“Raiser Innovation Award for Friction Welding” - 2013

CIRCULAR FRICTION WELDING OF CYLINDRICAL AND SFERICAL ELEMENTS

Instytut Spawalnictwa in Gliwice, Poland, www.is.gliwice.pl

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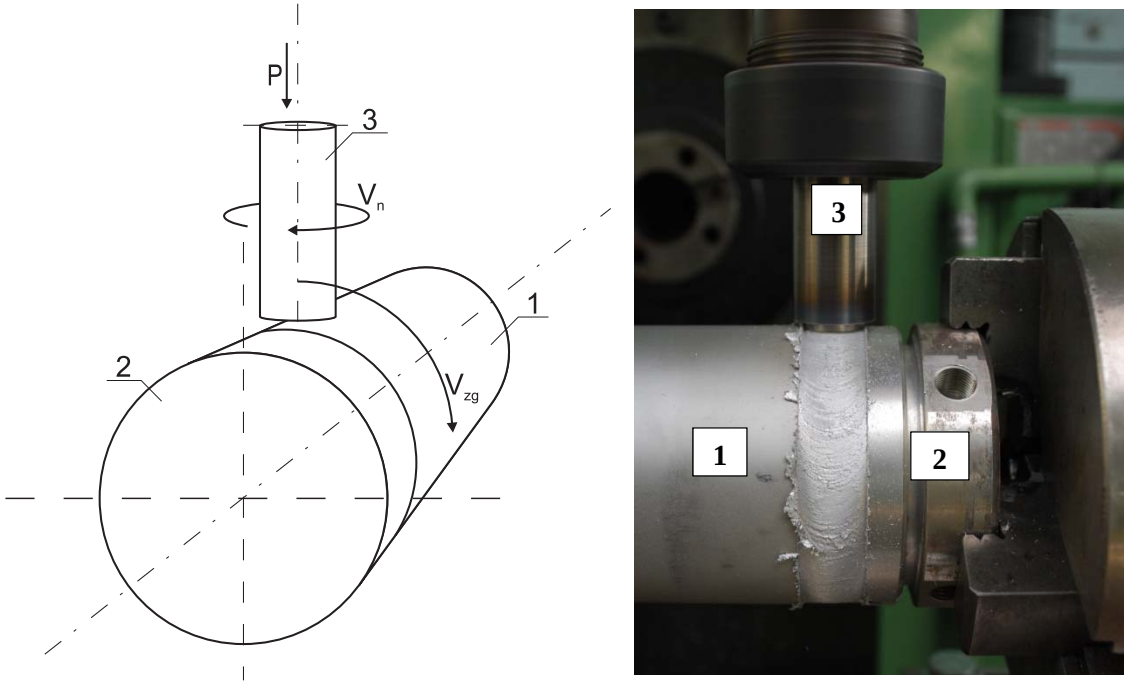
C*omprehensive publishable description of the project*

The application concerns new technology of friction welding of cylindrical and spherical parts made of unweldable or difficult to weld aluminium alloys, such as hydraulic cylinder applied in safety systems. The technology was tested e.g. by the REWA Company, which produces fire-safety systems with pneumatic actuators.

In the production of safety actuators, being the basic component of fire-safety systems, the joining process of the actuators components (cover with a cylinder) is essential. The quality of the acquired joint decides on its reliability and operation repeatability of the whole system during its long-lasting service. The applied process should ensure the required leakproofness at the pressure reaching several MPa. It should be emphasised that the cover and a cylinder are made of the material, which is unweldable using conventional welding processes (high-strength aluminium alloy EN AW 2017A). The currently applied technology of screwing, forging or gripping with the additional sealing measures is connected with large labour consumption while preparing the workpieces as well as low productivity and limited reliability of the joints.

The developed circumferential friction welding method uses the phenomena of heating and plasticising metals of selected parts of components being welded to produce a durable joint. During joining process the welded components, such as cylinder with a cover, are clamped in the machine, which prevents their movement. Specially developed rotating tool plunges into welded workpieces and heats, plasticises and stirs metals forming a circumferential weld. The shrinkage of heated and plasticised metal during cooling process causes mutual clenching of components what guarantees a weld of high strength and leaktightness. Thanks to its simplicity this welding process is reliable and fulfils all the requirements imposed on the welded joints of the safety hydraulic cylinders. A diagram of the friction welding process and the example of circular friction welding are shown in Figure 1.



a) *b)*

Fig. 1. The process of circular friction welding: a) a diagram of the process, b) process performed on the milling machine. 1 – cylinder, 2 – cover, 3 - tool; P – tool down force, V_n – rotation speed [rev/min], V_{zg} – welding speed (travel speed) [mm/min]

In order to obtain the required quality, repeatability and mechanical properties of the joint the welding tool should be set as in Figure 2.

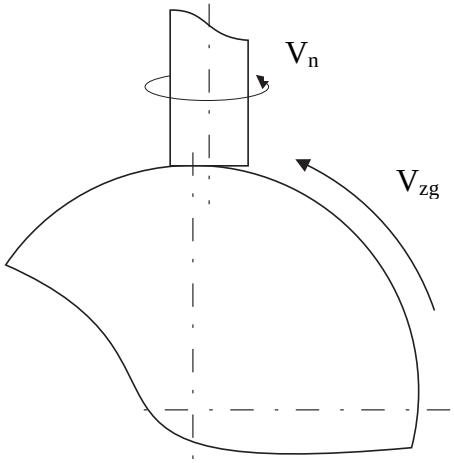


Fig.2. The diagram of tool setting relative to the worpiece – the axis of a tool is shifted relative to the axis of rotation. V_n – rotation speed [rev/min], V_{zg} – welding speed (travel speed) [mm/min]

Examples of the joint macrostructure are shown in Figure 3.

