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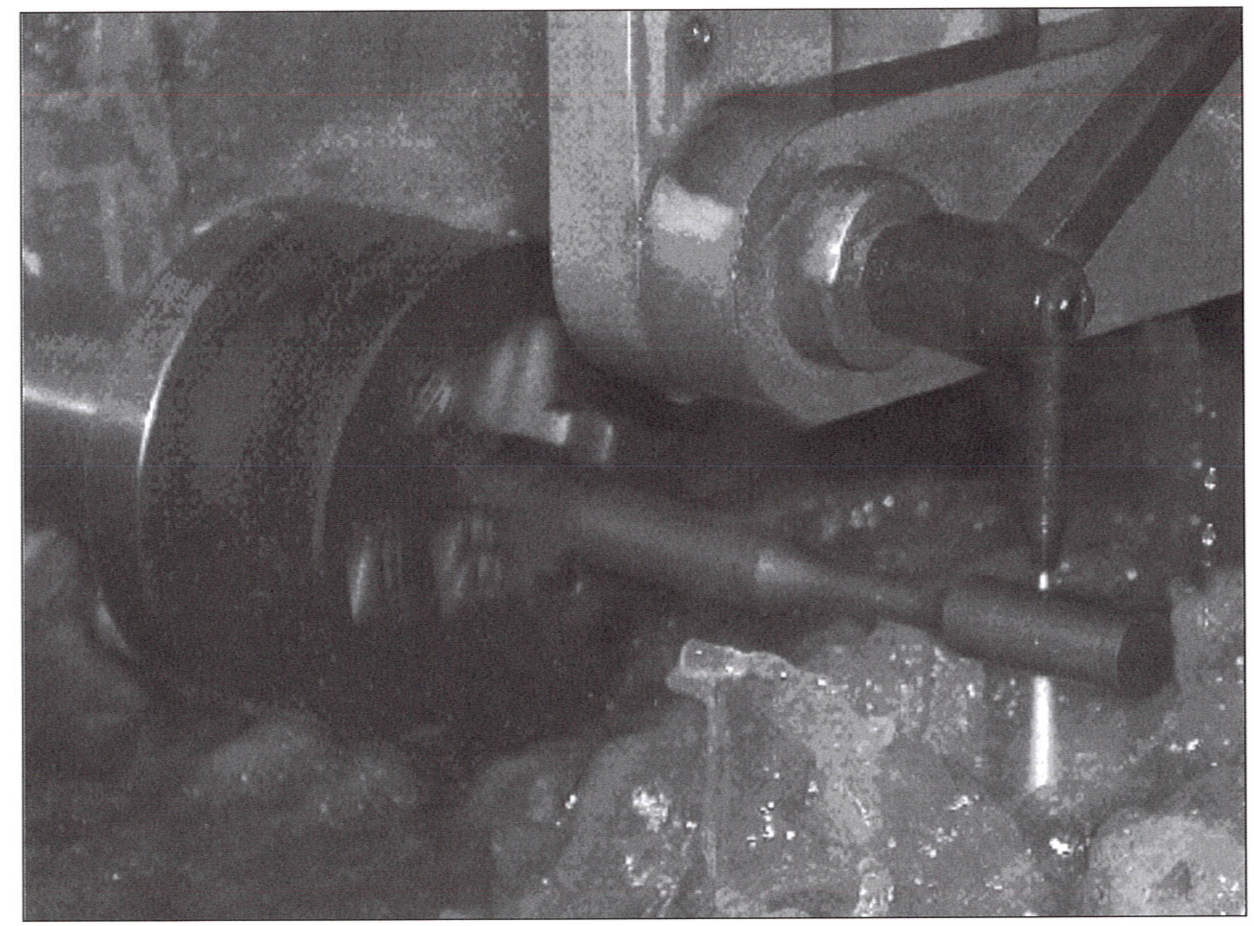
Abrasive Waterjet Used As A Tool For Producing Material Test Specimens



Abrasive waterjet turning of a fatigue test specimen. See article on page 2.

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Abrasive Waterjet Used As A Tool For Producing Material Test Specimens, from page 1

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ABSTRACT

This paper high-lights the potential for abrasive waterjet machining in the field of producing test specimens, pointing out advantages such as high machining efficiency, low material waste and flexibility in the sense that the method can be used for any material. Further, specimens can readily be cut from complex or difficult-to-handle work pieces as tubes or large sheets of material. Also, the benefit of being able to easily cut combinations of materials; as can be found in welded, soldered or adhesive joints; is shown. Two different applications are presented in this paper.

The first case deals with cutting of weld metal test specimens from plates and tubes. The benefits over conventional methods as sawing and milling are discussed from a geometrical point of view, as well as from a material properties point of view considering for instance work hardening in several of the machined material types. Further, the number of machining operations needed is significantly reduced.

In the second case, test specimens of an intermetallic compound (molybdenum silicide, $MoSi_2$) were produced using abrasive waterjet turning. It was found that the cost of manufacturing the test specimen with AWJ turning could be considerably lower than the cost using conventional manufacturing methods. An additional potential benefit from using AWJ in this context is the fact that the work piece for the specimen could be cut out from the bulk material of the product to be manufactured.

