How to make... a cylinder head

It starts with a rectangular cast iron blank - and a design drawing. The drawing shows the precise dimensions. From those basic materials a cylinder head is produced within one and a half days. But how?

A cylinder head has to be able to withstand temperatures as high as 700°C and ignition pressures over 200 bar when the engine is running. It closes off the top of the cylinder and forms the upper part of the combustion chamber. Fitted inside it are the inlet and exhaust valves and the fuel injector. So the cylinder head not only has to be made of absolutely top quality material, it also has to be precision manufactured.

Virtual production

The drilling and milling operations start not on a machine tool but on a computer. Every single drilling and cutting operation performed by the machining center to turn the metal blank into a finished cylinder head is programmed and simulated beforehand using the ProEngineer and NCSimul software. Bernd Scherer is an expert in such virtual machining. He is a production planner and NC coordinator at MTU. He describes the programming procedure thus: like the machine tool operator, he first selects the right tools for the specific cutting and drilling operations from the tool management system on the computer. Then he places the three-dimensional virtual cylinder head on the virtual machine table and secures it with the virtual workholding fixtures. With a few mouse-clicks he tells the ProEngineer software where and how much of the surface is to be cut away and where which holes are to be drilled. “The system helps to make sure you are always using the right dimensions,” Scherer explained. Then he programs the next step. “The tricky part of programming is finding the best possible sequence of movements on the machine tool so that all surfaces are efficiently machined and an economically and technologically perfect program is produced,” the expert added.

Computer simulation

To check whether the program is right, he then simulates the machining of the cylinder head on the computer. He can then see exactly how the tool moves and where there might be collisions between the machine and the workpiece. That is a major benefit because in real-world production, any collision can cause substantial damage to the machine, the tool and the machined part.

Cylinder head step by step

Then it is time for the real thing. The virtual machining program created in ProEngineer is transferred to the real machine tool. To be precise, two machine tools are used to transform the metal blank via a number of machining stages into a finished cylinder head. A machine operator places the cast cylinder head blank on the workholding fixture on the first machine table. He closes the large sliding doors of the milling machine and starts it up. From this point the process proceeds automatically. A milling cutter runs over the surface and cuts away the metal bit by bit. Hardly anything of the operation is visible, however. Coolant-lubricant - required, as the name suggests, for cooling and lubricating the cutting tool - splashes all over the machine tool windows. The first machining center machines the top and bottom of the blank in turn on its first and second machine tables. Afterwards, the machine operator checks the most important drilling, milling and clearance dimensions to make sure the process and the tools are working properly. The part then moves on to the second machining center where the surfaces on the sides are machined and drilled. The cylinder head is then cleaned in a washer. Afterwards, a production worker inserts the valve guides and seats into the drilled holes. Next, the casting is checked for flaws, cracks and other damage, cleaned and deburred.

Multi-stage machining

The second machining center finish-machines the valve guide holes and valve seat recesses at the same time so that they are exactly flush. Checking the geometry and dimensions to an accuracy of a hundredth of a millimeter after machining guarantees that the valves function perfectly. A second washing stage ensures that the technical cleanliness requirements are met. Finally, an assembly worker fits the protective sleeve and plugs. If the part passes the subsequent gas-tightness test, it is ready for the last production stage - the fitting of the inlet and exhaust valves which respectively let the air into and exhaust out of the combustion chamber. Then the cylinder head is fully kitted out for a long life of high performance operation on an engine.

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The cylinder heads arrive at MTU from the foundry as cast blanks. Before being passed on for assembly, their surfaces have to be machined and holes drilled.

An MTU production worker deburs the machined part, removing rough edges and shortings from the workpiece.