Shrinking to fit using cryogenics - Cryotherm analyses the market

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Cooling baths, filled with LiN, has been used to obtain a quick and reliable method of establishing a fit between automotive and engineering components – such as piston pin, connecting rod bushings and valve seat rings.

The latest application to join this trend is the production of integrated valve train modules – using a technique jointly developed by Volkswagen Sachsen, the Chemnitz-based development centre IAV and the special-purpose machine manufacturer USK in Limbach-Oberfrohna.

For this new joining technique, industrial gases specialist Cryotherm provides customised cooling baths and auxiliary equipment for a reliable supply of liquid nitrogen.

Cold makes it fit

The principle of this joining technique is the fact that most metals shrink when cooled down. Here the change in dimensions depends upon the temperature to which the material is cooled down and its specific coefficient of expansion. In what is known as joining by thermal expansion, the inner part of a joint shrinks due to being immersed in a bath with liquid nitrogen (-196 °C).

The extremely low temperature of the nitrogen causes a distinct shrinkage with short cooling periods. Once cooled, the component then has to be inserted into the outer part immediately. After the temperature equilibrium has been re-established, a firm interference fit is created.

As nitrogen is practically inert, there are no unwanted reactions with the materials. In contrast to high-temperature joining techniques, this process does not cause any scaling or microstructural change in the material; and the need for reworking by methods such as pickling or polishing is eliminated.

Whether or not the technique of joining by thermal expansion can be integrated into industrial production is a question that will be determined by the extent to which the process can be automated. The chilling takes place in cooling baths – these are compact, vacuum super insulated cryogenic vessels for liquid nitrogen. The components are immersed in the liquid nitrogen by a robot and then inserted into the appropriate mating part after having been cooled. The cycle time in this process has to be matched to the required cooling times.

Working together with prominent machine manufacturers, Cryotherm designs and produces cooling baths adapted to the specific production requirements as well as thermally optimised guideways and clamps for transporting the parts through the cooling bath.

These fittings are adapted to match the specific handling system of the machine manufacturer. The appropriate supply equipment for the liquid nitrogen is also contained within the scope of delivery and services. Customers can choose here between various supply strategies: small quantities, for example, can be supplied via mobile storage and transport vessels of the APOLLO® type while larger demands can be met from tank units via a vacuum, super insulated, transfer hose.

Of course, even with the best insulation for the supply hoses, a small proportion of the nitrogen will still evaporate. Vessels known as phase separators therefore supply the cooling baths exclusively with the liquid part of the coolant. A phase separator is in principle a vacuum super insulated vessel into which nitrogen flows from the transfer hose. At the base of this vessel, gas-free liquid nitrogen can be drained off via a connector at a pressure that can be adjusted to between almost 0 and 3-bar.

The gaseous nitrogen leaves the vessel in the upper part, and the feed line to the vessel is controlled automatically via a level regulator. The entire system has to be designed so that the build-up of ice and formation of condensate are, to a large extent, avoided. Control of the levels in the phase separator, and the cooling container, takes place fully automatically.

In addition to the direct method of cooling, which is very fast and safe because it involves immersing the parts in the liquid nitrogen, another option is to cool the workpieces indirectly. In this case, the parts are cooled only by the cold nitrogen gas. Using this method permits temperatures that differ from the boiling point of nitrogen.