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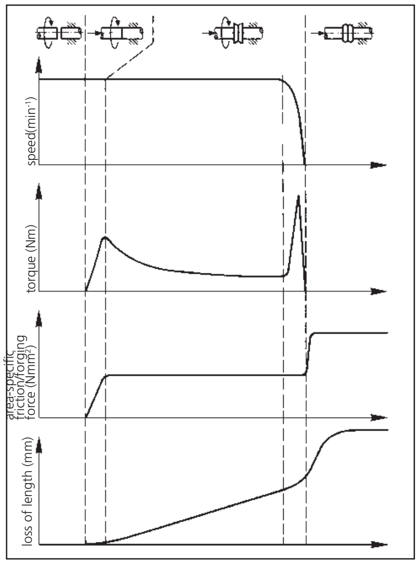
TECHNOLOGIE+TEILE

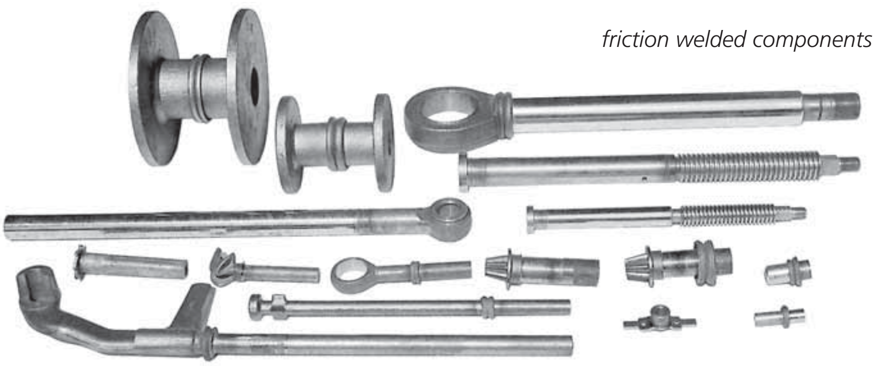
The Friction Welding Process

Friction welding reduces manufacturing costs



Friction welding process values

Friction welding is one of the most reliable joining processes for modern mass production. It therefore has a prominent place in many industrial manufacturing areas, yet its application possibilities for joining of metals of all grades and varied dimensions have to date not yet been fully exploited. The influence of easily controllable and measurable values (speed, pressure, time) has an advantageous effect during the process of friction welding. These values determine the starting and the finishing of the welding process during the development of the process ensuring friction welded joints of a high and easily reproducible quality standard.
A requirement for a component that is suitable for friction welding is at least an axially symmetric rotationally flat surface. The DVS1 information sheet 2909 »Friction welding of Metallic Materials« contains in part 3 valuable information on the development, design and manufacture.
The compulsion for rationalising the manufacture and for more and more cost-effective manufacturing of the workpieces demands as early as the design stage that new manufacturing processes are involved. A large number of difficult to form work pieces have previously been manufactured at a high cost through deforming,converting and metal cutting. By separating the parts into simple shaft sections, which are separately machined and joined through friction welding, simple operating sequences are now obtained, which reduces the manufacturing costs for semi-finished products.
For several years, friction welding has been offered as a service by contract friction welding job shops. This means that small and medium sized companies are given the opportunity to benefit from the advantages of friction welding without tying-up capital and without their own know-how.



friction welded components

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Walking made easy

Friction welded hip joint prosthesis

The most modern surgery techniques and the immense progress made in medicine today allow patients to be fitted several times over with hip joint prostheses. To do this, it is necessary to anchor the prosthesis more deeply into the bone that had been damaged by the previous prosthesis.
Friction welded hip joint prostheses are used for this purpose. The drop-forged blank of a normal prosthesis made of TiAl6V4 is lengthened with an appropriate round bar from the same material. By selecting suitable friction welding parameters, the grain structures can be modified in the area of the weld seam and heat-affected zone that withstand the impact loads. Extensive mechanical-engineering and metallographic examinations have shown that the friction-weld joint does not adversely affect the properties of the prosthesis. The machining of the joint seat of the prosthesis undertaken before the friction welding process requires a special clamping technique for accommodating the axial force.

hip joint prosthesis and blank

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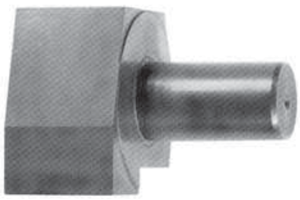
VDI Tool Holder