1. INTRODUCTION

Abrasive waterjets (AWJ) have due to its versatility become widely accepted as a tool for manufacturing parts out of virtually any material for various applications. The method is used in small job shops as well as in advanced manufacturing facilities in aerospace industry.

In modern industry high demands on product quality and safety, require standardized work procedures and accreditations. Due to this fact, test engineering has become a growing market. A significant field is the testing of materials and materials joints. Here, AWJ cutting has proved to be an efficient alternative to conventional machining in the manufacturing of the test specimens. Since the method causes minimal thermal and mechanical surface integrity deterioration, it is becoming increasingly used in material testing laboratories for test specimen preparation. In Sweden, several laboratories have found the versatility of AWJ cutting so useful that they have invested in a system of their own. This paper presents two Swedish applications where AWJ have proved useful for manufacturing of test specimens.

Testing and analysis of material samples is made on a regular basis at the different steps of a product's life cycle. For example, test specimens need to be produced for:

- Materials testing (e.g. tensile strength, impact toughness, fatigue strength and metallographic studies).
- Verification of manufacturing processes (e.g. local strength of material in components, welds, solderings and metallographic studies).
- Damage analyses of failed components (predominantly metallographic studies).

For the *first two applications*, metal test specimens can be directly turned to shape from solid bars. The circular shape is often preferred as edge effects can be minimized. In case of plate or tube material, or a full component, they are generally sawed out and then machined to specified shape, related to the type of testing. For hard materials, e.g. engineering ceramics, this procedure becomes more demanding, usually requiring diamond grinding for material removal. In general, also AWJ machining can be an efficient alternative method for machining this type of material, sometimes enhanced by the use of alumina abrasives which significantly increase material removal rates for several engineering ceramics (Kahlman et al).

In the case of a *damage analysis*, the analyzed object is a failed component. In general, only the location of actual material failure is of interest, whereas in such cases, the need is to extract only such a small portion of the component as to be able to accommodate it in the analysis equipment (e.g. SEM, microscope etc.).

Surface finish requirements of test specimen differ depending on choice of test method and material of the specimen. In general, tensile test specimens for material testing that are not high strength or that are ductile are usually rather insensitive to surface finish effects. The reduced sections of machined test specimens must, however, be free of detrimental characteristics such as cold work, chatter marks, grooves, burrs, etc. For fatigue testing surface irregularities

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Welcome WJTA New Members, from pg. 15

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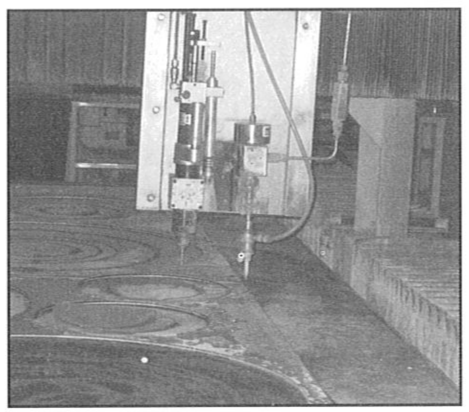
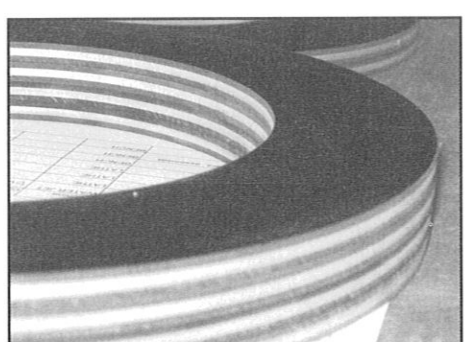
Retrofitting A Waterjet Cutting Machine, from page 8

Pikotek programs all its parts offline on a computer system in the office. Downloading nested parts programs sometimes took up to one or two hours, depending on the size of the nest and the individual parts in the nested program. The new Burny controls can accept programs much faster. Downloads that took up to two hours with the previous system, have been reduced to less than 10 seconds with the Burney controls.



Although the Burny controls and drive systems were primarily installed to solve excessive download times and poor machine accuracy, the new controls have supplied additional productivity improvements. Each new control displays the cutting sequence graphically and Pikotek can now verify download accuracy, part spacing and part separation without having to perform time consuming test runs prior to starting the actual cutting process. Another benefit in both controls is the operator's ability to interrupt the cutting sequence and cut another part, then return to the original cutting sequence without losing positional accuracy.



Below are just a few of the "before and after" observations shared by Schibbelhut.

Average time for operation

	Old control/drives	Burny 10LCD Plus/Servopak drives
Program download times	10 to 60 min.	3 to 6 sec.
Cutting speed (Laminated material)	20 to 22 IPM	30 to 31 IPM
Cutting speed (Fiberglass material)	60 to 70 IPM	240 to 250 IPM

Specific applications

Old control/drives **Burny 10LCD Plus/Servopak drives**

Program #1 cutting 200 each 2"-300

Program download time	1 hr. 50 min.	5 sec.
Cutting time	12 hrs. 15 min.	5 hrs 58 min.

Program #2 cutting 181 gaskets

Program download time	1 hr. 32 min.	7 sec.
Cutting time	8 hrs. 5 min.	4 hrs 20 min.

Program #3 38 gaskets

Program download time	35 min.	5 sec.
Cutting time	2 hrs. 7 min.	1 hr. 18 min.

