Complete machining of turbochargers

*The machining of a turbocharger poses particular problems due to the many different materials used in its manufacture, such as cast and nickel steel alloys and aluminium alloys. One leading tool supplier has developed an extremely cost-effective method for the complete machining of turbocharger components. This report by **H. Steidle** describes a method that makes it possible to machine all the features for the main bore in the turbine housing in only four steps using ISO combination tools, and use PCD combination tools for machining the compressor housing.*

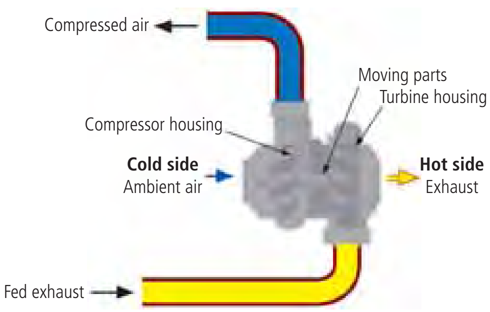

Fig 1 Function principle turbochargers

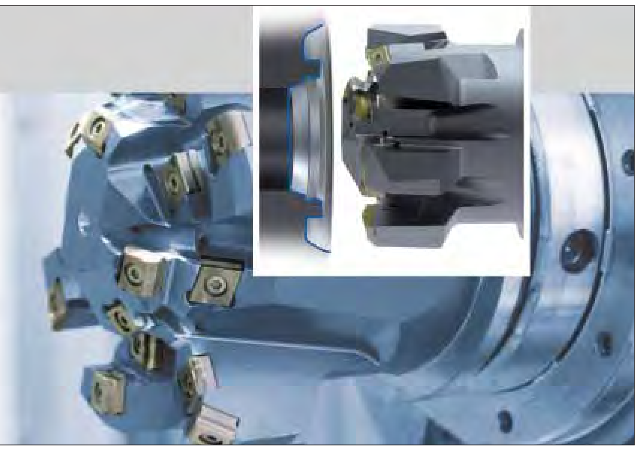

Fig 2 Six machining features and a control cut are made reliably, cost-effectively and precisely using this ISO combination tool

Low fuel consumption and reduced CO_2 emissions with the same or even higher engine performance: these are the requirements that confront engine developers in the automotive sector in this day and age. As a tried and tested method, the so-called "downsizing" principle has become established in recent years. In the case of petrol or diesel engines, any power loss resulting from the reduction in capacity is compensated for by fitting a turbocharger.

The principle is simple. The exhaust gases under high pressure are fed through the exhaust manifold to the turbine wheel and place it in rotation. The compressor wheel connected to the turbine wheel by a shaft draws in ambient air and compresses it. The air compressed in this manner is fed to the engine via the intake manifold. As a result the engine receives much more air. There is then more oxygen available for the combustion of a correspondingly larger amount of fuel.

The result is an increase in the engine's mean effective pressure and the torque, resulting in an increase in the power output. However, in practice turbochargers are extremely complex systems that require complex control technology to obtain optimum efficiency.

Manufacturing precision

Exhaust gas temperatures of up to 1,000 °C and spindle speeds up to 270,000 rpm require the highest possible manufacturing precision and the use of extremely heat-resistant materials. In relation to the machining requirements, turbochargers can be roughly split into three areas. The turbine housing made of heat-resistant cast steel alloys (hot side), the compressor housing made of aluminium (cold side), as well as the moving parts comprising the turbine wheel made of high temperature nickel-steel alloys, the welded rotor shaft and the compressor wheel made of high strength aluminium alloy.

German toolmaker, MAPAL has considerable experience in machining demanding workpiece geometries with difficult material properties. In conjunction with a very varied tool programme in almost all areas of machining, MAPAL as a leading tool supplier has developed an extremely cost-effective method for the complete machining of turbocharger components. This method makes it possible, for instance, to machine all the features for the main bore in the turbine housing in only four steps.

ISO combination tools with tangential technology

Complicated contours and recesses in conjunction with specific material properties for the turbine housing mostly made of high temperature cast steel alloys often make the machining difficult. MAPAL successfully uses ISO tools with tangential technology and in this way combines as many machining steps as possible.

Consequently, only two tools are needed for the pre-machining and semi-finishing machining of the complete main bore. One of these combination tools machines a total of six component features as well as a control cut. The highly positive installation position of the tangential inserts ensures soft cuts, a defined cutting edge rounding provides the necessary stability.

By using a specific cut distribution, circular chip segments are prevented from forming during the machining. If undetected, circular chip segments could cause damage in the installed turbocharger.

New machining method – interpolation turning

The contour of the recess for the V-band connection is a typical machining feature on almost all turbine housings. Conventionally, this contour is machined using multi-bladed chamfering milling cutters. The consequences are long machining times and only moderate tool lives.

By changing to interpolation turning tools with shaped inserts, MAPAL is making this machining particularly cost-effective. In practice it was possible to reduce the cycle times from 55 seconds to 35 seconds. The continuous cut during the approximately 30 interpolation revolutions results in an increase in the tool life of up to 40 % compared to milling.