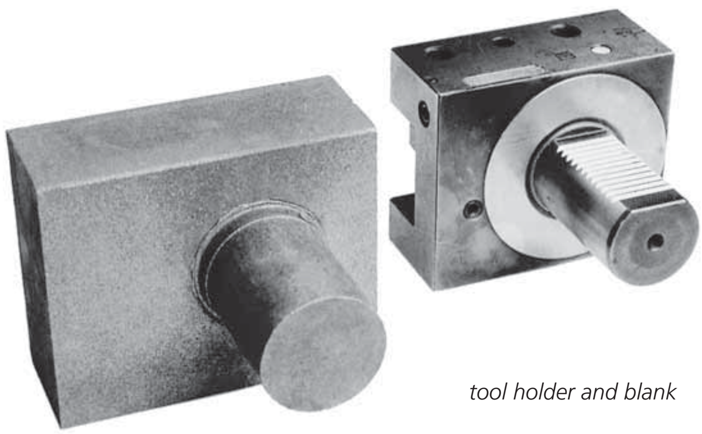
Friction welding reduces material and manufacturing costs



prepared blank

tool holder for NC-Lathes in compliance with DIN 69880

Standardised VDI tool holders in compliance with DIN 69880 are invariably used for accommodating stationary and driven tools in CNC-automatic lathes and machining centres. The machining of these tool supports from the solid is very cost-intensive due to the long machining time and high wastage. Friction welding offers a cost-effective and technically equivalent manufacturing alternative. Two sawn sections made from steel rod and square or flat steel bar are friction welded to a blank, which has only a small overall machining allowance. With complex structures, the square bar can be accordingly pre-machined as rod so that only one machining tolerance is required at the shank part, and no machining of the outer contour of the tool holder is required. The quality of the friction welded joint guarantees satisfactory and homogenous joining of the two components. Its properties are comparable with the variant manufactured from one piece. The tool holder blanks are manufactured from C45 and/or 16MnCr5 material. Hardening or tempering across the friction welded zone is possible without restriction.



tool holder and blank

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High-quality work pieces through friction welding

Friction welded precision cast components and shafts.

pinion shaft

front axle-carrier tube

With the further development of the precision cast- and precision forging technology, new avenues were sought to manufacture complicated forms in machine and gear construction. Many of these components usually have a shaft-like shank which requires the use of large and expensive presses and plants, and the break-even point is therefore soon reached, often limiting the use of this technique. By separating these parts into a shaped component and a shaft component, shaped components with low piece-weights are required.
Single components manufactured in this way are joined to a high-quality workpiece through friction welding. The special advantages of friction welding, which are a high degree of mechanisation, good reproducibility of the welding parameters, guarantee joints with a constant high level of quality.

gear shaft

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Design freedom through friction welding

Friction welding in gear construction

eccentric shaft

bevel gear shaft

Friction welding is often used in gear construction, with two advantages of friction welding being used. In one respect, friction welding offers the opportunity of combining high-quality hardened- and tempered steel with less expensive steel and in another a considerable amount of machining costs can be saved by using friction welding.

Pinion shaft

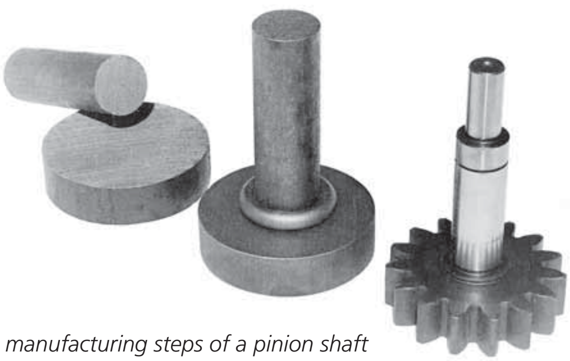
Both advantages become clear by the pinion shaft shown below and its development stages. By welding two sawn sections to one blank with low machining allowance, the manufacturing costs compared with other alternative methods of manufacture are very low. Furthermore, there is the opportunity of producing the two components from different materials to accommodate the stress. Materials used are carbon steel (C45, C60), case hardening steel (16MnCr5, 20MnCr5), or quenching and tempering steel (42CrMo4).

Bevel gear shaft

Machined components can also be joined with each other through friction welding. In the case of the bevel gear shaft shown made of C45k, the machining of the bevel gear is made easier. The welded-on stub shaft is machined after the friction welding. The full-area welding of the two shaft components to each other guarantees the full load of the component.

