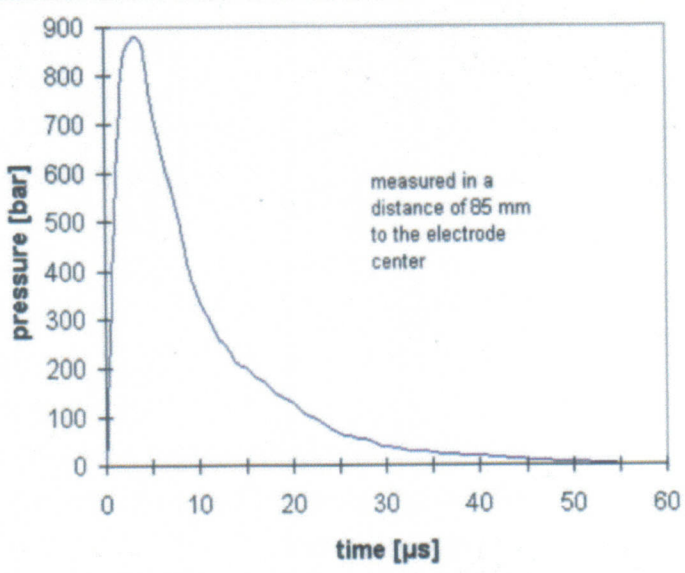
Final decoring, cleaning and discharging of metal chips at engine parts

Figure 1



Shock wave pressure curve

To fulfil the environmental and economical requirements for engines, especially cylinder heads have become more complex. Often water channels are designed with a thickness of only 2 to 3 mm and therefore hard to access from the outside. On the other hand, engine parts need extremely higher cleanliness levels due to smaller tolerances between all moving parts and an increased sensitivity to impurities of the new components installed. While a maximum 0.4 g of impurities were allowed for 6 cylinder heads in the past, nowadays the automobile industry discusses 10 mg or less. A few sand grains or one or two small metal chips from the tooling process suffice to miss the new automobile quality standard. A plug inside any channel of the casting will under no circumstances be allowed.

To solve this cleaning problem, Klein Shockwave Technology offers the Cerabite process which has been used worldwide in the lost-foam foundry industry over the past eleven years. With an expertise of over 6.5 million cleaned cylinder heads and blocks, Klein installed this plant technology for the final removal of any remaining core sand and layer at DaimlerChrysler's foundry at Esslingen-Mettingen in July 2006.

Removal of thin inorganic cores in inaccessible areas

Before the decision was taken to apply this new technology for the serial production at DaimlerChrysler, all known decoring procedures were tested thoroughly. The Cerabite shock wave technology proved to be the only procedure that guaranteed the removal of a very thin channel core inside the cylinder head. Due to the necessary coating of the core and the pre-defined wall thickness it may happen that in some areas an inorganic core arises. This effect complicates decoring considerably, especially because this area of the water cooling jacket is inaccessible.

The shock wave generated by underwater capacitor discharge is a special form of hydraulic energy application which is characterized by an extremely short rise time up to 400 bar/µs and a high pressure amplitude up to 1,000 bar (Figure 1). In this case, the indicated values refer to the plant concept for the cleaning of castings. The water serves as a loss-free transfer medium. At first, the shock wave spreads spherically with a velocity slightly above sonic speed = 1,450 m/sec for water.

Reflection of shock waves inside the casting reaches each area

When the shock wave strikes the border zone of another medium or another body, reflections are created along this border zone. The scope of these reflections depends on the acoustic impedance of the two bodies (media). The angle of impact on the border zone is also decisive. This feature also permits the reflection of the shock-wave energy at the casting surfaces and, therefore, penetration into all cavities. In this process, hard and brittle materials (such as sand cores and ceramic coatings or cores) are destroyed by the shock wave because they do not with-

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stand the quick pressure change of the shock-wave front.

