THE TANGIBLE BENEFITS OF TRUE QUALITY

Presented by: Mori Seiki U.S.A., Inc.

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THE MACHINE TOOL COMPANY

When faced with the development of a highly competitive global market, a world-leading aerospace manufacturer reevaluated its approach to quality, and designed a proactive system for eliminating the myriad of costs arising from its previous, traditional approach.

QPM Aerospace operates two state-of-the-art production facilities in the Pacific Northwest. The company is a perfect picture of success in a time of unprecedented challenges. While some American manufacturers have lost work to foreign countries with cheap labor, QPM has actually won jobs back from overseas competitors. The company is currently achieving 60% annual growth and has seen annual sales increase from $300,000 to $30,000,000 in just 10 years. These figures demonstrate the success that would not have been possible without dramatically shifting its philosophy on quality.

Determining Quality-Related Costs

Many manufacturers mistakenly assume the absence of any significant quality issues as long as their customers' standards are met. Contrary to this traditional way of thinking, study of QPM illustrates that the substantial benefits of a comprehensive approach to quality apply to all manufacturers, not just those struggling to meet their customers' quality requirements.

When determining the hidden costs of your current approach to quality, one of the first areas to consider is that of internal defect rates. While any successful manufacturer will know the current external defect rates of its operations, internal defect rates are typically of much less interest and sometimes are ignored altogether. It is important to realize that while internal defects may be unlikely to cause the loss of a customer, they still can exert a significant negative influence over your operations. While there is no hard and fast formula for determining the effect of internal defects, a quantifiable assessment can be obtained through detailed analysis focusing on the following individual costs:

- **How much do I pay for materials that are lost to scrap?**
- **How many labor and machining hours are wasted on defective parts?**
- **What are the costs of rework and the additional inspection required to ensure no external defects?**
- **When scrap occurs, how much does it cost to regain my schedule through overtime labor and expedited freight?**
- **How much am I spending to identify internal defects via Quality Control operations?**

Thanks to its unique approach to quality, QPM experiences virtually zero costs related to the above questions. Furthermore, this allows the company to provide extremely positive answers to the following questions as well.

- **Are my processes stable enough to achieve reliable and efficient automation?**
- **How quickly can I identify potential issues within my manufacturing processes?**
- **Once identified, are issues resolved before they become actual problems?**

QPM addressed these questions head on in its drive to maximize quality. Any manufacturer looking to improve their responses to any of the above questions would do well to study the model QPM has established.

A Solution That Didn't Exist

In the late 1990's, QPM Aerospace approached quality in the same way as most American manufacturers. Like the majority of its peers, the company operated an internal quality control department to identify and react to defective parts before they could reach a customer. Less than a decade later, QPM consistently achieves levels of quality nearly unheard of in the industry, yet the company no longer operates a dedicated quality control department. To understand the effectiveness of QPM's current system, it is necessary to examine the weaknesses of the traditional approach to quality.

QPM's previous quality efforts should sound very familiar to many manufacturers. After a batch of parts was machined, it would be sent to the quality control department for inspection. If the parts fell within a customer's specifications, they could be shipped out. When the necessary specs were not met, a part would have to be either reworked or scrapped entirely, and it would fall to the quality control department to determine what had gone wrong in the process.

The reactive nature of a traditional approach to quality is its most obvious shortcoming. While the system can effectively prevent the shipment of defective parts to customers, it does little to nothing to prevent the internal costs associated with their occurrence. When a part must be reworked or scrapped, it clearly generates additional expenses through labor, materials and the effects of inefficiency on other parts being produced.

Furthermore, by relegating the identification of manufacturing defects to a separate department, a company often makes the cause of such defects much harder to determine. By the time the quality department investigates the source of the problem, the conditions at the machine may have changed too much for it to be identifiable. The greater the amount of time that passes between machining and inspection, the greater the odds that the quality department will be unable to locate any flaws in the manufacturing process. In many cases, such problems can only be identified by searching for a pattern over time, with the company incurring additional waste and expense with each subsequent occurrence of a defect.

In addition to direct costs, the effects of a traditional approach to quality can significantly add to a company's complexity and inefficiency. Knowing that defects will occur, a manufacturer will typically produce an overage of parts and maintain a running inventory to ensure timely delivery. The management and maintenance of an inventory system to satisfy customers with hard and fast deadlines will complicate operations and generate additional costs.