Eccentric shaft

An eccentric shaft can be made from round bar sections through friction welding. The advantages of this solution to the problem are again saving in material and lower machining costs. The advantages of friction welding provide greater design freedom, which may be used for innovative product solutions.



manufacturing steps of a pinion shaft

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Low Costs and High Quality

Cost-effective manufacture of milling spindles

The special advantages of friction welding have, for many years, been successfully applied in the manufacture of milling spindles in compliance with DIN.
In the past, the geometric form of the components led to high costs in drop-forging or in machining from blank material. These costs are considerably reduced through the separation into a steep-angle taper component and a shaft component. The steep-angle taper component is conveniently produced as a forged component in large numbers. The smaller dimensions reduce the die costs, which furthermore are redeemed sooner by the large number of pieces. The shaft component is sawn from commercial steel bar in any diameter or length.
No further machining is needed before friction welding.
The allowance for the finished machining of the friction welded blanks is only 3 to 5 mm on the diameter, so that only minimum metal-cutting costs are incurred.
The brief application of heat and the narrow heat-affected zone give rise to the fact that with the case hardening steel 16 MnCr5 used, no expensive post-heat treatment is required. The necessary tempering of the finished component across the weld zone is possible without any problems and does not affect the quality of the friction welded joint.

steep-angle taper and shaft component

friction welded blank

tempered finished component

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Fun with driving and safety through friction welding

Used of friction welded components in automobile manufacture

lorry brake piston

dynamo armature

prop shaft

Friction welding has been used for many years in the automobile industry because of its reliability and economic viability. In modern motor vehicles, friction welded components are found in the most varied function elements, of which three examples are shown here:

Example: lorry brake piston

The elements of lorry brake pistons are subject to the highest safety requirements, which are met by friction welding. In the manufacture of brake pistons, a through a special burnishing and stamping process manufactured disc made of St 37-2 and a threaded stud made of X12CrMo517 are joined to each other. By complying with narrow tolerance zones, an installation-ready function element is produced here through friction welding, which is fabricated without further machining in the assembly.

Example: dynamo armature

The friction welding process is also used for a new generation of water-cooled dynamos for the manufacture of armatures. In this case, the drop-forged claw pole made of St 37-3 is friction welded to a round bar section made of C60. Apart from achieving an all-over joint in this case through the friction welding, the design of the drop-forging component is simplified in one respect and in another the machining costs are considerably reduced.

Example: Prop shaft

As many as two friction welded joints are used in the manufacture of a prop shaft. In separate welding processes the drop-forged end pieces made of Ck35 are welded to a tube section made of Ck35. By using friction welds, the wall thickness of the tube section can be reduced compared with other welding processes and therefore the moving mass is reduced. The quality of the friction welded joints is proven by the spot-check implementation of component bending tests.

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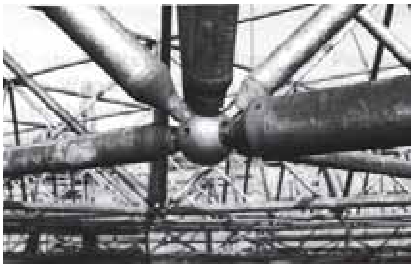
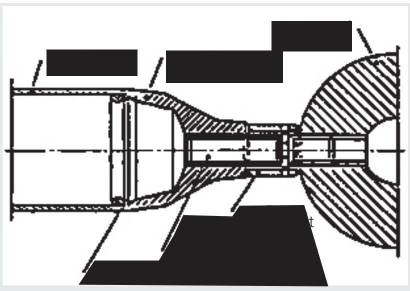
A modern joining process for steel-framed structures

