

- Abstracts of IIW Documents

IIW Commission IV : Special Welding Processes

Reported by - A. V. Thakur
Chairman, Indian Commission IV

IIW Doc : IV-453-88

HEAVY SECTION EB - WELDING

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Abstract

Over the last 10 years developments in high beam power have taken place in Europe and Japan. The high capital cost of the equipment has prevented a wide exploitation of the technology, except in Japan, where enormous Government support has assisted development. In Europe and USA, heavy section welding is performed in research laboratories and to a very limited extent in production. However, it has been extremely successful and economical with a four fold reduction of production time and also a return of investment within 2 year period; for example steam turbine diaphragm. For mass production, the chamber type system with external gun has the most advantageous. High pressure valve assemblies for power plants have been welded in different sizes (from 0.5 to 1.0 m diameter, weight 0.5 to 5 tons) with weld depths of 40-160 mm for more than 10 years using EB systems in 2 shifts and 3 shifts operation.

Non-vacuum EB welding is considered a powerful tool for the mass production of weldments with thicknesses upto approximately 10 mm and at present there are about 110 production welders in operation. R&D is being carried out to enhance welding depth upto 60 mm. A typical weldment on Cr-Ni steel of about 40 mm in depth is shown with 60 KW beam power under Helium shielding and welding speed of 600 mm/min.

Regarding EB guns for high thickness applications, high voltage guns are preferable, as they generate a narrower beam compared to low voltage guns. Towards selection of cathode material, tungsten seems the best compromise regarding emission density and its stability during service and operational life. Nowadays, CNC controls are able to fulfill all the requirements for controlling the welding parameters according to the task.

Scan tracking devices based on the principle of measuring the backscattered electrons is the required technique for observing the joining process in heavy section welding. To achieve deep welds with lowest heat input, a pulsed beam is used and it is possible to weld Al/Si alloy 70 mm deep using only 3 KW/150 KV. A martensitic steel application of 60mm deep with a pulsed EB of 9 KW beam power at a welding speed of 120 mm/min. Beam oscillation has an important influence on controlling and stabilizing of the keyhole effect as well as welding quality.

Since about 1967 turbine diaphragms have been welded by EB with a 150 KV pulsed beam upto a welding depth of about 80 mm. In 1985 the depth was increased to 150 mm in USA. EB guns of 50-100 KW beam power are capable of welding even 100 mm of copper in a single pass. A research project was carried out at the Welding Institute, UK, for encapsulating nuclear waste in disposal canisters fabricated out of copper. In production, at present, laminated, flexible, high current carrying electrical connections are EB welded upto 80mm in thickness with a 60 KW gun at 150 KV. To avoid weld defects due to porosity, the quality of copper material is of great importance. EB welding of Aluminium pistons has been used for 20

years in mass production with welding depth in the range of 30 to 100 mm. Only the Eb system with a pulsed beam is successful in reducing thermal defects during welding. 83 mm thick aluminium alloy nuclear core vessel has been EB welded for a company by the Welding Institute, UK.

IIW Doc : IV-442-87

EXPERIMENTAL ELECTRON BEAM WELDING OF THE NIMONIC - TYPE HEAT RESISTING ALLOY

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Abstract

The major problem when welding the heat-resisting nickel-based/Nimonic-type alloys is the formation of cracks in weld and heat-affected zones. The tendency to crack is the higher the thicker are the welded elements. The crack free welds can be obtained provided that the thickness does not exceed 5 mm.

The document describes the experimental EBW of the heat-resisting nickel-based alloy of 15 mm thickness on test specimens in the form of butt welded disc and shaft. One side welding with 100 KV high voltage and slow welding speed has been compared with double side welding with 28 KV high voltage and fast welding speed. Through x-ray examination and metallographic inspection it has been observed that porosity and cracks were present both in weld and HAZ.