The costs of maintaining inventory were especially high for QPM. The company produced batches of parts larger than its customers' orders, to both minimize the effect of potential defects and reduce inefficiency resulting from the long setup times required by many of its jobs. Because of the high costs of the aerospace components it manufactured, QPM's inventory made the company vulnerable to incurring substantial expenses if a customer made significant modifications to a part.

Mike Dunlop, President of QPM Aerospace, recognized the problems inherent to the industry's approach to quality and wished to eliminate them from the company.

"As the complexity of your operations increases, it becomes much more difficult to effectively track what's going on within your business," says Mr. Dunlop. "Hidden costs develop and they are very difficult to unearth with a traditional approach to quality. At QPM, we had a vision for a much more proactive method. Unfortunately, the tools did not yet exist to make that vision a reality."

The Impetus for Change

Historically, suppliers to the aerospace industry had faced nearly no demand for substantial price reductions. While successful manufacturers would avoid inefficiency, long contracts with set prices allowed them to survive without actively hunting it down and eliminating it. At the close of the 1990's, aerospace manufacturers began to face the first demands for decreased pricing from their customers. That trend increased dramatically in 2001.

While 9/11 affected the whole of manufacturing, it had particularly strong reverberations throughout the aerospace industry. As the airlines lost money, an immediate and strong demand for reduced costs trickled through the rest of the industry. The threat of cheap labor and foreign competition loomed large, and a substantial amount of work began moving towards overseas competitors.

QPM recognized that minimizing the cost of labor per part would prove the most effective means for combating offshore competition. The company had some experience in palletizing operations, but overall, its machining processes lacked the stability to implement full-scale automation.

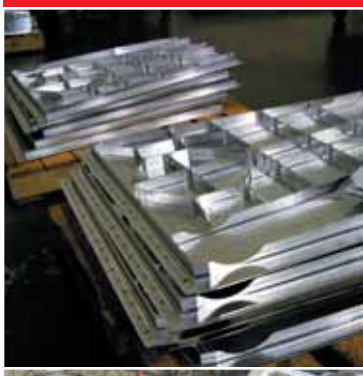
"There was no way we could compete with the low labor costs of overseas manufacturers," says Mr. Dunlop. "On the other side of that coin, that was really their only advantage. If we could level the playing field on labor costs, we knew that we once again would be at a competitive advantage."

For QPM, the choice became clear. The company could take action to stabilize its processes and implement automation, or it could watch jobs slowly make their way across the Pacific Ocean. The company searched extensively for a product that would help achieve total process stability. Finding none, QPM took its fate into its own hands.

The Power of Information

Like most within its industry, QPM's old quality system operated on a go/no-go basis. When parts were inspected, it was determined whether or not a customer's specifications were adequately met. If so, the part would be considered a 'go' and then shipped off to the customer. If a part failed to meet the necessary requirements, it would be labeled a 'no-go' and scrapped or reworked, as appropriate.

Perhaps the greatest deficiency of a go/no-go system is that it only recognizes and responds to deviations so severe as to render a part unusable to the customer. In other words, by the time a problem is identified, it has already cost the company money. It is obviously far more advantageous to reveal changes within the manufacturing process before they cause



variation beyond what is acceptable to the customer. To do this, a system needs to track deviations that are a mere fraction of the allowable tolerances. It also must contain the ability to analyze this data in a meaningful way, uncovering the potential for fatal defects before they occur.

As a first step in its efforts to redesign its quality efforts, QPM sought a way to collect and organize the massive amounts of internal data traditionally ignored by manufacturers. In the past, the quality control staff would make no notation of a part's measurements, but merely mark it as a 'go' or 'no-go' and discard the information. QPM realized the inherent value of this lost data and harnessed technology to manage it.

"The capabilities of the Internet had just begun to evolve when we were revising our quality system," says Mr. Dunlop. "I have a background as a software engineer, so I started looking at ways to capitalize on the new technology. These efforts resulted in the creation of our net-inspect™ software."

net-inspect is the end effect of six months of intensive software design by QPM. The system begins by harvesting all of the information previously discarded in traditional manufacturing operations. Measurement instruments such as height gauges, calipers and micrometers are outfitted with wireless data-transmission devices. As the specifications of each part are measured, the data is automatically relayed to the software, where it is saved for analysis.