Friction welded polygon space frame members



ice sports hall, frankfurt/main truss point



connection of a frame member of RFW-System Züblin to the node ball

The use of industrially prefabricated individual components is already realised to a very high degree in steel-framed structures. Further rationalisation has been achieved through the successful use of friction welding technology.
Ed. Züblin AG, as the applicant, and Klaus Raiser GmbH, as the manufacturer, have obtained the federal-wide approval for the friction welding process for the first time in steel-framed structures from the »Institut für Bautechnik« under the approval No. Z-144-9.
Klaus Raiser GmbH introduced this process to international specialist visitors at the »Schweißen und Schneiden ‚85« exhibition.
Friction welding, which has been used with great success in the metal working industry for many years, stands out in this respect by a high level of quality, manufacturing safety and easy reproducibility.
It reads in the approval notification: »the friction welded joints should be considered as a butt seam with full wall thickness and proven seam quality as specified in DIN 4100«. This means that the factor 1.0 is used for friction welded joints, which compared with other processes having a factor 0.8 corresponds to an increase in the allowed load of 25 %.
The sawn-off tubes are friction welded to the drop forged connecting pieces. The tubes and forged parts are manufactured from St 52-3 material in diameters from 60.3 to 127 mm, with wall thicknesses from 2.6 to 12 mm and in lengths of 6 m. The manufacture is carried out on the basis of precisely specified standards, the set data are controlled by a monitoring system and each weld is recorded.
The external inspection is carried out by FMPA Baden-Württemberg on the basis of an inspection contract; spot-check tensile tests down to fracture are conducted during the manufacture, the fracture must occur in the tube cross section. Frame members produced in this manner become high-quality support elements with the minimum of material consumption through subsequent machining to length and applying a screw thread.

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Materials from A to Z

Aluminium to Zirconium Oxide

7-metal shaft

Al-CrNi specimen component formed after friction welding

A great advantage in friction welding is the possibility of joining the most varied materials to each other. The fact that the joint formation does not outflow over the fusible phase, makes it possible to join very different materials.
A large number of friction welded material combinations are used in industry. Friction welding is widely used in joints of ferritic with austenitic steel. Such joints are used in almost all industrial sectors.
In addition, the possibility of joining steel with cast materials is also utilised.
Even more interesting than the possibilities for the joining of different steel materials are the possible combinations of different non-iron material with each other or with steel. In vacuum engineering these are primarily aluminium-steel joints which are used. Steel-copper joints for pressure cast pistons and aluminium-copper joints for the electrical industry are also made by friction welding.
The list of materials that are joined to each other using friction welding can be continued without nearly any restriction from aluminium to lead, hard metal, magnesium, nickel based alloys and tungsten to zirconium oxide.
Many of the material combinations have been proven in practice, others, such as ceramic-metal joints, are being implemented. The possibilities for friction welding of different materials have surely not yet been exhausted.

different ceramic-aluminium joints

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On the move

Friction welded lorry axles

The automotive industry was one of the first sectors to recognise the many possibilities of Friction welding and consistently made use of this for their products as early as the end of 60's. Today, Friction welding is increasingly used as an economic and reliable joining process in areas where the highest static and dynamic strength characteristics are required. Friction welded car wheel rims and friction welded lorry axles are the »driving« proof of this. Because of the good joining properties of Friction welding, the wall thickness of the axle bodies forged from S355 material could be reduced for lorry axles. The higher loaded axle pins were produced from S460QL, which is a higher-grade material. The resulting weight reduction has a positive effect on the lorry pay load and fuel consumption. The high joining accuracy of Friction welding makes it possible for the welded-on bearing pins to be fully machined before welding, thus eliminating the need for costly and laborious lathe machining after welding.

rear axle

front axle

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Manufacture revolutionised

Friction welded piston rods

friction welded piston rods

The Friction welding process has completely changed and simplified the manufacture of piston rods for hydraulic cylinders. In the past, piston rods were produced either from forged component blanks or by fusion welding. The blanks then had to be turned, ground and individually chromium-plated, a costly and laborious process. Friction welding makes it possible to use chromium-plated material by the metre and surface-hardened bar stock, as needed. This is cut to length for the Friction welding and finish-machined at the end not welded. In principle, both the piston and the head piece can be friction welded to the rod. The connecting component can be either a forged, cast or flame cutted part manufactured from solid material. Depending on the required tolerance, the head pieces are finish-machined before or after the Friction welding.

Friction welding makes it possible to use the same connecting components for various rod lengths and diameters. The standardisation of the connecting components allows the manufacture of larger piece numbers and reduces the tool and die costs.
In contrast to the fusion welded piston rods, the entire rod cross-section can be welded using Friction welding, leading in many applications to the fact that a smaller rod diameter can be used. The reduction in weight of the hydraulic cylinder associated with this is a significant factor in many areas of the agricultural and building machinery industry. Furthermore, Friction welding allows the use of various heat-treated steels for the manufacture of piston rods. Frequently used are 20 MnV6, 39 MnV6 and 42 CrMo4. Different materials may be used for rod and connecting component.

Components and finished piston rod

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