The proper welding conditions have been established with optimised parameters to ensure defect free welds on the specimens with wall thickness of 14, 20 and 30 mm. But still microcracks were present in the grain boundary in HAZ. The chromium carbides precipitation at the grain boundary in HAZ causes embrittlement of metal at the grain boundary and its tendency to crack due to thermal stresses. The application of double solutioning treatment prior to welding has resulted in carbides precipitation inside the grains and thus eliminates embrittlement of metal at grain boundaries.

IIW Commission V : Testing, Measurement and Control of Welds

Reported by - Mr. Baldev Raj
Chairman, Indian Commission V

Doc : V-832-87

CLASSIFICATION OF X-RAY FILMS NEW RESULTS AND PROPOSALS.

Heidt, H., Schnitger, D., Stade, J

Abstract

The classification of X-ray films has been the matter of serious discussions for quite some time. The basic idea of classifying the films is to contribute to good and constant image quality. The authors opine that granularity would be the best parameter for the classification of films. After a brief description about the methodology of measurement of granularity, a good description of the influence of developer is given. The authors then proceed to classify the existing films from various companies into different classes based on gradient and granularity. This classification appears to be quite simple and unambiguous.

Doc : V-856-87

AN INTRODUCTION TO ACOUSTIC EMISSION TECHNOLOGY (AET) FOR IN-PROCESS INSPECTION OF WELDS.

G. L. Goswami

Abstract

This document discusses the technique and system along with the acoustic emission parameters important for weld quality analysis. This also deals with the application of this technique in different welding processes like TIG, resistance, electro-slag and submerged arc.

A detailed description about the acoustic emission system, sensors, instrumentation, data recording etc., have been given in the document. It reviews the present day status of the Acoustic Emission Technology as an on-line weld quality monitoring technique.

Different welding processes produce their characteristic weld defects and accordingly acoustic waves are generated. In TIG welding, weld cracking has been successfully monitored using AET. It is evident that there is a sudden increase in the acoustic activity when weld cracking takes place. Even detection of the lack of penetration seems to be possible by this technique. Defects like porosity or pin holes which produce relatively weak acoustic signals may be difficult to detect.

Detection of defects by AET during various other welding processes like submerged arc welding, electro-slag welding, resistance welding, electron beam welding and laser beam welding have been discussed in this document.

This technique requires a lot of initial experimentation with a particular weld application for driving out the optimum acoustic parameters, this technique is more useful in repetitive production welding jobs. With the introduction of sophisticated instrumentation in AET, it is possible to carry out the test even in noisy shop floor environments. Large number of reports on the subject of AE in recent years is a clear indication that it is getting importance in welding industry.

Doc : V-858-87

ASSESSMENT OF WELD QUALITY OF LOW ALLOY STEEL BOILER DRUMS - A CRITICAL STUDY

B. B. Mishra

Abstract

This document highlights the importance of complimentary NDT techniques which have improved the quality of welded components and reduced the rate of rejection in the fabrication of low alloy steel boiler drums.

In each stage of fabrication of low alloy steel vessels, there is a lurking fear of developing defects particularly cracks in the material or weld. Hence it becomes imperative for quality control personnel to devise a fool proof method of assessing quality so that no intolerable defect escapes the testing procedure.

The recommended practice for butt welds as per the governing codes is radiography or ultrasonic testing preceded by either magnetic particle testing or dye penetrant inspection.

The document describes the NDT methods adopted by one of the boiler drums manufacturer which have resulted in better quality of welds and less rejection. The initial dye penetrant inspection and subsequent radiography done as per code requirement cleared seams of boiler drums as free from defects. But the complementary NDT tests (MPT and UT) adopted by the manufacturer revealed a few cracks in the weld seam hither to cleared by radiography. The welds were gouged to see the defects visually to conform the findings of ultrasonic testing. The manufacturer observed that when only dye penetrant inspection followed by radiography was done, the seams made in the vessels had more than 25% repairs and it cost the company 10% of the total fabrication cost to repair the seams and a delay of 20% in the total cycle time.

After introduction of magnetic particle inspection followed by ultrasonic testing, the defects in the seams came down the 3% and the delay also was considerably reduced which has results the company a good amount of cost saving.