While the software in and of itself would have proved a valuable tool, QPM wanted to ensure that it received the highest possible benefit from its efforts. If net-inspect were used in a quality control department, it would aid in the identification of trends leading up to the production of a defective part, but the process would still be reactive. The company hoped to enact a proactive system that would eliminate errors before they happened. To achieve this goal, QPM decided to eliminate its quality control department and move the responsibility of part inspection to the actual machine operators.

By placing computers and wireless-equipped measurement devices at each workstation, QPM planned to attain real-time evaluation of its machining processes. As soon as a part was machined, the operator would take its measurements, which would automatically be fed into net-inspect. That data would populate an Internet site and instantaneously show where the part's specifications fall on a control chart. This would allow for any deviation in the process to be recognized immediately, long before it evolved to the point of causing a part to be out of spec.

With a plan for its vision in place, QPM began the process of reorganizing its shop. One of the foremost challenges would be shifting the philosophy of its employees and convincing them to embrace the change. Tangible benefits would play a large role in gaining full adoption of the new system.

Solving Old Problems

Because of its nature and scope, the successful implementation of net-inspect required complete buy-in from every level of the company. Initially, some employees were resistant to the change. Proper use of the system would expose a mistake to every level of the company. It was vital to demonstrate that net-inspect was created to help the employees, not police them.

"QPM prides itself on possessing a motivated and talented workforce," says Mr. Dunlop. "We have always had an attitude that focuses on perfection and finding the best way of doing things instead of the easiest. It was of the utmost importance that our employees realize that net-inspect was a tool developed to make their jobs easier."

As soon as it was implemented, net-inspect began providing value to QPM and its machine operators. On one specific job, the company was machining an aerospace component from copper beryllium. QPM had experienced sporadic problems with the part, which required a tolerance of .00025". From time to time, an entire batch of parts would be produced out of spec and have to be scrapped. The resulting costs of materials and lost machining time were unacceptable. Additionally, without locating the precise source of the problem, the company was forced to consider the job too unstable to consider for automation. It was exactly the type of problem net-inspect had been invented to solve.

The component had always been machined during the night shift, which made the cause of the inaccuracy difficult to track down. Each time a batch had to be scrapped, the operator that had run the job would be questioned. On every occasion, the operator swore that he had done nothing to the fixtures and had used the same program and setup that had previously produced the part successfully. Despite these assurances, it seemed that some slight operator error could be the only possible explanation.

By using the analysis functions within net-inspect, QPM was able to determine that no problems existed with the job's tooling, programming or fixturing. Further examination ruled out error on the part of the machine operator. Once enough information from the job had been entered into the system, the company was able to narrow the cause of the problem down to the material being used.

Upon close inspection, it was discovered that the specifications of the material were too wide to guarantee the accuracy needed by the customer. At the harder end of the material specs, the tool would remove up to .0002" too little material. Simultaneously, at the softer end of the specs, the tool removed up to .0002" too much material. The material itself was only capable of holding the required tolerance when its hardness was at or near the center of what had been specified. QPM was able to make the appropriate changes in its material specifications, solving the problem and proving that the previous scrap had not been due to operator error.

"With net-inspect, we are able to be much more aggressive in playing detective and finding the cause of a problem within any of our work," says Mr. Dunlop. "Our defect rate was slightly below the industry average when we implemented the software. Almost immediately, we were able to reduce it by a further 60%. net-inspect did exactly what we had hoped, which is stabilize our processes to the point that we could comfortably implement strategic automation."

Getting More out of Machinery

Through net-inspect, QPM was able to achieve an extremely high level of process stability in a relatively short time. This shift gave the company confidence in its ability to begin implementing automation that would improve competitiveness with manufacturers overseas.

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"We took a leap of faith and trusted the statistics," says Mr. Dunlop. "If you have a system that instantly picks up on any deviation and you take permanent corrective action whenever a deviation occurs, you basically eliminate all of the potential for something to go wrong. With the process under complete control, you can run it lights out on a perpetual basis."

Once net-inspect had allowed QPM to eliminate the chance for error, the company began moving heavily into automation. Over the course of several years, QPM integrated 3 machining cells with 16 pallets and one cell with 24 pallets. All of the cells incorporate horizontal machining centers and Linear Pallet Pools (LPP's) from Mori Seiki.