In conclusion Schibbelhut stated, "Accuracy and productivity went up and overtime went down. We plan to see a return on our new retrofit investments in less than a year."

Contributed by CMC Burny, Cleveland, Ohio, phone: (800)321-8072, fax: (216)642-2199, www.burny.com

Nominations Open For WJTA Board Of Directors

"Nominations for the WaterJet Technology Association (WJTA) Board of Directors are now open," says WJTA Secretary Jack Russell. "The duties of the directors are truly challenging and rewarding."

The terms of office of Craig Anderson; G.J. DeSantis; Mohamed Hashish, Ph.D.; Randy Kruger; George A. Savanick, Ph.D.; and David A. Summers, Ph.D.; will expire in August 2005. Therefore, nominations are sought for six (6) board members, each to serve a four-year term of office beginning August 20, 2005.

The WJTA bylaws provide that no more than one of the elected board members may be from the same company or organization. Therefore, board members may not be nominated from the same company or organization already represented on the board by individuals whose terms expire in 2007, including: Jack Russell; DeBusk Industrial Services Company (Pat DeBusk); Advisory Council (Lydia Frenzel, Ph.D.); High Pressure Equipment Company (Larry Loper); NLB Corp. (Forrest Shook); and StoneAge, Inc. (John Wolgamott).

According to the WJTA bylaws, any WJTA member in good standing (2004 membership dues paid) may submit a nomination(s). Nominees must also be WJTA members in good standing. The deadline for making nominations is **March 18, 2005.** Your nomination(s) should reach the WJTA office **no later than March 18, 2005.** To submit a nomination(s), complete the Nomination Form and return to:

Chairman, Committee on Nomination
WaterJet Technology Association
906 Olive Street, Suite 1200
Saint Louis, MO 63101-1434
Phone: (314) 241-1445
Fax: (314) 241-1449

Remember, nominations must be received **no later than March 18, 2004.**

Nominations/Elections Procedures

In accordance with the bylaws of the WaterJet Technology Association, revised in 2002, nominations and elections to the Board of Directors include the following procedures:

- At least two calls for nominations to the board of directors will be published in the *Jet News*. The first call for nominations appears in this issue. **Nominations will be accepted through March 18, 2005.**
- An official ballot listing the eligible nominees and a brief biographical sketch for each individual will then be forwarded by mail to all eligible voting members of the Association on May 18, 2005. **Signed and executed, ballots must be mailed to the Association's office for tallying by July 1, 2005.**
- The names of newly elected board members will be announced in the *Jet News* and on the WJTA web site.

Only eligible members of the WaterJet Technology Association may submit a nomination and nominees must be eligible members of the WaterJet Technology Association.

WJTA WaterJet Technology Association Nomination Form

Name Of Nominee ____________________ Title ____________
Address ____________________
City ____________________ State ____________
Country ____________________ Postal Code ____________
Telephone
In US/Can (____) ____________ (area code) Outside US/Can [____] (____) ____________ [country code] (city code)
Fax
In US/Can (____) ____________ (area code) Outside US/Can [____] (____) ____________ [country code] (city code)

Attach biographical information with a brief statement of your nominee's mission and vision for WJTA.

Name Of Nominator ____________________ Title ____________
Address ____________________
City ____________________ State ____________
Country ____________________ Postal Code ____________
Telephone
In US/Can (____) ____________ (area code) Outside US/Can [____] (____) ____________ [country code] (city code)
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In US/Can (____) ____________ (area code) Outside US/Can [____] (____) ____________ [country code] (city code)

Articles On Hydrodemolition Published In *Jet News*: Index

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Conjet Launches New Hydrodemolition Machines	10/97: p. 7
Hydrodemolition	11/00: p. 8,13
Hydrodemolition At A Historic Swimming Pool In Finland	5/03: p. 7
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Hydrodemolition In A Portuguese Dry Dock	10/99: p. 1
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Practical Aspects of Hydrodemolition	9/00: p. 2,20

Safety Committee Solicits Comments On Improvements To Recommended Practices

The WJTA Safety Committee hereby solicits comments regarding improvements to the publication, Recommended Practices for the Use of Manually Operated High Pressure Waterjetting Equipment. While Recommended Practices is reviewed periodically at the biennial conferences of the WaterJet Technology Association, your comments and suggestions for improving the publication are invited and welcome anytime.

Please address your comments and suggestions to: Safety Committee, c/o WJTA, 906 Olive Street, Suite 1200, St. Louis, MO 63101-14134, fax: (314)241-1449, e-mail: wjta@wjta.org, web site: www.wjta.org.

3.4 Advantages and Possibilities using AWJ Turning

The cost of manufacturing the test specimen using AWJ turning should in this case be compared to using diamond wheel grinding. As no optimization effort was made yet for the selection of the AWJ turning process parameters, the exact savings can not be quantified. However, considerable economical savings from using AWJ turning can be foreseen in this early stage for this application.

