workers into teams with a team leader rather than a foreman. The teams were given a set of assembly steps, their piece of the line, and told to work together on how best to perform the necessary operations. The team leader would do assembly tasks as well as coordinate the team, and, in particular, would fill in for any absent worker—concepts unheard of in mass-production plants.

Ohno next gave the team the job of housekeeping, minor tool repair, and quality-checking. Finally, as the last step, after the teams were running smoothly, he set time aside periodically for the team to suggest ways collectively to improve the process. (In the West, this collective suggestion process would come to be called "quality circles.") This continuous, incremental improvement process, *kaizen* in Japanese, took place in collaboration with the industrial engineers, who still existed but in much smaller numbers.

When it came to "rework," Ohno's thinking was truly inspired. He reasoned that the mass-production practice of passing on errors to keep the line running caused errors to multiply endlessly. Every worker could reasonably think that errors would be caught at the end of the line and that he was likely to be disciplined for any action that caused the line to stop. The initial error, whether a bad part or a good part improperly installed, was quickly compounded by assembly workers farther down the line. Once a defective part had become embedded in a complex vehicle, an enormous amount of rectification work might be

needed to fix it. And because the problem would not be discovered until the very end of the line, a large number of similarly defective vehicles would have been built before the problem was found.

So, in striking contrast to the mass-production plant, where stopping the line was the responsibility of the senior line manager, Ohno placed a cord above every work station and instructed workers to stop the whole assembly line immediately if a problem emerged that they couldn't fix. Then the whole team would come over to work on the problem.

Ohno then went much further. In mass-production plants, problems tended to be treated as random events. The idea was simply to repair each error and hope that it didn't recur. Ohno instead instituted a system of problem-solving called "the five why's." Production workers were taught to trace systematically every error back to its ultimate cause (by asking "why" as each layer of the problem was uncovered), then to devise a fix, so that it would never occur again.

Not surprisingly, as Ohno began to experiment with these ideas, his production line stopped all the time, and the workers easily became discouraged. However, as the work teams gained experience identifying and tracing problems to their ultimate cause, the number of errors began to drop dramatically. Today, in Toyota plants, where every worker can stop the line, yields approach 100 percent. That is, the line practically never stops! (In mass-production plants by contrast, where no one but the line manager can stop the line, the line still stops constantly. This is not to rectify mistakes—these are fixed at the end—but to deal with material supply and coordination problems. The consequence is that 90-percent yield is often taken as a sign of good management.)

Even more striking was what happened at the end of the line. As Ohno's system hit its stride, the amount of rework needed before shipment fell continually. Not only that, the quality of the shipped cars steadily improved. This was for the simple reason that quality inspection, no matter how diligent, simply cannot detect all the defects that can be assembled into today's complex vehicles.

Today, Toyota assembly plants have practically no rework areas and perform almost no rework. By contrast, as we will show, a number of current-day mass-production plants devote 20 percent of plant area and 25 percent of their total hours of effort to fixing mistakes. Perhaps the greatest testament to Ohno's ideas

lies in the quality of the cars actually delivered to the consumer. American buyers report that Toyota's vehicles have among the lowest number of defects of any in the world, comparable to the very best of the German luxury car producers, who devote many hours of assembly-plant effort to rectification.