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this endeavor a success," says Mr. Dunlop. "If you purchase equipment that can't perform consistently and reliably, it completely negates any efforts towards total process stability. The craftsmanship of Mori Seiki's machines and automation products is at a level that supports the paradigm shift we were attempting."

Implementation of the pallet systems had tremendous effect on QPM's overall productivity. Some jobs experienced dramatic gains just from moving from vertical to horizontal machines. When machined on 2 4-axis vertical machining centers, a titanium splice plate used on wing lifts for Boeing 727's had a cycle time of over 65 hours. By moving the component to a palletized horizontal machining cell and using net-inspect to perfect the machining process, QPM was able to reduce the cycle time to just 26.8 hours.

In addition to improved cycle times, the changes undertaken by QPM provided significant gains in machine productivity. In cells containing Mori Seiki LPP's, the company routinely achieves daily spindle utilization of over 23 hours. With the exception of the time required for tool changes, pallet changes and routine maintenance, the machines are cutting metal constantly.

The increased utilization rates are coupled with decreased labor requirements. Rather than constantly attending to a machine, operators now simply set up a day's worth of pallets and then let the machine run unattended. As parts are completed, the operators unload them and efficiently enter their measurements into net-inspect, ensuring continued process stability. Traditionally, the cost of labor comprised between 12% and 18% of total part cost. By using automation to allow each employee to perform a significantly higher amount of work, labor rates have, on average, dropped to just 2% of a component's cost.

Furthermore, automation has eliminated the negative effects of setup times on overall efficiency. For many components used in the manufacture of airplanes, QPM's customers might only require one of a particular component per month. Since setups can now be completed without causing machine downtime, QPM can economically produce a lot comprised of a single part. This allows for faster turnaround to customer demand and eliminates the need for keeping a large inventory system, along with the associated risk of incurring the costs that arise from design revisions to parts already produced and stored in inventory.

The increased productivity and decreased labor costs provided a drastic boost to QPM's competitiveness. The company has experienced steady growth in annual sales every year since launching net-inspect and moving into automated machining. In 2006, the company has achieved a 60% increase in annual sales over the previous year. A significant portion of this growth has occurred by recapturing work that had previously gone to Southeast Asia, a true testament to the effectiveness of QPM's approach to quality and process optimization.

From Operators to Experts

While QPM's unique quality program has had many highly visible effects, it has also produced results that are less obvious, but just as beneficial. The dissolution of a

dedicated inspection department and the adoption of net-inspect served to increase operators' responsibilities, while providing them with a tool to rise to the occasion. Today, QPM's machine operators possess a level of skill and knowledge that is uncommon in the industry.

"Our employees have really evolved from machine operators to full-fledged advanced process managers," says Mr. Dunlop. "Their confidence level and the intellectual component that they put into our operations are dramatically increased. Anyone on our floor can pull process charts on any job and identify the challenges it's experienced in the past, what corrective actions were taken and the current stability of the processes. Their intimate involvement in the actual process of manufacturing has transformed them beyond the traditional role of a machinist."

In effect, the data generated by net-inspect helps to educate those who use it on the processes they are monitoring. Subsequently, that increased knowledge allows the users to get more out of the system and also be more effective in identifying any potential issues that threaten to add inefficiency to the manufacturing process.

The increased abilities of QPM's operators has consistently allowed a fast resolution to problems that would have taken much longer prior to the implementation of net-inspect. One such instance arose when a component started showing deviations after being moved from one machining cell to another. A particular hole on the component was sometimes being machined outside of the customer's specs. All of the obvious variables were immediately ruled out, as identical fixtures, machines, tools and programs were being used.

QPM employees turned to net-inspect to search for any differences in the way the two cells were used to produce the part. When no variation was found in the machining of the component itself, the operators used net-inspect to analyze both cells and the jobs that were running previous to the part in question. This led to a quick resolution of the problem. On the new cell, the tool used to machine the problematic hole was also used extensively on the preceding job. In the old cell, the tool had sat idle for a significant amount of time. The difference in the temperature of the tool altered its performance just enough to push the part towards being out of spec. QPM took permanent corrective action, adding a duplicate tool to the cell so that a cool tool could be used to machine the hole. A problem that would have been extremely difficult to identify in the past was quickly smoked out through the use of net-inspect.

