Delphi reduces scrap and improves quality with boring / reaming operations.

Delphi Automotive Systems (Dayton, Ohio) recently embarked upon a major capital expansion program to increase the manufacturing productivity of automotive air conditioner components. The focus of the project centered on developing and implementing a more precise and cost effective method of cylinder boring in a high-silicon (16-18% Si, 4% Ni) aluminum die casting. With plants across the globe, and the potential demand of nearly five million parts per year, the Delphi management team was willing to evaluate a large number of manufacturing processes and vendors.

The part, an air compressor body, has up to six cored holes which are to be bored and chamfered to a specified required surface finish of 4 Ra. The existing machinery with single point boring tools was unable to achieve the specification, and thus allowed a deviation to 6 microns. Cycle times were high and there was an unacceptable scrap / rework rate. When coupled with additional secondary labor costs to size and match pistons to the holes, the need to explore new technology became evident.

Delphi specified a "lean manufacturing concept" with minimized automation systems when detailing the project's requirements. The decision also incorporated vertical machining centers to handle the drilling, milling and boring operations performed on the compressor body. Four vendors submitted integrated systems for evaluation. After several months of testing and validation, Delphi project engineers awarded the contract to Reynolds Machinery (Dayton, Oh) based upon their combination of a OKK PCV40 vertical machining center running tooling from Komet of America (Schaumburg, Il) and subsidiary Dihart with coolant and chip processing systems provided by Mayfran International (Cleveland, Oh).

Reynolds, was the Primary Integrator of the project and took the responsibility to bring together the machinery, fixturing, programming, tooling, filtration systems and the coolant suppliers and meld them into a cohesive turn key system. Acting as an Integrator, Reynolds was charged with developing a viable system to meet the project's parameters for quality, efficiency and cost. The system Reynolds ultimately submitted to Delphi is made up of several key components from leading manufacturers, with custom engineering to adapt "off the shelf" technologies to the project's specific needs.

The components were initially assembled at Reynold's facility, where CPK Studies were conducted. The fixtures were operated for six months, during which time controls were programmed, test cutting was performed, and speeds and feeds were set . The testing and evaluating phases of the project were conducted prior to the awarding of the contract by Delphi. Reynolds also had to guarantee the system's performance once it was up and running at Delphi's facility. "Obviously, this was an large undertaking, and not without risk," said Dan Chalk, Integrator Manager at Reynolds, "we worked for over a year just to reach the testing stage, then we ran the tooling 8 hours a day for months on end just to validate the concept and after all that, we didn't know we had won the contract until the final hour."

Reynolds was able to show Delphi consistent, repeatable evidence that the OKK machines with high pressure, through-the-tool coolant delivery, running the Komet and Dihart tools would greatly reduce cycle times while improving surface finish of the cylinder holes. An additional benefit of the system is the virtual elimination of operator gauging and inspection which reduces cycle time and improves productivity.

Using a Komet Special ABS 50 modular tool which incorporates three PCD inserts to do the rough boring and chamfering of both ends eliminates multiple operations from the previous system. The Komet boring bar operates at 13,500 RPM and a feed rate of 200 IPM for the semi-finish boring operation It then circular Interpolates a 30° camfer on the front and back sides of the part. Incorporating three PCD inserts allows for higher penetration rates vs. the single point boring system that was being used previously, yet achieves a better micro finish of the rough bore in the cored holes of the die casting. Its ability to perform a secondary front and rear camfering operation reduces tooling costs and tool change time, while creating more space in the turret of the machining center.

Once the semi-finish operation is completed, the special Komet/Dihart PCD Reamer 38.1250 immediately follows to finish the cylinder. It is a micro-adjustable tool with six radial differential flutes and 100% PCD flanks on each cutting edge with a technically advanced bevel grind on the lead angle. Dihart inspects each cutting edge to assure that there are no micro cracks or micro chips in the cutting edges. This ultra precise inspection operation allows Komet/ Dihart to deliver a tool that consistently creates a two micron finish in less than one second per hole. During testing and validation, Reynolds was able to set speed and feed rates of 3,000 RPM at 125 IMP for the reamer. It achieves 12 Ra surface finish, size control of 2 microns with Concentricity 2.7µm resulting in a Mirror Glass Type Finish that is repeatable *from machine to machine,* part to part. "The adjustability of the tool allows us to target a mean bore on every part once the tool is preset," said Thomas DeVilbiss, Senior Manufacturing Engineer at Delphi. Using Statistical Process Control, Delphi has been able to achieve a goal of 1.67 CPK . "The Dihart reamer will create that mean bore over a long period of time," said DeVilbiss.

The impact of the Komet / Dihart tooling system's speed and precision actually reduced the capital expenditures at Delphi. The original specifications called for a manufacturing cell with

four vertical machining centers running single point boring tooling. Based on an impressive cycle time of 84 seconds with the Komet / Dihart system, Reynolds was able to reduce the cell requirement to three machines while producing a consistently higher quality finished part. Delphi has also been able to take advantage of the valuable floor space opened up by the reduced footprint for the required machinery.

An important operational requirement of the process centered upon the need for an ultra pure, chilled, high pressure coolant supplied with filtration level to 5 microns. Process tolerances, speeds and feeds, and the thermal properties of the casting necessitated the assistance of a specialist. Reynolds turned to Mayfran for application engineering and integration assistance.

The coolant / chip processing system consisted of the following major components including: a chiller, sequential filtration, chip and coolant conveyor and a high pressure pumping system. Mayfran Engineers were able to assemble a complete package which required less than fifty square feet of floor space, yet delivers 8 gallons per minute of coolant at 1000 PSI. The high pressure pumping system and chillers came from Japan with the OKK machining centers and had to be mated to Mayfran's Concept 1000 conveying system. The filtration system is a largely customized three stage sequential process (50 micron, 25 micron, 5 micron) that progressively removes chips and contaminants from the coolant prior to pumping to the chilling unit. Reynolds conducted testing on many brands of coolant before selecting Blaser Vasco 1000, an environmentally friendly vegetable oil based product.

The overall success of the Delphi project is an example of their Engineers' willingness to explore new manufacturing processes, and of a group of key vendors working towards a common goal. The Integrated nature of the system required open lines of communication at every facility, "this proved that there is more to making a good product than the tooling," said Heinz Luettmann, Product Manager for Dihart Reamers, "its an example of unprecedented cooperation and the application the latest technologies."