To make most efficient use of the shock-wave energy, two cylinder heads are immersed contemporaneously into the water and positioned on each side of the electrode (Figure 2). During every shock-wave generation, both cylinder heads are submitted to a uniform impact of the shock-wave energy with an effective area of about 100 mm in diameter. In this area, the shock-wave energy can penetrate effectively into any apertures of the cylinder head. Treatment is usually where the combustion chamber of the cylinder head is situated. Due to reflections at the inner wall of the shock chamber, the rear sides of the cylinder heads are cleaned as well. In the case of hard full-ceramic cores, e.g. of impeller wheels, the shock wave is led into the casting focussed by reflectors. Depending on the number of cylinders, the cylinder heads are treated lengthwise on 4 to 6 positions. As the effective area of the shock wave is large enough, a mechanical change of tools for the treatment of different types of castings is not necessary; a highly accurate positioning of the castings in front of nozzles or very small effective areas is not needed either. Only the casting fixtures are especially developed for the individual casting type.

Cycle time of 25 seconds for one cylinder head

The casting fixtures are holding devices into which the cylinder heads are put loosely by a robot. A second robot then hands over the filled casting fixture to a shifting axis (Figure 3) which positions the fixture and thus the cylinder heads in front of the shock-wave-generating electrode. To reach a cycle time of only 25 s for one cylinder head, it was necessary to reduce the dead time for the shock station to an absolute minimum. As this dead time is only the handling time for the casting fixtures, the solution resulted in using two robots for this task. The first robot discharges the treated casting fixture at the shock station (Figure 4) and, immediately after that, the second robot charges a fixture with new castings. This layout for the Cerabite process creates a cycle time of less than 50 s for the simultaneous treatment of two cylinder heads. Additionally, the discharging robot washes the shock-treated castings while the shock station treats the next castings. Subsequently, the robot puts the casting fixture down onto a transmission station.

Chaotic charging with 4-/5-/6-cylinder castings

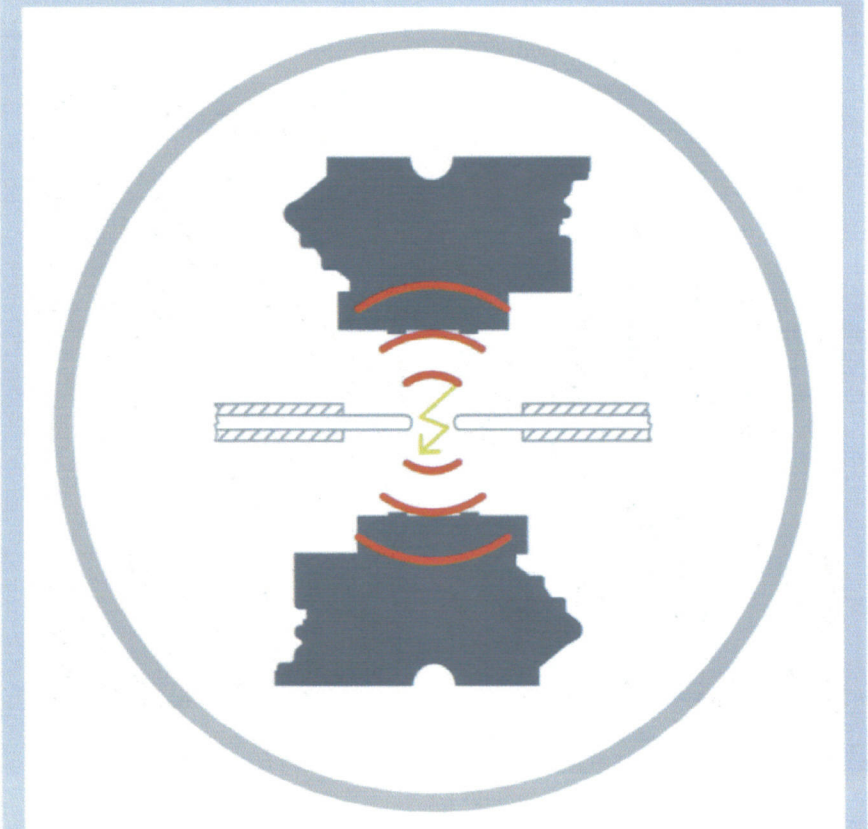
Robot number 3 that is only used for individual cylinder heads, picks up the cleaned castings and places them onto a roller conveyor. Then it picks up a new cylinder head from a second roller conveyor and charges it into the casting fixture at the transmission station (Figure 5). The robot gripper for cylinder heads is designed to handle 4-cylinder, 5-cylinder and 6-cylinder heads, just as one casting fixture is able to contain a 4-cylinder, 5-cylinder or 6-cylinder head. Chaotic charging of the Cerabite plant with different casting sizes is possible with the same grippers and fixtures without any change. The additional treatment for cylinder 5 or cylinder 6, if such castings are transmitted to the shock station, will be done automatically in result of a sensor signal from the incoming roller conveyor.

