The Monument of Monuments

Lean thinkers call a "monument" any machine which is too big to be moved and whose scale requires operating in a batch mode. (They would apply the same term to a hub airport, a centralized computer system, or a centralized engineering department—to anything that requires batches to operate and can't be moved as the value stream changes.) Because continuous improvement and changing processing requirements require the continuous movement of machines, monuments are evil, another form of *muda*.

The monument in question in North Haven was the massive, $80 million complex of twelve Hauni-Blohm blade grinding centers, custom-made in Germany and installed in 1988 as Pratt attempted a high-tech leap over its competitors. The idea had been very simple: Totally automate the grinding of the blade roots for turbine blades using the world's fastest and most sophisticated equipment.

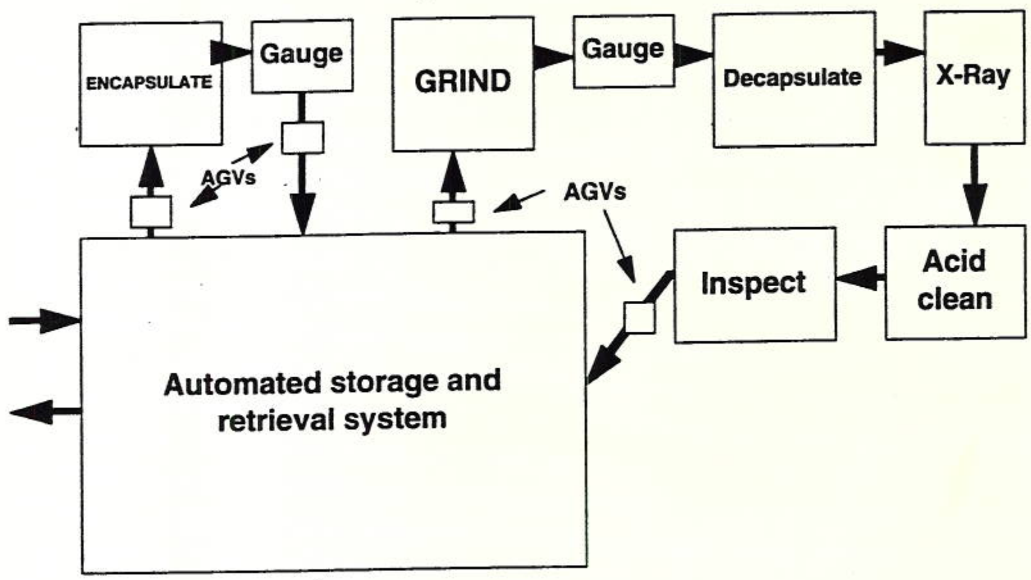
Prior to the late 1980s, North Haven had placed each blade in a series of nine grinding machines for a total processing time of eighty-four minutes. The objective was to grind smooth the base of each turbine blade so it would snap snugly into the disc holding it in the engine. This approach was labor-intensive, due to direct labor needed to watch machines, conduct frequent gauging, and position parts in machines. In addition, indirect effort was needed to move parts from machines to storage areas and then to the next machine, now located some ways away in the degraded "flow" system.

The new system used twelve massive grinding centers with twelve axes of motion. Each center could perform all of the grinding steps formerly accomplished by nine machines and could grind a blade in only three minutes. What was more, the centers were fed and unloaded robotically and the parts were carried to and from storage by an automated guided vehicle (AGV). No direct or indirect hourly labor was required.

Still, there were problems. The forces applied to the blade by the grinders were so severe that the blade was destroyed if held by standard positioning fixtures which concentrated the tremendous forces at a few points on the blade. Therefore, it was necessary to encapsulate the blade, excepting the area to be ground, in a low-temperature alloy to spread the forces evenly over the whole blade. Encapsulation, conducted by a machine with a large vat of liquid metal, expensive molds, and long changeover times, was a batch process, so it was necessary to take the encapsulated parts to a storage area until they were needed by the Blohm machines. This task was handled by AGVs and an automated storage and retrieval system. (ASRS, as it was called, was identical in concept to the system Toyota tried in its Chicago warehouse, as described in Chapter 4.)

There was another problem, which was that the low-temperature alloy had to be removed from the blade after the grinding operation. Several sophisticated steps were then required to ensure that the alloy was truly removed. (Even microscopic amounts of the alloy would cause hot spots and rapid failure of the blade once in the engine.) These involved X-rays and an atomic absorption process using caustic chemicals to test for trace elements of alloy. This last step created a serious environmental problem of radioactive acids as well. The system as it was installed is shown in Figure 8.4.

FIGURE 8.4: AUTOMATED BLADE GRINDING CENTER



Yet another problem was the changeover times needed for the Blohm grinders to convert from one family of parts to another. Because of the need to move layer after layer of automation away from the grinding tool in order to change it, eight hours were needed for every changeover. The planners of the system apparently believed that extremely long runs of parts would be possible—permitting completely automated mass production—but in practice Pratt needed to make small numbers of a wide variety of blades. The long changeover times prevented this and required the production of large batches of each part type instead.

