Abstracts of IIW Documents ......(CUTTING)

I-904-90
Quality classification of thermally cut surfaces — comprehensive review of different standards
by Gunnar Engblom and Katarina Falck (Sweden)

A good classification system for thermally cut surfaces should contain the following :

— description of the parameters to be measured and classified;

— measuring methods;

— grades that refer to different areas of application for the cut surface. Will it, for example, be welded afterwards, and if so by means of what method, or will it be incorporated as a free edge in a structure ?

A quality classification system that meets the above requirements would facilitate :

— communications between customer and manufacturer regarding quality requirements :

— communications between designer and cutting operator by enabling the quality requirements to be specified on the drawing;

— the right choice of quality level by the designer, i.e. neither too high nor too low;

— the right choice of cutting machine for different cutting jobs by planners;

— the work of quality inspector;

— product development, for example, of cutting nozzles;

— welding mechanization where the surfaces to be incorporated in the welded joint have to meet high quality requirements.

The text describes the standards for quality classification of thermally cut surfaces existing in several countries. The emphasis is on the German industrial standard DIN 2310 from 1987.

IO-926-90/0E & IA-394-90/0E
Improvement in Bonding Strength of Si_3N_4-Mo Joint by Controlling Reaction Layer Thickness
by Yoshikuni KAKAO. Kazutoshi NISHIMOTO* and Kazuyoshi SAIDA**

Effect of the reaction layer on bonding strength of Si_3N_4-Mo joints bonded using Cu-base active insert metals was investigated in order to improve the bonding strength by controlling the reaction layer thickness. Bondings of Si_3N_4-Mo joints were conducted in vacuum at 1573K for 0-4. 8ks to alter the reaction layer thickness. Bonding strength was evaluated by tensile tests.

Bonding strength of joints could be improved up to about 100MPa, 90MPa and 120MPa by controlling the reaction layer thickness to about 40 m, 2 m and 4 m for Cu-5%Cr, Cu-1%Nb and Cu-3%V insert metals, respectively. In the joints with optimum thickness of reaction layer, the fractured surfaces were composed of the surfaces fractured in the reaction layer and at the interface between Si_3N_4 and reaction layer. Microstructures in reaction layers with less that optimum thickness were almost homogeneous, and the shape of interface between Si_3N_4 and reaction layer was almost flat. Defects such as porous zone and crack occurred in reaction layers with more than optimum thickness, and unevenness of the interface became larger.

The insufficient reactivity of insert metals against Sin_3N_4 provided the inferior bonding strength, and it was due to fracture near the interface between Si_3N_4 and the reaction layer. The defects in the reaction layer also caused to decrease the bonding strength.

DOC I-934-91/0E & IA-398-91/0E
Joint Characteristics by Ni Brazing Alloy (Repot 1)
by Youichi Hisamori

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In this study, the influence of brazing process conditions on the Ni brazed joint (Ni-Cr-B) strength of SUS304 stainless steel was investigated by the tensile test, microscopy, EPMA and SEM. The effects of the brazing clearance, the brazing temperature, and the holding time at the brazing temperature are described. The tensile test results show that the Ni brazed joint strength of SUS304 depends on the brazing clearance and the brazing temperature. The results obtained are as follows;

(1) The brazed joint strength depends on the brazing clearance and the maximum strength is obtained at the brazing clearance of 20 μm. (2) In the metallographical analysis, it is observed that considerable amounts of Ni rich fragments concentrate at the central line zone of the brazing layer. The mass of Ni element may correspond to the original brazing alloy. At the clearance exceeding 50 μm, the segregation (B-Cr) can be observed at the central line zone of the brazing layer. (3) The brazed joint strength depends on the brazing temperature and the minimum strength is obtained at the brazing process temperature of 1380 K. The temperature (1380 K) enhances the segregation of the brazing alloy and the joint strength is related to its segregation (B-Cr) size.

I-937-91/0E
Energy Redistribution in Laser Cutting
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This paper begins by describing laser cutting in terms of a simple energy balance. The various components of the equation are then described and investigated, particularly the thermal losses from the cut zone.