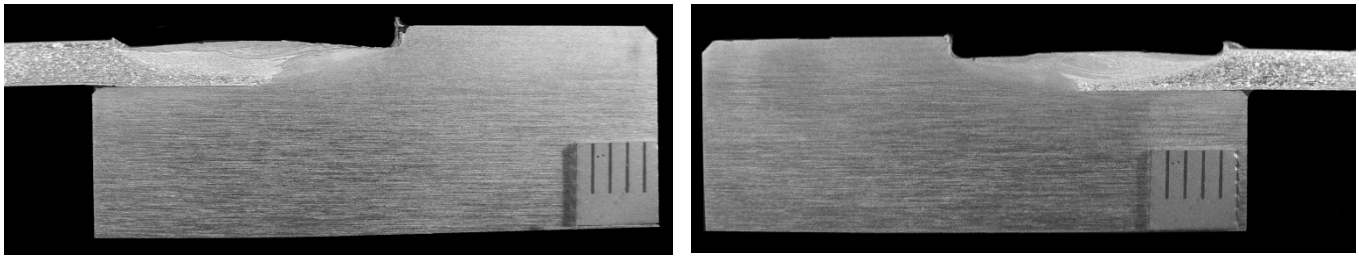


Fig. 3. Macrostructure of friction welded joint of a cylinder and a cover

This method may be applied for joining cylindrical parts, such as hydraulic cylinders with covers, pipes with closures or spherical components, e.g. parts of valves. Figure 4 shows the examples of fabrications made using the new technology.

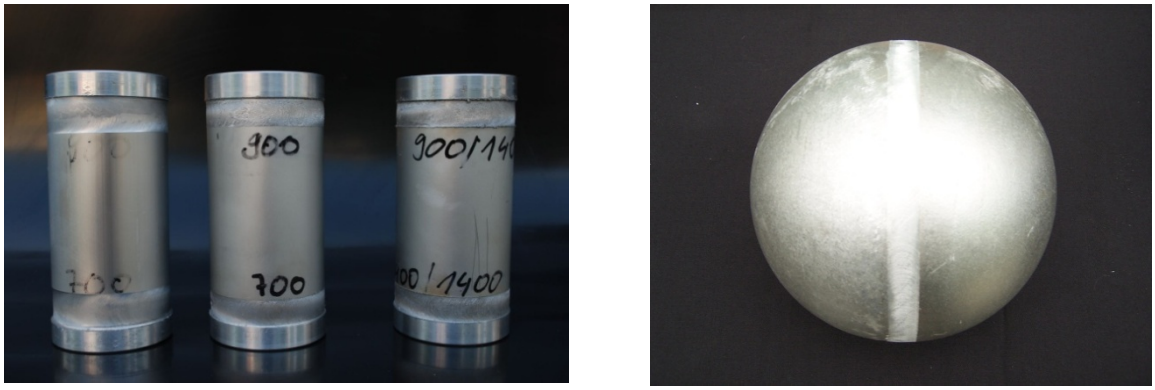


Fig.4. Examples of fabrications friction welded using the new technology. a) pipes welded with covers; b) valve balls

The process of joining components may be conducted on the special friction welding devices but also on the machines built on the basis of milling machines – Figure 5.

Fig. 5. The workpiece prepared for friction welding on the adapted numerically controlled milling machine

In comparison to the currently applied methods of screwing, forging or gripping with the additional sealing measures, this technology of friction welding makes possible to produce joints of higher fatigue strength. This enables the application of higher working pressure. The hydraulic cylinders produced up to now operated with constant pressure of 0.8 – 4.0 MPa and instantaneous pressure up to 8.0 MPa. The hydraulic cylinders produced using friction welding process are able to operate at sustained pressure of up to 10.0 MPa and instantaneous pressure up to 12 MPa.

Due to the fact that in friction welding additional sealing materials are unnecessary, it is possible to raise the temperature of the hydraulic cylinders operation. Up to now the temperature range was from 20 to 80°C, by reason of the sealing application (maximum working temperature may reach 300°C). At present the constant temperature may exceed 150°C.

With changing the method of joining the cylinder with its cover, working parameters of the hydraulic cylinders are also changed. When the method of screwing, forging were used, the smoke flap valves could operate under the load of 500 N/m^2. The application of friction welding increases the reliability of operation under the load by 100% (up to 1000 N/m^2).

The workpiece after the pressure hydraulic test is shown in Figure 6.

Fig. 6. The pipe was destructed at the pressure of 17 MPa without damaging the welds

In the result of the application of new friction welding technology in production of hydraulic cylinders the production flexibility and capacity of REWA Company have improved. Basing on the old technology of screwing or forging of elements only one diameter of hydraulic cylinders was produced. The implementation of the developed technology made possible to produce the wide range and variety of hydraulic cylinders (of various diameters, lengths, opening possibilities, blocking, etc.). Thanks to the new technology the costs of production are reduced by 50% comparing to that in case of production using conventional processes (screwing or forging).

Apart from measurable (economical) effects, the application of friction welding technology in production of the safety hydraulic cylinders allowed for assuring the safe work conditions for welding personnel, accompanied with very low harmfulness to the natural environment. Any harmful gases or dusts are not generated during friction welding process – the process is characterised by low nuisance for the machine operator. There is no need for shielding gases application. Friction welding is a welding process but in this case the same conventional mechanic protection as for machining process are sufficient.