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"The software helps our operations on multiple levels," says Mr. Dunlop. "net-inspect helps our employees learn our machining processes inside and out, and then points them in a very specific direction whenever a problem does arise. It's accurate to say that it has truly transformed our business."

Overcoming Your Potential Challenges

Perhaps the most significant hurdle to implementing a system like QPM's is the challenge it poses to a shop's employees. With every aspect of the machining process tracked and analyzed in real time, mistakes show up instantaneously and are completely visible to an operator's managers and peers. For QPM, they are also available to customers, as the company provides its customers with full access to the information contained in net-inspect. Many shops simply do not want that level of exposure and scrutiny applied to their operations. For those that do, alleviating any apprehensions on the part of employees will be vital to the endeavor's success.

When shifting to a quality system such as net-inspect, the attitude with which it is implemented plays a large role in gaining acceptance from employees. If employees feel like they are being micromanaged or spied upon, they will resist and resent the effort from the outset. It is important to avoid this perception and to assure operators that the system is a valuable tool at their disposal, meant to increase their abilities and responsibilities within their jobs.

"When net-inspect was first announced, some of our employees were concerned that it was there to allow management to look over their shoulders," says Mr. Dunlop. "As they became familiar with the power of the system, they realized that it put a wealth of resources at their disposal, allowing them to rise to any challenge they encountered. They have now embraced the philosophy and tools so completely that if we were to take net-inspect away, I honestly believe we'd face a mutiny."

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For those that wish to completely follow QPM's model, automation will also pose a distinct set of challenges. Inevitably, discussion of automation leads to debate over whether jobs might be lost to machines. QPM took the viewpoint that, in today's global market, there are areas of the world that possess a significant advantage over American manufacturers through their low cost of labor. The most straightforward means to eradicating that threat is increasing the amount of value American manufacturers receive for their labor costs.

As foreign competition loses its price advantage, work that was previously lost overseas begins to migrate back to American manufacturers. Additionally, elimination of the labor advantage means that work that has always been completed overseas can be pursued and won by American manufacturers. QPM has experienced success in winning jobs over foreign manufacturers in both of these circumstances.

"We have a seen a lot of American companies outsourcing work to chase low labor markets," says Mr. Dunlop. "First they set up plants in China. As that economy grows and wages rise, they move on to India. Soon they'll be moving to Berundi or Botswana. If manufacturers in the US reduce their labor costs enough to nullify the advantage these companies are seeking, the work will come back."

In the wake of the industry's nosedive at the end of 2001, QPM was forced to undertake a layoff. Since then, the company has not needed to eliminate any jobs, despite its expansive automation efforts. In fact, QPM has experienced such strong growth that its volume of work has required hiring of new employees, despite the minimal amount of labor going into parts produced. Additionally, since labor makes up such a small percent of overall cost, QPM is able to pay its employees better than ever before. As the company's employees have moved from traditional operators to process engineers, their salaries have been increased to reflect the additional value they are providing. Contrary to the industry's doomsayers, QPM's success has shown that automation can not only create jobs by winning work from overseas, but also raise the compensation of those jobs.

Conclusion

Necessity is the mother of invention. That concept has become so commonplace, and perhaps even clichéd, that its truth is sometimes overlooked. QPM Aerospace provides a stunning example of just how applicable that simple phrase remains. When faced with demands for lower costs and high competition from low wage countries, the company developed an entirely new philosophy and the tools necessary to make it a reality. In a single decade, a willingness to question and redefine the status quo increased annual sales by one hundred-fold.

When QPM Aerospace began the redefinition of its approach to quality, it employed 10 people dedicated solely to quality inspection. At current sales levels, it would take over 20 full-time employees to guarantee the necessary levels of quality. Through integration of net-inspect, 2 employees can accomplish all necessary inspection, resulting in a significant reduction of overall costs. The increased productivity and elimination of scrap provide even greater savings, making QPM Aerospace truly competitive on a global level.

"If you look at the history of American manufacturing, challenges have nearly always brought about phases of rapid progress,' says Mr. Dunlop. "Despite the obvious advantage of low wage countries, we have innovated and found ways to succeed. As we've discovered at QPM Aerospace, a comprehensive, proactive approach to quality can have an amazing effect on cost and efficiency. This is precisely the kind of evolution that has always made US manufacturers so resilient and by embracing it now, they can guarantee their future success."