Doc : V-873-87

THE APPLICATION OF FITNESS FOR PURPOSE CRITERIA IN DESIGN, FABRICATION AND INSPECTION OF WELDED PRODUCTS.

Abstract

This document deals with non destructive testing in relation to the fitness for purposes assessment of welded structures. It concentrated on the detection and assessment of metallurgical defects, particularly cracks and other planar defects, both surface breaking and hidden.

The term "fitness for purpose is taken to refer to the rational assessment of structural integrity by fracture mechanics. The consequence of this for NDT is a challenge to prepare rational defect acceptance criteria which are compatible both with the requirements for defect detection and evaluation imposed by fracture mechanics and with the limited capabilities of the NDT techniques. The document deals with the reasons for pursuing a fitness for purpose approach for NDT such as :

- 1) to extend the range of materials, welding procedures and operating conditions.
- 2) on an exceptional basis during manufacture, to allow concessionary acceptance of defects which are rejectable according to quality control criteria.
- 3) during the service life, to allow the critical reassessment of the plant in order to demonstrate the continued absence of significant defects and hence to allow continued operations, deferment of repairs, and possibly plant life expansion.

Regarding the choice of NDT techniques, the document recommends that each weldment should be considered from the point of view of geometry access, surface condition, material, likely defect types and fracture mechanics requirements for defect detection. In most cases, this will point to one technique or, more usually, a combination of NDT techniques which are most suited for the detection and quantitative evaluation of the defects of concern.

Regarding fitness for purpose approach, the document recommends that certain prior conditions must be met before NDT can be usefully applied.

- a) the design, access and surface preparation should take into account the requirements of various NDT methods for the detectability and evaluation of defects of structural concern. In particular, it must be recognized that root profile and weld cap condition significantly affects the capabilities of all NDT methods for the important inner and outer regions of the weld.
- b) There is a need to design and plan the fabrication and to set sufficiently high quality levels with future inservice inspections in mind.

IIW Doc : V-879-88

TESTS FOR EVALUATION AND CHARACTERISATION OF BLACK LIGHT LAMPS AND FLUORESCENT PENETRANTS

Abstract

Non-destructive tests performed with penetrant liquids and magnetic particles are among the most common methods of inspection of the surface integrity of industrial components. The use of fluorescent products in the sensitivity of inspection requires a constant check of their properties. This document gives the data of the results of experimental tests carried out on some types of penetrant liquids and black light lamps by ENEA in Rome (Energy Research Centre) and the Institute Italiano della Saldatura (IIS) in Genoa.

The tests carried out on penetrant liquids and on black light lamps showed that the results obtained by testing some of their properties (e.g. lightning power, spectral output, fluorescent intensity etc.) are not sufficient for the formation of correct qualitative evaluations if they are considered separately.

Experimental laboratory tests demonstrated that this is true also for testing other properties such as wetting properties, penetrant washability and sensitivity, developer absorption capacity, efficiency of sprays etc.

Those qualitative tests have to be extended in order to evaluate quantitatively the reliability and sensitivity of the inspections as a function of possible variations of the properties of the products or equipment.

IIW Doc : V-923-89

ANNUAL STATEMENT 1988-89 OF COMMISSION V OF IIW

R. S. Sharpe

Abstract

This document consists of the Chairman's introductory comments and three sections A,B and C dealing with Pre Helsinki, Helsinki assembly and Post Helsinki proceedings respectively.

Section A deals with record of sub-commission, working group and working party meetings held during 88-89, publishing actions and sales of Commission V documents.

Section B deals with daily records of decisions taken during Commission V meetings, the substance of resolutions taken during Commission V at Helsinki, abstracts of Commission V papers presented and new terms of reference for other commissions approved.

Section C consists of forward work programme of Commission V, tentative dates for forthcoming meetings of the Commission, addresses of Commission V officials and list of National delegates to Commission V.

