

An Advanced Repair Technology: Narrow-Groove Welding

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Hickham Industries, a Division of Sulzer Turbomachinery Services, has become a leader in the weld repair of industrial turbomachinery. In order to cut down welding time and welding material consumption, Hickham offers – in addition to current capabilities – a new welding process: Rotating Tungsten Narrow-Groove Welding, an advanced automated arc welding process.

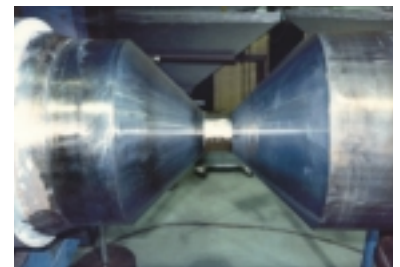
The most common weld repairs made to highly-stressed shafting are Submerged Arc Welding (SAW) repairs. This technology has been successfully used until now to add or replace material on rotors. However, the attachment of stub shafting via this process requires the application of large amounts of filler material. Figures 1[■] and 2[■] show the groove joint prep configuration for SAW. A typical stub shaft repair may take up to 20–125 pounds of weld metal. Machining the stub shaft and rotor will take several hours longer for SAW than for narrow-groove weld prep.

FASTER AND WITH LESS WELDING METAL

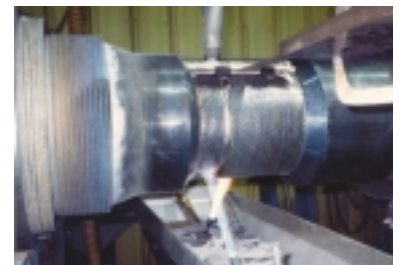
Rotating Tungsten Narrow-Groove Welding (RT-NG), a newly developed welding process for the repair of turbomachinery, has had a great impact on joint preparation, filler

metal deposit, heat input, and arc-on time, etc. In contrast to SAW, a typical RT-NG stub shaft repair may take up to only 2–30 pounds of weld metal, and arc-on time is about three times faster than SAW, with the repair quality being equal to or better than SAW.

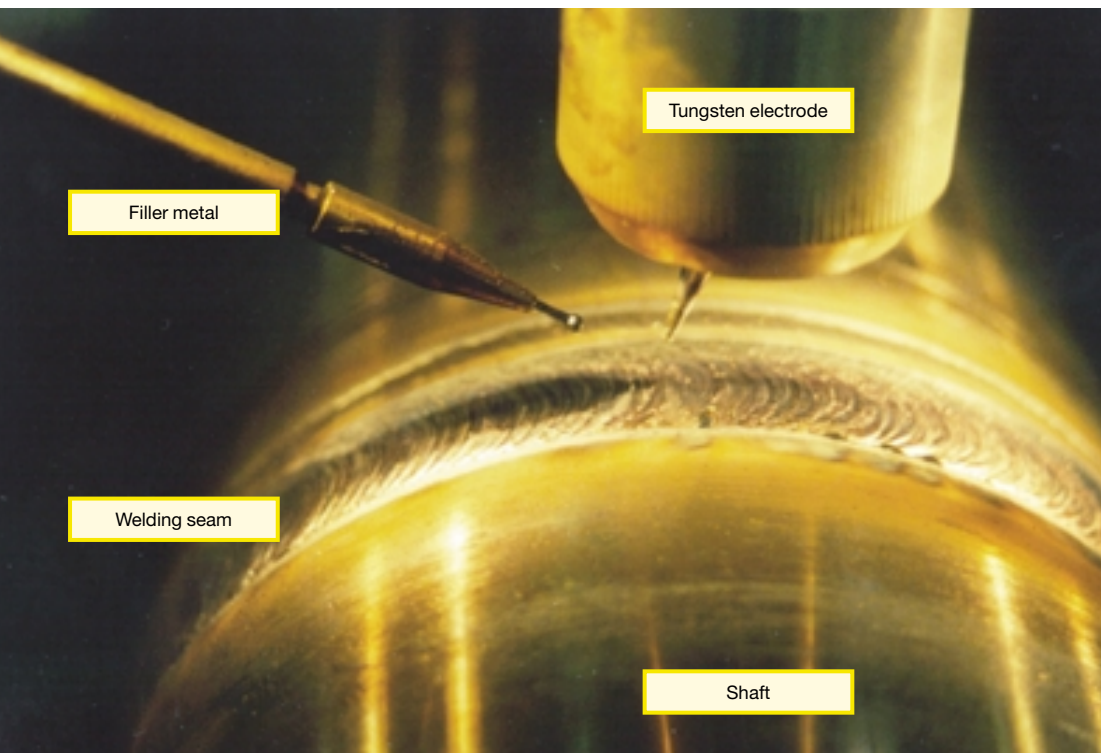
The RT-NG process uses an inert gas to protect the weld zone (molten puddle) from the atmosphere. The process directs arc energy to achieve consistent side-wall fusion by transverse rotation (side-to-side oscillation) across the width of the weld groove with an angled tungsten electrode (Fig. 3[■]) and provides effective deposition rates with all position welding capabilities. The necessary heat for welding is provided by an electric arc between a virtually non-consumable tungsten electrode and the work piece. Because the electrode is essentially non-consumable, a weld can be made by



1[■] Submerged Arc Welding (SAW) is the conventional process for stub shaft repair. Look at the groove joint before welding starts.