In a similar industrial case for which a new material is being developed, larger pieces will be cast and sintered, and the final shape will be produced using a combination of AWJ machining, EDM and grinding operations. Due to an inherent variation of defect-density it would be advantageous to be able to extract the specimen from the same material batch as the actual part. This yields representative measurements of material properties. In this context an important feature of the abrasive waterjet is that it can be applied to cut out work pieces from a larger bulk material. As it is possible to use AWJ turning for producing cylindrical shapes also for irregularly shaped cross sections, a test specimen can easily be turned from, for instance, a square work piece. Figure 6 shows schematically an extraction of a square-sectioned work piece. The cut-out can be made using slotting (milling) or cutting, depending on the thickness of the bulk material. For the part in question a feasibility study is under way looking into the possibility of extracting a specimen work piece. This must be made in an appropriate stage of the manufacturing taking into account the whole manufacturing of the part.

4. CONCLUSIONS

- AWJ has shown to be a viable method for extracting weld test specimens out of plates and tubes.
- The most important advantages in cutting weld test samples are reduced costs and a negligible influence on the cut surface properties.
- Abrasive waterjet turning has a potential for economical savings in manufacturing of round cross-sectioned test specimens in difficult-to-machine materials such as ceramics and inter-metallic compounds.
- Tolerances and surfaces produced using AWJ turning are adequate for round cross-sectioned tensile test specimens.
- It is possible to use AWJ turning also for irregularly shaped cross sections. Therefore, work pieces for a test specimen can easily be extracted from the bulk material of a part, giving a better representation of the materials characteristics.

5. REFERENCES

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Carlström, E. et al: "Keramguiden", Swedish Ceramic Institute, 1989.

Hobbacher, A.: "IIW Fatigue design of welded joints and components" Abington Publishing, 1996.

Holmqvist G., Öjmertz, K.M.C., Bergengren, Y. and Fronzaroli, M.: "Influence of Abrasive Waterjet Cutting on the Fatigue Properties of Extra High-Strength Steel ", proc. 10th American Water Jet Conference, Houston, TX, USA, 1999.

Kahlman, L.; Öjmertz, C. and Falk, L.: "Abrasive-waterjet testing of ceramic thermal wear", Wear, n.248, 2001, p.16-28.

SIS – Metalliska material (Swedish Standards Institute – Metallic Materials): "SS-EN 287-(1-2), Approval testing of welders – Fusion welding - Part 1 to Part 2", 1997.

SIS – Metalliska material (Swedish Standards Institute – Metallic Materials): "SS-EN 288-(1-9), "Specification and approval of welding procedures for metallic materials - Part 1 to Part 9", 1995.

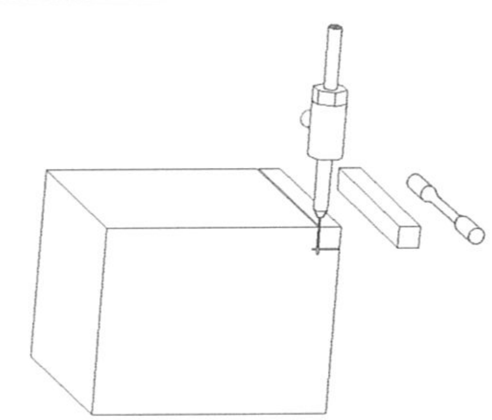

Figure 6. AWJ extraction of workpiece from a larger piece of material.

become more critical (ASM Handbook, 2000).

Testing laboratories find the AWJ process produces surfaces of satisfactory quality for tension tests of metals. The effect of surface irregularities of AWJ cut surfaces on fatigue properties is an area that still needs further investigation. A study on AWJ cutting of extra high-strength steel was performed in order to investigate whether AWJ cut surfaces produced fatigue lives comparable to conventional cutting methods of structural steels (Holmqvist et al., 1999). These tests indicated that the AWJ produced surfaces on fatigue test specimens yielded fatigue strength levels comparable to test specimens produced by machine flame cutting or shearing, as specified by the International Institute of Welding (Hobbacher, A., 1996). It was, however, noticed that on those individual test samples yielding the shortest fatigue life, the crack was initiated on the surface rather than at a corner, which was the case of most of the specimens. This indicates that on some specimens the AWJ process might have produced relatively rare irregularities or imperfections, possibly related to individual abrasive grains embedded in the surface, that act as initiation sites and thereby reducing the fatigue life.

2. EXTRACTING WELD AND SOLDERING SAMPLES OUT OF PLATES AND TUBES WITH ABRASIVE WATERJET CUTTING (APPLICATION 1)

2.1 Background

At present Sweden is adapting to European and international welding regulations. This means that a great number of welders need a certificate according to the Swedish standard SS-EN 287 (SIS, 1997) from an independent third party research laboratory to prove their welding skills. The standard SS-EN 288 (SIS, 1995) provides conditions under which tests are to be carried out i.e. welding process, welding position, material, dimensions, type of Welding Procedure Specification (WPS) etc. Every welder has to perform a number of procedure tests which will be subject to an evaluation proving the quality of the welds.

(continued on page 6)

Abrasive Waterjet Used As A Tool For Producing Material Test Specimens, from page 5

The evaluation consists of both destructive and non-destructive testing. Non-destructive tests count fracture tests in the surface as well as underbedded cracking. The destructive testing includes metallography as well as tension, bend and impact tests.

2.2 Extracting test specimen

The destructive testing requires test specimens with a certain geometry and surface integrity depending on type of test that is to be carried out. The conventional method to extract a test specimen includes:

1. *Sawing* – To extract a rectangular section out of the plate or tube. To access the inner of the material, i.e. the welded area, sawing is needed. (See figure 2.)
2. *Milling* – Milling is used to produce the correct tension test specimen shape.
3. *Grinding* – If the material is sensitive to work hardening (e.g. copper, titanium), the strain hardened surface of the test specimen resulting from the milling operation needs to be removed by grinding.