The water inside the shock chamber will be cleaned at intervals by screening of metal chips and sedimentation of sand and layer inside a water container. The collecting tank at the bottom of the water container is also handled by one of the robots.

Cleaning results at the foundry of DaimlerChrysler

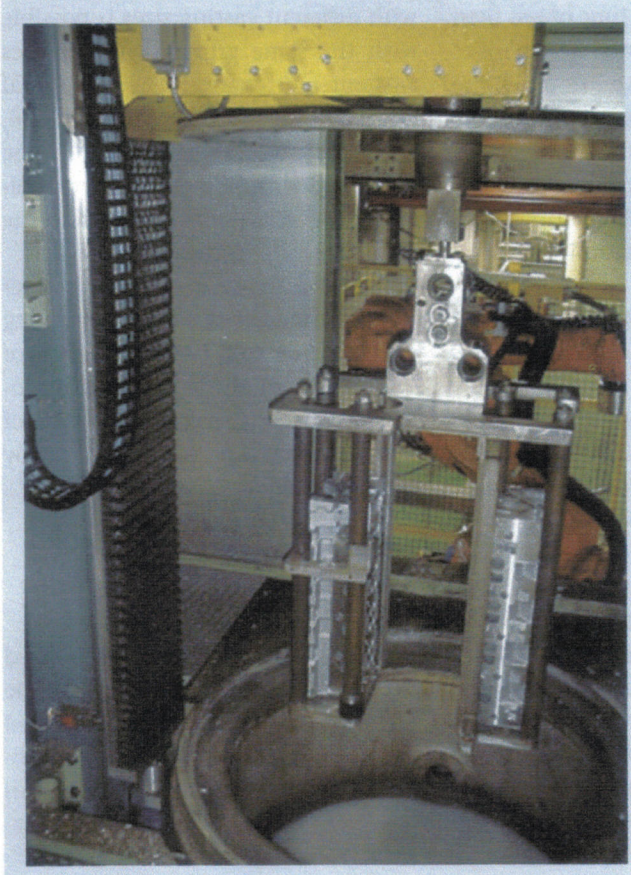
To date, DaimlerChrysler has cleaned almost 300,000 cylinder heads with the shock-wave process. A project carried out at DaimlerChrysler proved the efficiency and reproducibility of the pro-