Two experimental programs are described, one of which examines the phenomenon of reflection of the laser beam in the cut zone, the other establishes the variation of conductive losses as a function of material thickness.

I-938-91/0E, DOC. IE-111-90
LASER CUTTING OF MAGNESIUM ALLOYS
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Lasers are now used to cut a wide variety of materials. Light metals and light metal alloys are generally considered difficult to cut although data for cutting aluminium and titanium has been published in recent years.

Magnesium is another light metal with good mechanical properties and a very low density. Magnesium alloys are most commonly used in the form of die castings or extrusions, but a subsequent machining operation and the separation of pieces is often required. Laser cutting is a possible production method for separating small castings, hole making or profiling magnesium alloys.

This paper presents data associated with CO_2 laser cutting of 6 mm magnesium plate. The cut quality has been evaluated using surface profilometry. For each cut edge a number of accurately positioned, parallel profile traces were taken in order to evaluate the change of surface roughness with distance from the top of the cut edge.

During the course of the investigation, it was discovered that very accurate control of the laser power was necessary in order to get a high quality cut edge. This power control was made possible by using the laser in it's pulsed mode.

I-939-91/0E, REBW-9317, 1990-12-20
GAS-SUPPLY SYSTEMS FOR CO_2 LASERS
by Gert Broden and Rolf Taje AGA AB, Lidingo, Sweden

High purity-specifications are often laid down for laser gases and assist gases which are used in CO_2 laser cutting and welding devices. This is only sensible if this gas quality is not only present in the gas cylinder but also maintained in the rest of the installation. When designing the gas-supply system and choosing the components to be used care must therefore be taken to meet this requirement since otherwise the purity of the gases at the final point of use can be substantially reduced.

1-940-91/0E, IIW-DOC-IE 115-91
Laser Cutting of Steel-Cut Quality Depending on Cutting Parameter,
by Prof. Dr.-Ing. U. Dilthey, Dipl-Ing. M. Faerber, Welding Institute, Aachen University, Federal Republic of Germany
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This research has been sponsored by the Minister of Research and Technology.

Laser beam cutting is gaining increasing influence on the industrial production. On one hand laser beam cutting completes the classic thermal cutting processes within light sheet sector, on the other hand its special advantages like small kerfs and heat affected zones "HAZ" as well as the top quality of cut surface requires laser cutting for greater sheet thickness. Moreover, the universal use of laser beam workstations for cutting of ferrous and non-ferrous material as well as for welding, drilling etc. has been decisive for increasing willingness of installation of laser beam workstations.

The at present available laser beam power and its high beam quality (TEM_{00}) of up to 1500 W enable cutting of unalloyed steel sheets within thickness range of s=12 mm in an excellent cutting quality. In light sheet sector a cutting speed of more than 10 m/min can be achieved, thus determining the realizable cutting quality basically on dynamic behaviour of beam and material manipulation.

I-941-91/0E, IIW — LOWE
Laser Beam Cutting of Stainless Steel
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Laser radiator is a sophisticated cutting tool for the machining of stainless steels, if the process is adapted to the material properties as well as to the requested cutting result concerning e.g. quality, speed and costs. This paper gives an overview of possible and convenient procedural variants of CO_2 laser beam cutting of stainless steels. Besides the technological aspects of these methods and their parameter dependences, some fundamental considerations and the outcome of a computer simulation mode are described.

DOC SC IE-113-91, I-942-91/0E
Bevel cutting

by Gert Brodén, Gunnar Engblom, Katarina Falck, March 1991

In bevel cutting, especially at large bevel angles, problems can arise with notching and loss of cut. In order to gain a better understanding of how to avoid these problems, systematic cutting tests have been performed where the cutting parameters, such as the nozzle-to-work distance, have been varied. Acetylene was used as fuel gas. In order to limit the scope of work, attention has been focused on bevel cutting with one torch. Loss-of-cut speed, notching speed and maximum speed for approved quality have been plotted against bevel angle in bevel cutting graphs.