As an alternative to using these three operations, abrasive waterjet cutting has shown to be an interesting alternative method for extracting test specimens. This applies especially for the commonly used testing of butt welds of plates and tubes, see figure 1 and 2. For tubes, generally several test specimens are extracted consecutively along the perimeter. Det Norske Veritas Sweden AB (DNV) have used abrasive waterjet cutting for extraction of test specimens since 1997, and the test specimen preparation has furthermore been studied at Chalmers Waterjet Lab. The results finally convinced DNV last year (2002) to make an investment in a 2°-axis machine intended solely for this purpose.

DNV uses AWJ cutting for plates and tubes in all types of materials like steel, high-alloyed steel, stainless steel, titanium, copper etc. The most important advantages and drawbacks for this AWJ application are:

Advantages with AWJ:

- No heat affected zones.
- Negligible strain hardening of outer layer (consequently does not require subsequent material removal).
- Cuts various materials and shapes (contours) with the same tool.
- Can easily be used for both plates and tubes.
- Time and cost savings are made by reducing sawing, milling and grinding to a single AWJ cutting operation.
- The test specimen can be extracted directly from an arbitrary location within the plate or tube, without any excessive material removal, see figures 1 and 2.

Drawbacks with AWJ:

- A blasting effect occurs inside the tube which is hard to avoid, even when a catcher is inserted in the tube. This damages the surfaces of the non-cut specimens.
- Small diameters combined with greater wall thickness lead to geometrical errors of the test specimen.
- Cut surfaces are not suitable for all types of tests without subsequent surface finishing treatment (e.g. fatigue testing of hard materials).

3. ROUND CROSS-SECTIONED TENSILE TEST AND FATIGUE TEST SPECIMENS IN INTER-METALLIC COMPOUND (APPLICATION 2)

3.1. Test Material and Conventional Manufacturing Methods

In this industrial case test specimens from an inter-metallic compound were produced using abrasive waterjet

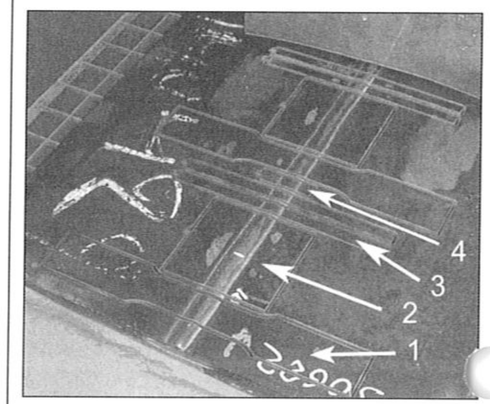

Figure 1. Different types of weld test specimens taken out of one procedure test:
1. **Tensile test**
2. **Impact test (to be split up into smaller test pieces)**
3. **Bend test**
4. **Metallography**

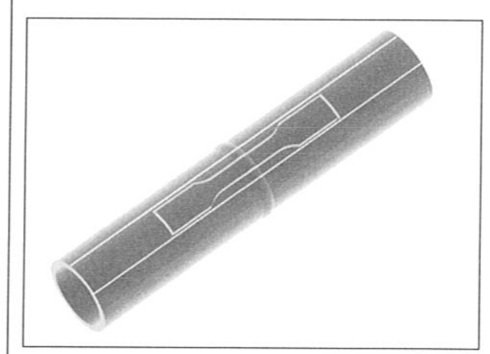

Figure 2. Schematic picture of one weld tensile test specimen taken in a tube. The lines show how the test specimen is to be extracted using sawing.

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Welcome WJTA New Members, from pg. 11

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WJTA WaterJet Technology Association

2005 WJTA American Waterjet Conference

August 21*-23, 2005 • Marriott Houston Westchase Hotel • Houston, Texas

Abstract Submission Form

For each paper to be submitted for consideration, please complete this form, **attach a copy of the abstract**, and mail or fax to WJTA by **December 31, 2004**. Authors will be advised by **February 28, 2005**, regarding the decision of the Abstract Review Committee. Please mail or fax this form even if you email your abstract.

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- ❑ Legal
- ❑ Other__________

Process
- ❑ Cutting
- ❑ Drilling
- ❑ Surface preparation
- ❑ Cleaning
- ❑ Stripping
- ❑ Safety
- ❑ Milling
- ❑ Jet-assisted
- ❑ Other__________

Related Industry
- ❑ Generic
- ❑ Shipyard
- ❑ Mining
- ❑ Construction
- ❑ Aerospace/Aircraft
- ❑ Automotive
- ❑ Oil/Gas/Refinery
- ❑ Quarrying
- ❑ Other__________

Jets
- ❑ Waterjet
- ❑ Abrasive-waterjet
- ❑ Abrasive suspension jet
- ❑ Pulsed
- ❑ Cavitation
- ❑ Polymer Jets
- ❑ Other__________

Material
- ❑ Metal
- ❑ Rock
- ❑ Glass
- ❑ Ceramic
- ❑ Composite
- ❑ Concrete
- ❑ Other__________

Environment
- ❑ Field work
- ❑ Factory work
- ❑ Submerged
- ❑ Nuclear
- ❑ Demilitarization
- ❑ Offshore
- ❑ Other__________

*August 21 is reserved for the short course(s).