2[■] The conventional SAW requires high filler metal weld deposition.



3[■] Positioning the newly developed Rotating Tungsten Narrow-Groove Welding (RT-NG) system prior to arc striking.

fusion of the base metal without addition of filler metal. In most cases, a filler metal may also be used, depending on the requirements that have been established. The equipment includes in-the-groove video cameras and digital controls for precise manipulation during welding (Fig. 4[■]).

The use of an RT-NG process offers the following important advantages: It reduces the groove preparation, the arc time, the overall heat input, the heat-affected zone (HAZ) width, and the distortion. Furthermore, it allows for the production of superior quality welds, generally free of defects, and for precise control of the welding variables.

4[■] A new shaft end is being attached by the RT-NG process. Video cameras looking into the groove ensure precise control.

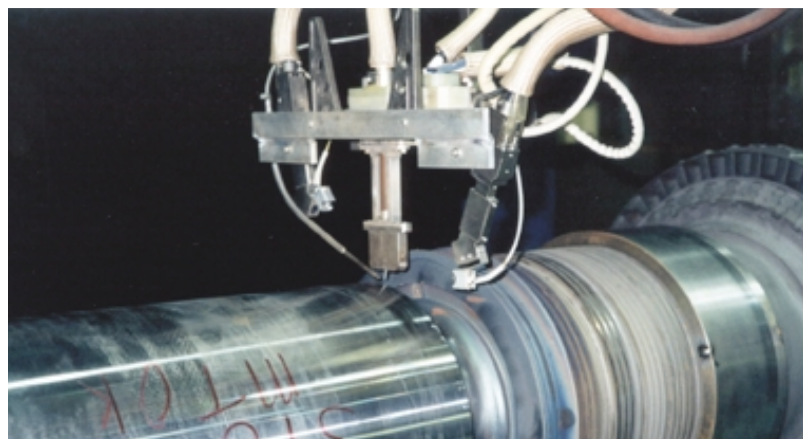
REPAIR PROCESS DEVELOPMENT

To qualify a weld procedure, test samples are prepared using a mock-up simulating the actual configuration that would be weld-repaired and machined to final dimensions. During the initial weld and stress relieving process phases of the mock-up test, evaluations are made as to the ease of welding, weld quality, and at the same time generating the mechanical test specimens. After completing the welding of a mock-up per the pro-

posed procedure, the mock-up is tested and approved by a third-party accredited test facility. The following tests validate the process:

- Bend test
- Tensile test
- Metallurgy photomicrograph
- Chemical analysis, hardness readings, and impact test of base, HAZ, and weld metal

The application of the repair process is specifically targeted to highly-stressed rotors used in turbomachinery.



QUALIFIED REPAIR PROCESS

Once a rotor is characterized as serviceable, Hickham Industries' qualified and standardized repair procedures are used in the repair of the damaged area(s) of the component. These procedures are structured to assure a high-quality and consistent weld repair. Below are the repair steps that are followed:

- The rotor is machined for welding to assure that all damaged base material is removed and the HAZ of the weld is positioned in a non-critical area. Position of the weld is often decided after subjecting the rotor to a Finite-Element Analysis (FEA). FEA application to a rotor repair methodology is a key factor to success.
- The rotor is non-destructively tested (ultrasonically) after rough machining to assure that suitable base material is available for the weld deposit.
- The rotor is weld-repaired, using a qualified weld procedure like RT-NG repair.
- The weld is rough-machined for non-destructive testing.
- Non-destructive testing (ultrasonic) is conducted on the weld-repaired area.
- The weld is stress-relieved in the vertical position to minimize distortion.
- Hardness tests on both the weld deposit and base metal are conducted to assure that the final hardness criteria are achieved.

- Non-destructive testing (ultrasonic) is conducted on the weld-repaired area after stress relieve.
- The rotor is final-machined to engineering drawing requirements.
- Final non-destructive testing (magnetic particle) is conducted on the weld repaired area.

All processes and tests are performed strictly to the written procedures, and all results are documented.

SUBSTANTIAL CUSTOMER BENEFITS

Figure 5[■] shows the application of RT-NG to a 30-MW steam turbine used in a syn-gas compressor drive application. The steam turbine is double-end-driven, and one end developed a crack near the coupling attachment. By use of the RT-NG technology, the shaft end

was reconfigured and returned to service in a short period of time. Substantial benefits accrue to turbomachinery owners when this repair or recovery technology is applied to their equipment. Savings in time, product loss and new part charges are substantial. Ω

FOR MORE DETAILS

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5[■] A weld repair technician with remote pendant is finalizing a 30-MW steam turbine rotor shaft end.