In order to avoid having to incline the torch too much in bevel cutting, special adapters are available for attachment to the torch. A special bevel cutting head is required in order to use propane as a fuel gas in bevel cutting. Such a head was recently developed by AGA. The head, which consists of a cutting nozzle and a separate preheat nozzle, is presented in greater detail in this compendium, along with a cutting table.

1-943-91/0E (ex DOC 1E-117-91)
Trends in materials, welding and cutting

by K Falck, AGA AB

The eighties saw rapid development of welding and cutting technology. The same dramatic rate of change will probable not occur during the nineties. This means that the trends which we can see today in this sphere will continue for some time to come.

Two key words today and for the nineties are *productivity* and *quality*, The MIG/MIG method, which during the eighties surpassed the MMA method, will continue to gain ground. Productivity and quality are being continually improved by the introduction of new techniques like pulsed arc welding, rotating electric arc, narrow gap welding, new materials (e.g. tubular wire), new shielding gases and mechanization. In TIG welding, which is a quality method, the productivity can be raised by hot wire filler and/or narrow gap welding. Other welding and cutting methods which we will hear about during the nineties are plasma, laser and electron beam welding, plasma and laser cutting, and water jet cutting.

On the materials side, the use of high strength, extra high strength and stainless steels will increase in pace with their development and improvement. Other important construction materials will include aluminium, titanium, polymers and composites.

The third key concept during the nineties will be improved working environment. The interest in working environment has already been keen during the eighties. Increased environmental consciousness and difficulty in recruiting to the trade will however mean that continued efforts have to be made to further improve working environment.

I-944-91/0E, IA-397-91/0E
Review of The State Of The Technology for Joining Ceramics for High-Temperature STRUCTURAL APPLICATIONS

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Ceramic materials have traditionally been used at relatively low temperatures, or under low stress at high temperatures, in applications that take advantage of such favorable properties as high hardness, wear and corrosion resistance, electrical resistivity, and low friction. These applications have included electrical insulators, crucibles, and pump and valve components for the chemical industry, and in drawing and extrusion dies. Only in the past two decades have major efforts been made to use ceramics in structural applications that include a combination of conditions including significant tensile or flexure stresses, a range of temperatures and corrosive environments. The ceramics that are being developed to meet these needs make up one segment of the broader class of materials that in Japan are referred to as "fine ceramics" or in the United States as advanced ceramics or high performance ceramics. Materials of this type are generally produced by state-of-the-arc technology and are therefore also known as high-technology ceramics. Advanced or fine ceramic materials also include the electronic ceramics such as those used as substrates and encapsulants, ionic conductors, piezoelectric devices and high critical temperature superconductors; but these materials, and the technology to join them is outside the realm of this review. The main driver for much of the interest in structural ceramics is the desire to improve the efficiency of various automotive engines. For example, in recent reviews of the current research on ceramic joining technology in general,[1-3] all three authors place a strong emphasis on the research and development in their respective countries aimed at utilization of structural ceramics in advanced heat engines. A second major thrust area, at least in the United States, are programs aimed at developing ceramic heat exchangers to recover the waste heat that is traditionally lost in the high-temperature, corrosive exhausts of industrial furnaces.

In recent years it has become more widely recognized that one of the key technologies that will enhance or restrict the use of ceramic materials in the above mentioned high performance applications (e.g., advanced heat engines or heat exchangers) is the ability to : reliably join simple-shape components to form complex assemblies, join unit lengths of material to form large systems, or join ceramic components to metals. Although ceramic joining technology has been highly developed over the past fifty years or so, most of the effort has been expended in developing materials and techniques for applications at "low" temperatures and with low stress requirements. The development of technology for joining ceramics for use at elevated temperatures, at high stress levels, and in dirty environments has been much more limited.

For the purposes of this review we will consider three major processes for joining ceramics to ceramics or to metals : diffusion welding (sometimes referred to as diffusion or solid-state bonding), brazing with metallic filler materials, and brazing with nonmetallic filler materials i.e., glasses. As it is difficult for any one review of the technology for joining of ceramics to be all inclusive, we have tried to make this review complimentary with two excellent reviews in the recent literature. ■