Mail completed form and abstract, **NO LATER THAN DECEMBER 31, 2004**, to: **Conference Coordinator, 2005 WJTA American Waterjet Conference, WaterJet Technology Association, 906 Olive Street, Suite 1200, St. Louis, MO 63101-1434, USA, telephone: (314)241-1445, fax: (314)241-1449, email: wjta@wjta.org, web site: www.wjta.org**

Retrofitting Waterjet Cutting Machines With New Motion Controls And Drive Systems: A Case Study

Located in Lakewood Colorado, outside Denver, Pikotek is the world's leading manufacturer and distributor of critical service flange gaskets, spring-energized jacketed seals and electrical flange isolation kits for the oil and gas production, gas transmission, power generation and utilities industries. With over 15 years of experience sealing the most demanding applications, Pikotek's products provide sealing solutions of unparalleled quality and performance.

All of Pikotek's products are manufactured to comply with ISO 9001:2000 as certified by Lloyd's Register. All gaskets fully comply with ASME Boiler and Pressure Vessel Code Section 8, Divisions 1 and 2, ASME B16/B31 and API 6A piping specifications and are approved and used by the world's major pipeline companies and construction contractors.

Pikotek manufactures its products with two Ingersoll-Rand abrasive waterjet cutting systems for cutting both high and low pressure flange gaskets. Both waterjet systems are mounted to x – y cutting tables that, for ten years, were directed by numerical control technology. According to Larry Schibbelhut, Pikotek Production Manager, they were experiencing problems with finished part accuracy, part program-downloading time and unreliable tolerances. With high quality standards to meet and critical customer applications to satisfy, Pikotek could not allow its product quality to suffer. "We needed to do something to improve the quality of our old systems and we were considering new cutting machines," stated Schibbelhut.

Since the mid 1990's Dave DeHoff and Gary Gibbs of Colorado Cutting Systems have been servicing the Pikotek machines. DeHoff and Gibbs suggested Pikotek consider retrofitting

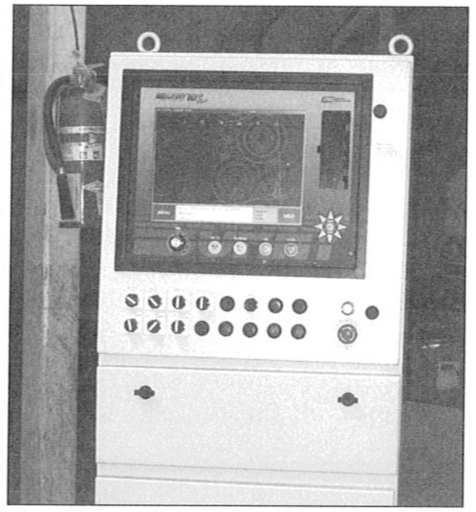
(continued on page 8)

Retrofitting A Waterjet Cutting Machine, from page 7

the existing machines with new PC based numerical controls and new drive systems. "In order to maximize productivity, Pikotek needed a control that could increase speed while maintaining accuracy," said Gibbs. "In order to meet these needs, we recommended Pikotek retrofit both machines with the Burny 10LCD Plus PC based numerical controls and a Burny Servopak drive system." In addition, Colorado Cutting Systems recommended Pikotek replace the drive rack on the machines. The retrofit package would be designed to correct all the current problems at a fraction of the cost for new machines. "In addition to a cost savings upfront, Burny products are solidly-built, reliable-controls that require virtually no post-installation service calls," added DeHoff. "Because of our experience with Burny controls we were confident the Burny 10LCD Plus would exceed Pikotek's expectations."

Although both systems used Ingersoll – Rand waterjet systems, the existing cutting machines were from different manufacturers with different numerical control configurations. Colorado Cutting worked closely with Burny to design two similar, yet different, retrofit systems to solve Pikotek's requirements.

One machine was retrofit with a Burny 10LCD Plus control, mounted in a special machine console, that contained all the input and output processing for the waterjet and new drive system. The drive system was mounted separately from the Burney Control in order to accommodate the cutting machine frame. In addition to the new Burny Servopak drive system, Colorado Cutting also replaced the drive rack on both travel axes.

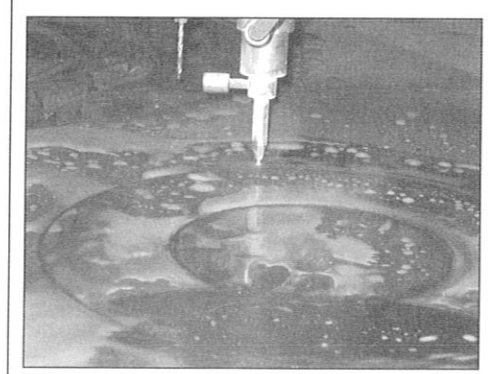


The second machine was also retrofit with a Burny 10LCD Plus control, but in a special standalone cabinet that contained the Burny control along with all the process input and output circuitry and the Burny Servopak drive system. The existing numerical control for this machine was originally in a standalone cabinet and it was determined that bringing in a complete new standalone cabinet was more economical than rebuilding and retrofitting the existing cabinet. Burny worked closely with both Colorado Cutting and Pikotek in order to deliver a system that would easily and quickly replace the existing cabinet.