Finally, many of the direct and indirect hourly workers had to be replaced by skilled technicians who debugged the elaborate computer system controlling the entire process (with two thousand parameters). In the fall of 1993, when Ed Northern arrived, there were twenty-two technicians tending to the needs of the Blohms, a number not much smaller than the number of direct workers needed for the old manual system.

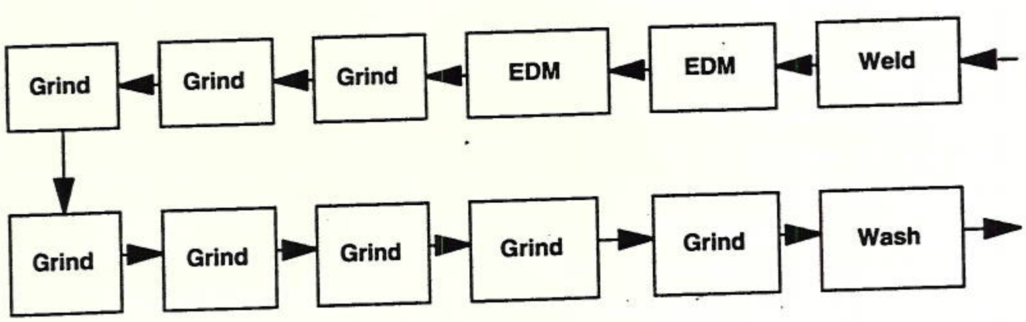
In the end, eight of the nine processing steps involved in the new system, plus the AGVs and the ASRS, added no value whatsoever. What was more, the three minutes of grinding time were accompanied by ten days of batch-and-queue time to get from the beginning of the encapsulation process to the end of the deencapsulation process. And the complex machinery was temperamental. Even at the end of a lengthy learning curve, it was difficult to get past about an 80 percent yield. A disappointing result from an $80 million investment.

We mention the Blohm grinders because they exemplify a whole way of thinking which is now obsolete. The twin objectives of speeding up the actual grinding—what you might think of as a "point velocity" within a lengthy process[36]—and the desire to remove all hourly workers because of their "high" cost per hour both miss the fundamental point. What counts is the average velocity (plus the length of the value stream) and how much value each employee creates in a typical hour. (We'll return to this point in the next chapter when we discuss German "technik.")

Initially, North Haven tried to work around the Blohms, placing their step in the turbine blade fabrication process behind a "curtain wall" so it would not interfere with single-piece flow in the rest of the process. But this was difficult. The great majority of the cost in the total process was caused by the Blohms, and their erratic performance thwarted attempts to achieve smooth flow in the rest of the process. They needed to retire.

By late 1994 the process mapping team at North Haven had the answer. They proposed to replace each Blohm machining center with eight simple three-axis grinding machines utilizing ingenious quick-change fixtures to hold the blades firmly in the machines without the need for encapsulation.[37] Each cell would have one worker to move parts from one machine to the

FIGURE 8.5: LEAN BLADE GRINDING SYSTEM



Cell with eight 3-axis grinding machines and two electrostatic discharge (EDM) machines (drawn to larger scale than Figure 8.4)

next by hand, standardize his or her own work, gauge parts to check quality, change over each machine for the next part type in less than two minutes (with the help of a roving changeover assistant), and make only what was needed when it was needed.

By increasing actual processing time from three minutes to seventy-five minutes, the total time through the process could be reduced from ten days to seventy-five minutes. Downtime for changeovers could be reduced by more than 99 percent (as each of the nine machines was changed over just-in-time for the new part coming through). The number of parts in the process would fall from about 1,640 to 15 (one in each machine plus one waiting to start and one blade just completed). The amount of space needed could be reduced by 60 percent. Total manufacturing cost could be cut by more than half for a capital investment of less than $1.7 million for each new cell. No encapsulation; no AGVs; no automated storage warehouse; no deencapsulation with its environmental hazards; no computer control room with its army of technicians. Lean thinking at its best, as summarized in Table 8.1.

TABLE 8.1: LEAN VERSUS MONUMENTAL MACHINING

	AUTOMATED BLOHM GRINDER	CHAKU-CHAKU CELL
Space/product cell (sq. ft.)	6,430	2,480
Part travel (ft.)	2,500	80
Inventory (average per cell)	1,640	15
Batch size (number of blades)	250	1
Throughput time (sum of cycle time)	10 days	75 min.
Environmental	Acid cleaning & X-ray	No acid, no X-ray
Changeover downtime	480 min.	100 sec.
Grinding cost per blade	1.0 X*	0.49 X*
New blade type tooling cost	1.0 X*	0.3 X

* The exact numbers are proprietary. The point is that the cost of blade grinding has been cut in half, and the cost of tooling for a new part has been reduced by 70 percent.

When the first of the new cells—called *chaku-chaku*, meaning "load-load" in Japanese—went into operation at the beginning of 1996, North Haven was on its way to a cost and quality position, using a high-wage, high-seniority workforce with "simple" machines in a World War II vintage (but immaculate) building, that no one in the world could match.

The latter fact led to the final step of Ed Northern's strategy. He knew that lean thinking would continually free up more workers and resources. Unless he proposed to continuously hand out termination notices and explain to his work teams why they should continue to put their hearts into working for a company with no apparent interest in protecting their jobs,