The main achievement of the year was the completion and acceptance of IIW Guidance Document on Fitness-for-purpose. Another achievement was the active steps taken during the year to link the work programme of the commission more to ISO activity and the "fast route" for converting IIW documents into ISO standards.

IIW Doc : V-933-90

SUBCOMMISSION VE - ANNUAL REPORTS 1989/90

Abstract

This document narrates the activities that have been carried out by Sub commission VE during the period 1989-90, and the future work programme for 1990-91.

Eddy current finite element modeling work has been started by NDT Centre Saarbrücken. With austenitic weldments the distribution (electrical conductivity, magnetic permeability) was measured at the surface of the weld to be modeled. The same distribution must be assumed beneath the surface using a successive approximation algorithm.

Working parties were formed to characterise black light lamps and liquid penetrants, characterisation of non-metallic welds, and residual stress measurements at the welds.

For 1990-91, the following programmes are planned.

1. Numerical modeling studies on electric, magnetic and electro-magnetic techniques of NDT.
2. Analysis of methods to measure strain and stress, definition and realisation of a round robin action to determine the capability of the different measuring methods.
3. Study of the state of art for testing non-metallic weldments and preparation of an IIW document for the next annual assembly.
4. Preparation of an IIW document summarising the state of standardisation for characterisation of black light lamps, starting with activities to liquid penetrant inspection of welds.

IIW Doc : V-934-90

ANNUAL REPORT OF SUB COMMISSION VC FOR 1989-90.

Abstract

This document gives the activities carried out by Sub Commission V C during 1989-90 and future work planned for 1990-91.

A chapter on non-destructive testing for fitness for the purpose concept for weld structures had been completed and the working group will further focus its activities towards the goal of validation of UT techniques for weld inspection.

A document on ultrasonic inspection of clouded components has been prepared.

The following works are planned for 1990-91.

1. Preparation of a revised manual for the ultrasonic inspection of ferritic welds.
2. Validation of ultrasonic techniques for weld inspection.
3. Characterisation of ultrasonic probes for weld inspection.
4. Modern imaging techniques for automatic ultrasonic inspection methods and their importance for the weld inspection.

IIW Doc : V-935-90

COMMISSION V WORKING GROUP 2 "NON-DESTRUCTIVE TESTING OF OFFSHORE WELDED CONSTRUCTIONS"-ANNUAL REPORT 1989/90.

Abstract

This document indicates the following main technical topics dealt by the working group during 1989-90.

- Reliability and comparative evaluation of surface techniques.
- Offshore/underwater eddy current examination.
- Fabrication versus inservice NDT.
- Underwater NDT equipment and personnel qualification schemes.
- New trends and developments in offshore NDT.
- Automated and remotely operated NDT equipment for underwater use.

During 1990-91, the working group has decided to revise the DOC V 908-89 "Information on Practices for Underwater Non-destructive Testing" and review special problem areas, new techniques and applications and collect and systematise information of general interest. These will be given in the form of guidelines or recommendations to IIW.

IIW Doc : V-905-89/OE

TRENDS IN QUALITY ASSURANCE DEVELOPMENT IN THE WELDING ENGINEERING.

Abstract

After outlining the general tendencies in quality assurance, the report goes on to show what developments in future may be expected on this aspect in the welding engineering. The document covers the planning phase, the technical code of rules, quality assurance with manual (product control) and fully mechanized or automatic welding processes (process control), quality assurance systems and their certification.

Doc : V-911-89

FLAW GROWTH MONITORING AS AN AID TO LIFETIME PREDICTION

M. G. Silk, A. D. Whapham and C. P. Hobbs

Abstract

Due to the construction of more and more new plants, the demand for increasing precision in non-destructive flaw sizing technique is also growing. Monitoring the growth of the flaws by newer NDT

techniques has come in a long way as an aid to lifetime predictions of plants. Both the time of flight diffraction (TOFD) technique and the alternating current potential drop (ACPD) technique might achieve procession of 0.25 mm of better in estimating flaw growth. The monitoring approach will prove to have economic benefits. This document reviews the justification for monitoring and presents experimental flaw monitoring data. Theoretical and experimental approach to this effect have been dealt in detail in this document. From the analysis it is shown that monitoring to determine flaw growth rate is the technique which will provide quantitative data for assessment. It is claimed that monitoring will reduce the amount of unnecessary repair and if repair is required the timing of the repair will be optimized. Monitoring thus result in savings in repair and shut down times without impairing the essential safety of structures.