In order to maintain production cutting, each machine was retrofit separately and Schibbelhut stated that in each case, "The machine was down for less than a week." Schibbelhut went on to say, "The results of the retrofits exceeded our expectations.. Productivity is up and it's like we picked up a third machine."

Since the installation of the Burney retrofit systems, the following machine performance improvements have been noted:

Machine number one had traverse speeds of 100 ipm before the retrofit and can now traverse between cuts at 400 ipm. Previously with the old drive system and motion algorithm in the old numerical control, cutting speeds were typically 20 ipm. With the new Burny 10LCD Plus and its advanced motion algorithm and the new drive system, cutting speeds have increased to 30 ipm on the material Pikotek cuts. The old drive system position feedback was replaced with a new high accuracy differential encoder system, which also helped improve accuracy. Schibbelhut said, "Thanks to the new drive mechanics, cut accuracy has gone from +/- .030 to +/- .010."



Machine number two had cutting speeds of 80 ipm on certain fiberglass material using the old system. After the retrofit, cutting speeds on the same material increased to 240 ipm. Accuracy on this machine increased to +/- .010 at 200 ipm cutting speed.

(continued on page 18)

2005 WJTA American Waterjet Conference

August 21-23, 2005

Marriott Houston Westchase Hotel • Houston, Texas, USA

Announcement and Call for Papers

Impressive progress and a fast-growing understanding of the diversified applications of waterjet technology are generating a growing excitement in the industry. New techniques and applications are being developed and current ones are being improved. Waterjet technology, now being used in nearly all types of industry — manufacturing, mining, construction, concrete, stone, aerospace, engineering, process, and medical industries — continues to expand at a rapid pace.

The **2005 WJTA American Waterjet Conference** will focus, from a practical and scientific viewpoint, on the most up-to-date advances in waterjetting equipment, techniques, and applications. The areas to be addressed include, but are not limited to:

- Abrasives, Water, and the Environment
- Advanced Industrial Applications
- Advances In High Pressure Technology
- Automotive and Aerospace Applications
- Cleaning and Coating Removal
- Components and Systems
- Construction and Non-Manufacturing Applications
- Contractor Applications and Processes
- Demilitarization, including Removal of Land Mines (Demining)
- Drilling Applications
- Excavation, Tunneling, and Mining Applications
- High Pressure Equipment and Systems
- Hydrodemolition
- Jet Mechanics
- Jet-Material Interaction
- Manufacturing Processes
- Market and Future Needs
- Novel Jets and Applications
- Process Modeling and Control Studies
- Rock Cutting
- Safety, Training, and Environmental Protection

Commercial and academic authors are encouraged to submit titles and abstracts for consideration. To submit an abstract(s), please complete the abstract submission form on the back of this sheet, attach a copy of your abstract(s), and forward to the attention of the Conference Coordinator at the WaterJet Technology Association. **The deadline date for submission of abstracts is December 31, 2004.**

An Abstract Review Committee consisting of five referees will review the abstracts. Authors will be advised by **February 28, 2005**, regarding the decision of the Abstract Review Committee.

The 2005 WJTA American Waterjet Conference is organized by the **WaterJet Technology Association** and is endorsed by the **International Society of Water Jet Technology**. The WaterJet Technology Association looks forward to providing this forum and to your involvement and participation.

Authors - Please Note

- Papers must be original. Papers must not have been published elsewhere or be pending publication.
- A nonrefundable publication fee of $495 is required. **This publication fee will be waived if at least one author registers (Full or Combo) for the WJTA Conference.** Also, one registration is good for multiple papers. The deadline date for receipt of your final paper will be **April 22, 2005**. The publication fee or payment for a Full or Combo registration is due no later than **June 3, 2005**. Your paper will not be included in the Proceedings if the publication fee or registration fee is not paid by this date.
- Papers and presentations must be in English. Papers should be no longer than 15 printed pages. A "Paper Guide" containing directions for submitting papers will be forwarded to you after your abstract is accepted. Papers that do not follow the "Guide" will be returned to the author(s) for correction(s) or charged a fee for revisions made by the WaterJet Technology Association office.
- Papers should be free of commercialism.
- Papers should be submitted as a Word file and a PDF file. If an author cannot produce a PDF file, a fee may be charged to convert a Word file to a PDF file if the Word file requires significant reworking (e.g., page breaks, pictures moving).

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NLB Opens California Branch Office

NLB Corp. has added a regional office in California for the convenience of customers in the western United States. The facility has NLB high-pressure and ultra high-pressure waterjet pump units for sale, rent or lease. It also gives waterjet users a local source of factory-trained service and a showroom full of the latest NLB accessories for general and specialized applications.

The new branch, located near Long Beach, brings to five the number of NLB regional offices around the United States. The address is 1323 E. Hill Street, Signal Hill, California 90755; phone (562)490-3277, fax (562)733-0780. A toll-free number, (877)652-2254, is available.

Branch manager Edward Regnier has 10 years of experience in the waterjet industry, and for the past two years has been an NLB technical service representative.