During interpolation turning, the machine spindle is changed from speed-controlled operation (spindles, circular milling) to position control operation and can be controlled like an axis. To produce a helical cutting edge feed similar to facing on a lathe, an approximation of tangential arcs is required. On programming these arcs using the X/Y axes, the spindle as the C axis can exactly track the central angle. The cutting edge remains in contact during the entire machining process.

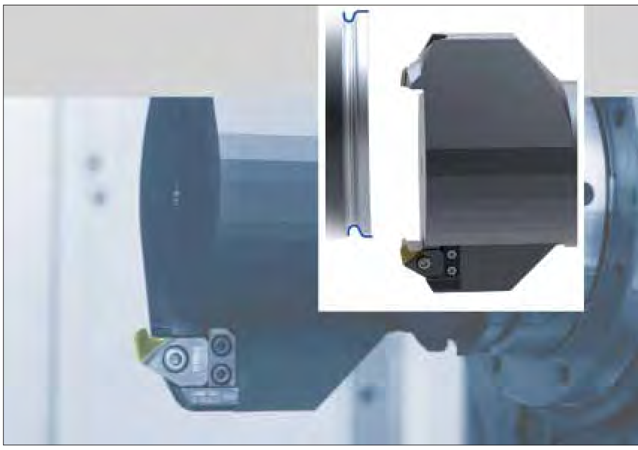

Fig 3 The MAPAL interpolation turning tool reduces the cycle time by 60% compared to a chamfering milling cutter and at the same time increases the tool life by 40%

Lathe not needed

Irrespective of whether turbine or compressor housing, to finish machine the complete contours inside the housing, it was often necessary to also use a lathe in the conventional machining process. MAPAL is replacing this time-consuming and expensive machining process using TOOLTRONIC®, a mechatronic tool system for machining centres. This features a fully-fledged interchangeable tool axis that makes it possible to machine any contours or recesses and is regulated using the machine control system. The drive unit can be equipped with various machine interfaces. Power and data are transferred inductively.

To machine the inner contours of the turbocharger housing, the drive unit is combined with a linear actuating tool. The fine machining of the contour is then performed using a mounting tool with turning inserts.

Using two ISO combination tools, one an interpolation turning tool and the other the TOOLTRONIC system, the complete machining of the main bore of turbine housings is carried out in four steps and on machining centres.

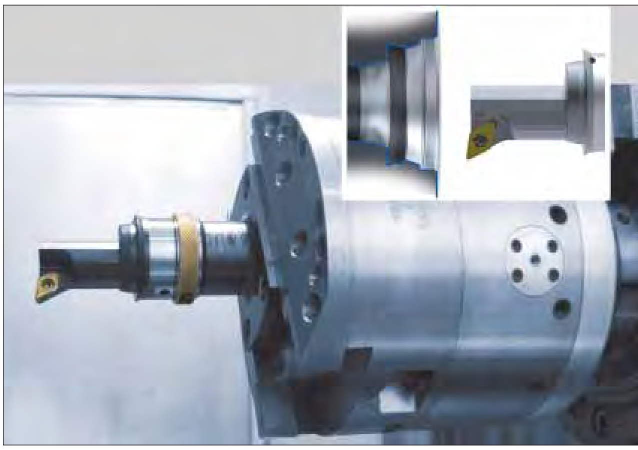

Fig 4 Linear actuating tool with mounting tool for the effective machining of contours on the turbocharger housing

High performance PCD tools

Similar to the turbine housing, contours, recesses, chamfers, the machining of faces as well as gun boring operations are the key machining features on the compressor housing. As inside this type of housing only ambient air circulates, there are no increased requirements on the temperature resistance. However, to keep the total weight of the complete turbocharger low, the compressor housing is cast in aluminium alloys and is therefore predestined for the use of MAPAL PCD tools. In this area MAPAL fully utilises its experience and manufacturing abilities in the design and manufacture of complex PCD tools. A PCD combination tool for machining the main bore in a compressor housing made of AlSi8 impresses in practice due to the combination of several machining steps. (see Table 1). For the complete machining of this compressor housing, a total of 11 tools are required.

Along with its impressive special tools and innovative machining methods, MAPAL also offers interesting solutions for the remaining machining tasks on turbochargers. As part of MAPAL customer services, the complete project planning, through delivery and starting-up the tools, up to and including support to the ongoing manufacture of turbochargers is provided. ◆

Recessing		
Spindle speed	n	5,500 rpm
Cutting speed	v_c	518 m/min
Feed	f	0.4 mm
Feed rate	v_f	2,200 mm/min
Fine boring		
Spindle speed	n	2,500 rpm
Cutting speed	v_c	268 m/min
Feed	f	0.12 mm
Feed rate	v_f	300 mm/min
Countersinking		
Spindle speed	n	60 rpm
Cutting speed	v_c	16 m/min
Feed	f	0.2 mm
Feed rate	v_f	12 mm/min

Table 1 Typical range of MAPAL PCD tooling

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