Figure 2



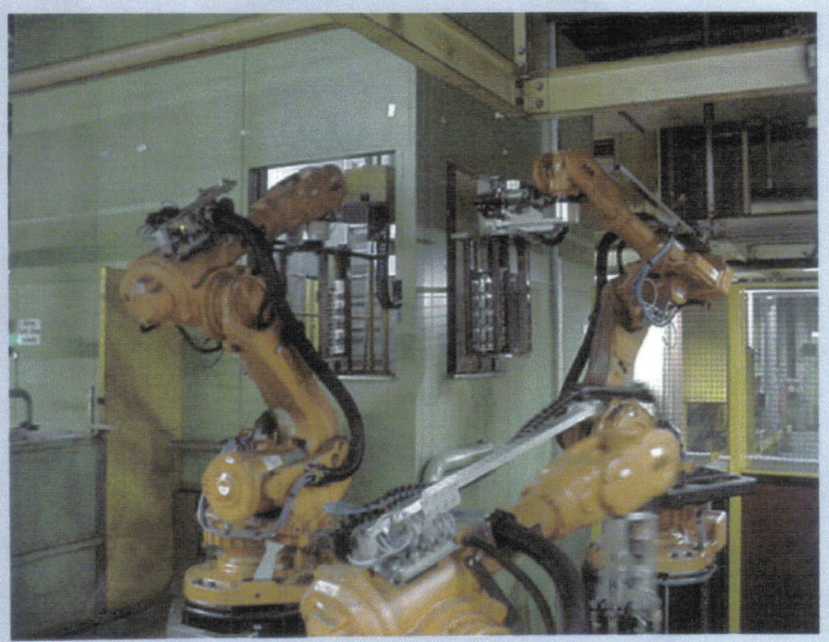
Section view of shock chamber charged with two castings

Figure 3



Casting fixture hands over to positioning and shifting axis

Figure 4



Two robots change casting fixtures at shock station

cess. For reasons of quality assurance, however, some cylinder heads are still taken out of the serial production every day and checked by extensive X-ray tests. So far neither adhering dirt residues, let alone plugs could be detected in any case. Detailed tests show that adhering coatings and sand grains in all areas of the cylinder head are reliably removed from the surfaces. Depending on the complexity of the casting, a washing process following the shock-wave treatment is necessary to rinse the loosened sand particles out of the inner geometry of the castings. As the shock-wave treatment is executed on unfinished cylinder heads, the application of conventional washing techniques to remove particles resulting from the final tooling process is needed anyway. For other applications it would be equally possible to integrate the required washing procedure into the Cerabite shock-wave system.

Removal of metal chips

With regard to the removal of metal chips, extensive tests were carried out in the laboratory of Klein Shockwave Technology parallel to serial production at DaimlerChrysler. One basic principle applies to the shock-wave process just as to any other procedure for the removal of chips: The less metal chips reach the inner geometry of the castings, the least efforts are needed to remove them. To this end, it is most efficient to wash the castings under inner pressure during the tooling process. If this is not possible or cannot be added subsequently to existing plants, it is recommended to rinse the inner channels by flooding water through those openings into which chips cannot penetrate during the tooling process. An advantage of this process is that chips are removed which are still stuck in the inlet areas of the openings and which would otherwise have to be pressed through the complete inner channels of the cylinder heads. Due to the handling by robot, such a pre-flooding can be integrated into the Cerabite plant.

One special difficulty is the removal of chip jams which consist of long spiral chips. These chips can by no means be pressed through narrow passages unless they are destroyed with the help of the applied technique. Tests at Klein

Figure 5

Robot charges cylinder head into casting fixture at transmission station (Photos: Klein Stoßwellentechnik)

showed that such spiral chips up to a maximum thickness of approx. 0.3 mm are broken by the shock-wave treatment and then pressed outwards through the inner channels of the casting by subsequent shock waves, provided the channels are not constructed as dead ends.

Summary

A cleaning process for engine blocks and cylinder heads that has been applied in the automobile industry for years also proved to be effective to remove core-sand plugs from the most difficult areas in highly complex cylinder heads. Due to the high degree of cleanness that can be achieved with regard to sand and coating residues as well as the reliability in removing metal chips, the Cerabite process provides a solution to achieve the high cleanliness levels required for the final cleaning of cylinder heads to fulfil the new quality standards of the automotive industry.