WJTA Administration

Best wishes for a Happy, Healthy and Safe New Year from the WJTA Officers, Board of Directors & Staff!

turning. The material was predominantly a molybdenum silicide ($MoSi_2$), which is used as a refractory material for industrial furnaces and heating applications. The standard process for the manufacturing of parts in the material, usually rods or tubes, is by extrusion of a prepared paste, followed by drying and sintering. Among the material characteristics can be pointed out a Vickers hardness of 9-11 GPa and a fracture toughness of 3-4 MPa$\sqrt{m}$. The material can thus be characterized as relatively hard and very brittle, and the characteristics correspond to that of engineering ceramic materials. These features render the material very difficult to machine, why previously possible machining methods for producing more intricate shapes have been limited to electro-discharge machining and/or diamond grinding and polishing. The method of choice until today for producing round cross-sectioned test samples in the material has been to use diamond wheel grinding to the final shape from a rod. Technically, forming (pressing) of a green body to a more near-net-shape would be possible. However, this has not been used for this material and would therefore require extensive testing and development. Furthermore, it would only be economical for large production series.

When testing the material properties of inter-metallic materials as well as engineering ceramic materials, there is generally a quite large scatter in test results. The reason for this is according to Carlström (1989) that these materials are very sensitive to defects, as well as the fact that the defect-density can vary considerably. The defects can be in the form of pores, impurities or accumulations of material components due to poor mixing. The sensitivity to defects is generally higher for materials with low fracture toughness, which is typical to these materials.

3.2 Test Specimen

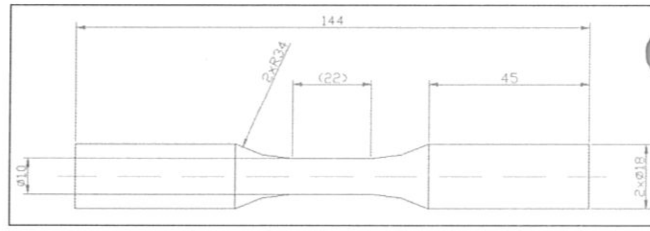

Figure 3. Test specimen geometry for testing of inter-metallic compound.

Figure 3 shows the geometry of the test specimen. Generally, round cross-sections of a test specimen is favorable since edge effects are avoided, making results more reliable and generally more consistent. The geometry in this case can be used for either tensile or fatigue testing. A fatigue test requires a surface roughness in the middle part of the specimen to be 0.2 µm or better. A threading of the ends can be a necessity for some types of equipment. In the present case, a testing device equipped with a hydraulic gripping mechanism is to be used, therefore a plain cylindrical shape is sufficient.

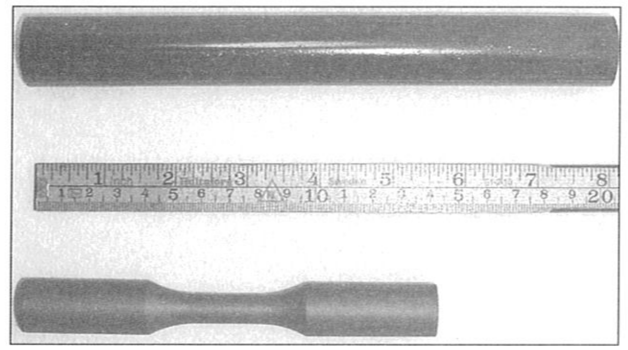

Figure 4. Work piece (top) and turned final test specimen (bottom).

3.3 Machining of Test Specimens using AWJ Turning

The work piece for the AWJ turning operation was a rod of 25 mm in diameter. Figure 4 displays a rod and an AWJ machined specimen. The glossy surface of the rod is a glass phase of the material occurring from the material processing. This phase is slightly more brittle than the base material. Figure 5 shows a specimen being turned. The rod was fixed in a chuck. No tail-stock was used. It was shown that the specimen could be turned in a series of 5 cuts using a parameter setting for typical abrasive waterjet cutting applications. Both ends were cut-off using AWJ turning. The geometry and surfaces produced were adequate for a tensile test. The surface roughness (Ra) produced was in the range of 2 µm. Consequently, for a fatigue test, the specimen would have to be polished.

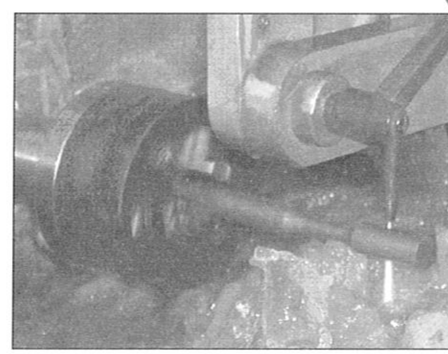

Figure 5. AWJ turning of a fatigue test specimen. Also pictured on the cover.

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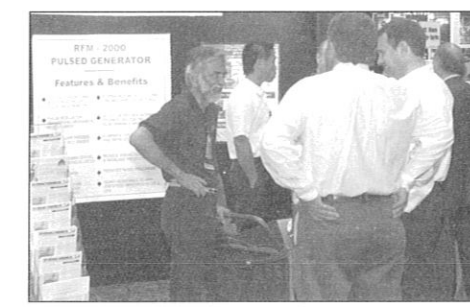
Early January



Watch your mail in early January for the Exhibitor Prospectus! You won't want to miss this opportunity to exhibit your products at the 2005 WTJA American Waterjet Conference.

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