Optimize

Milling Turbine Housing Made Affordable

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Downsizing makes engines more economical. In order to ensure that their performance is not compromised, turbochargers are increasingly being used to compensate in smaller vehicles. The market is growing – but so is the pressure on prices. Walter has developed a new milling cutter system to meet the specific requirements of thin-walled turbine housings, which reduces machining costs by up to 15% per part.

Vehicle fuel consumption needs to be reduced – not just in the lab. Legal provisions from all over the world are driving the automotive industry to implement measures in almost every vehicle class. This has given rise to huge challenges for the automotive industry. An important factor: Turbochargers that squeeze high performance out of small yet efficient engines. However, the turbochargers themselves are also under pressure to be smaller, more efficient and, importantly, more cost-efficient.

Reducing Machining Costs

"[Walter] expect – and studies by leading turbocharger manufacturers agree – that the number of turbochargers used for gasoline engines will experience a 2.5-fold increase over the next five years," says Rolf Buob, Component Manager for turbine housings at Walter AG – for more on this topic, read the interview with Rolf Buob at the end of this article. Currently, turbochargers for gasoline engines place particularly high demands on machining when compared with diesel engines. The exhaust gases in the turbine housing reach temperatures of between 1000 and 1050 °C; in diesel engines, however, they reach relatively low temperatures of between 800 and 850 °C. "Temperatures of 1000 °C or higher require high temperature-resistant steels, typically chrome-nickel alloy steels. These austenitic heat resistant cast steels typically have 10% Nickel and 20% or more Chromium are constantly being developed further and it is becoming more and more difficult to machine them," explains Buob.

They also make the turbine housing the most expensive component in terms of machining. Buob explains further: "[Walter] anticipate different machining costs for each component, depending on the presence of an exhaust manifold." Above all else, a high chrome content reduces tool life. "There are applications where tools only last long enough for twenty to thirty components." For comparison: The materials used for diesel engine turbine housings extend the tool life by up to five or ten times, while also being 50% faster to machine.

Walter machining experts have therefore developed a new milling cutter concept especially for roughing, semi-finishing and finishing turbocharger housings. It reduces the all-important cost per finished part, while also significantly improving surface quality. Over the course of the development process, the cartridge system used for finishing, which had previously been the norm, was replaced with an intentionally simple tool design with a fixed insert seat. This "Plug and Play" solution eliminates the need to carry out presetting operations, which required accuracy to between 3 and 5 μm.

16 Cutting Edges Reduce the Pressure on the Workpiece

Further saving measures: Walter uses identical indexable inserts with 16 cutting edges as semi-finishing and finishing inserts. Previously, the market standard was to use twelve for semi-finishing and four for finishing. This also simplifies inventories and eliminates errors when changing the indexable inserts.

The indexable inserts are coated with PVD or CVD and are available in various geometries. Indexable inserts belonging to the Walter WSP45S or WSM45X grades are typically used. Short cutting edges reduce the pressure on the unstable components. This results in reduced vibration, which improves surface quality, increasing it by approximately 30%. "Overall, these measures lead to improvements in handling and process reliability," says Buob.

As a rule, every third to fifth insert is positioned differently on the finishing tool. The position of the semi-finishing inserts can be adjusted by approximately 5° in the same way as when carrying out rough machining; the finishing inserts are positioned to cut in a flat plane. Rolf Buob explains: "This is why [Walter] distinguish between semi-finishing and finishing inserts on the same tool, even when the inserts are identical. Only the insert seats are rotated differently." The cutting speed when finishing is approximately 450 sfm at a feed rate per revolution of up to 0.157 inch. This milling cutter is also available for machining allowances of up to 0.118 inch for roughing in particular. Here, the indexable inserts are aligned uniformly both axially and radially, in contrast to the finishing face mill. They all have the same function for machining operations.

However, the new milling cutter concept does not mean that development has finished. Walter is expected to make further advances involving new PVD coatings that are currently still in development.

The Power of the Turbocharger

Turbochargers essentially consist of a turbine and a compressor that are both mounted on the same shaft. They work with vane or blade wheels to convert the energy from the exhaust gas flow into rotational motion and to transfer the flow energy to the fresh gas. In order to do this, turbochargers can use either pressure (constant-pressure turbocharging) or the kinetic energy of exhaust gases (pulse turbocharging) as their energy source. The exhaust stream forces the turbine wheel on the exhaust side to rotate. The torque is transmitted by a shaft to the compressor wheel in the intake manifold. The compressor in the intake manifold increases the fuel/air mixture throughput of each induction stroke of the engine.

Variable Turbine Geometry turbochargers feature adjustable guide vanes arranged on a vane ring encircling the turbine wheel. With variable turbine geometry (VTG), the inclinations of all guide vanes surrounding the turbine wheel can be adjusted simultaneously and almost continuously during engine operation.

Interview: Rolf Buob, Turbine Housing Component Manager, Walter AG

"Plug and Play"

Roughing and finishing turbine housings is particularly challenging in the case of passenger cars with spark-ignition engines. The material is extremely tough and difficult to machine and the walls are thin, which therefore makes the workpiece unstable and the cost pressure high. But the market is growing. For this reason, Walter has developed a special solution. mav spoke to Component Manager Rolf Buob.

Manufacturing a turbocharger requires many different machining steps. How was it decided that the process of milling the housing should be the area to give rise to new developments?

Buob: The proportion of tool costs for roughing and finishing a turbine housing amounts to approximately 15% of the total costs. In contrast to other machining processes, substitution is relatively simple. A corresponding development that both reduces the costs per part and improves quality can guarantee progress, both for the housing manufacturer and the tool supplier.

What measures did you implement in order to achieve this?

Buob: We use the same indexable inserts as semi-finishing and finishing inserts. This is new for this type of tool. Additionally, the indexable inserts each have 16 cutting edges with increased service lives and therefore increased usability. As a result, the costs per component for the metal cutting tool, which are all-important in the automotive industry, are reduced by up to 40% – in some cases up to 70%. The costs of cutting tool material for the turbine housing come to approximately 50% of the total costs of the component. In machining production environments, this is usually around 4%. Milling applications represent between 10% and 20% of the costs of cutting tool material – divided approximately equally between roughing and finishing. We expect to see an overall effect of approximately 4.5-5% on the costs of a turbocharger, which can be achieved very quickly.

The new milling cutter is also intended to improve surface quality – how will it achieve this?

Buob: In this sector, a surface quality of approximately RZ 10 is usually required. We have achieved Rz 5 and have absolutely no problems fulfilling customer requirements with the system. This is possible thanks to the optimal cutting length of 4 mm, which applies a lower pressure. These housings are very unstable because their walls are only between 2.5 mm and 3 mm thick. This quickly leads to vibration and, as a result, chatter marks. Up to now, there has always been a compromise between machining speed and surface quality. We can resolve this conflict.

Why have you chosen to use a fixed insert seat instead of the customary cartridge seat?

Buob: Adjusting the finishing inserts using the standard cartridge makes the tool more expensive and reduces the possible number of teeth. This ability to adjust the inserts is advantageous for standard applications of varying batch sizes because the tool can easily be modified to meet different conditions. This flexibility is not necessary in the case of large quantities, however. For this reason, we decided to use the fixed insert seat. With the elimination of an adjustment step, it almost becomes a "Plug and Play" solution. In any case, we are required to manufacture the seats for the finishing inserts extremely precisely so that they all run exactly parallel to one another.