Doc : V-915-89

RELATIONS BETWEEN CONVENTIONAL STATISTICAL QUALITY CONTROL AND NON-DESTRUCTIVE EXAMINATION OF WELDS.

Abstract

Industries manufacturing in large series or in mass production use statistical quality control methods as an important tool in their quality management system. This document aims in drawing relations between conventional statistical quality control and non-destructive examination of welds. Advanced application of fitness for purpose criteria in welding relies heavily on probabilistic methods. This also applies to NDT. The document insists that it is essential to distinguish between the statistical methods employed in a conventional statistical quality control and the statistical analysis of the results from non-destructive examinations performed as a part of probabilistic approach. The document has taken reference from various IIW, ISO documents for defining standards, acceptance quality level, classification of discontinuities, inspection procedure etc.

Doc : V-894-89

X-RAY REAL TIME (RADIOLOGY) FOR WELD INSPECTION

Abstract

This paper describes in brief the various equipments available for real time radiology as the conversion screen, image intensifier tube, linear arrays etc. After a brief overview of the state of art in X-ray equipment, image recording and digital image processing techniques, the use of modulation transfer functions for performance evaluation of radioscopic equipment is dealt with. The advent of automatic recognition of weld defects and its advantages is also dealt with. This report is essentially a summary of the progress reports 1, 2, 3 and 4 on the subject mentioned above

Doc : V-895-89

TYPICAL USAGE OF RADIOLOGIC SYSTEMS : REPLIES TO A SURVEY

T. A. Siewers

Abstract

The image quality indicators used till date are basically meant for film radiography applications wherein they measure parameters as contrast and spatial resolution. With the advent of real time radiology systems, the object can be oriented in a variety of ways and examined without manual intervention. While in film radiography it was possible to place the IQI appropriately between exposures for easy detection, this is not so in case of real time systems. Further, the existing IQI would not be able to measure all the important features of these systems as geometric distortion etc. A survey was conducted to ascertain the features users would like to have in IQI's meant for real time systems. This paper essentially summarises the

results of the survey. It was observed from the replies that an array type IQI which could evaluate the entire field is preferred by many. Based on the replies it was decided to design an appropriate array IQI and have a round robin evaluation.

Doc : V-896-89

THE INCREASE IN EFFICIENCY OF THE AUTOMATED ULTRASONIC INSPECTION

V. A. Troitskil, Yu. K. Dondarenko, Y. B. Eskov

Abstract

This document deals with NDT of welded joints and ways for solving problems of the increase in assessment accuracy of results of defects copy in the USSR by means of visualization. Such systems decrease well know contradictions of results of UT and RT. The visualization of UT makes it possible to determine the sizes of defects in different planes to evaluate the type of defect.

The document indicates that the typical signs of the modern trends in the larger diameter pipe NDT method advancement and applications are: inspection process automation, computer aided inspection process controls and test results processing, improvement of the indication systems and the inspection visual display quality connection of the inspection installations to production lines.

The industrial applications of microprocessor opens the prospects for creating the appropriate systems with softwares and acoustic tract digital data processing unit interfaces. This will greatly improve the inspection objectivity and productivity.

The document deals with various types of automatic inspection system. It indicates that there exists the possibility to completely automate the ultrasonic testing processes with the help of versatile manipulators which are computer controlled by the main programme and additional adaptive systems for automatic control. Thus the defect detection process should be accomplished by the round robin programme and the defect measurement process should include the adaptation elements or run by the programme with variable parameters which depend on a particular defect.

Doc : V-897-89

AUTOMATED ULTRASONIC TESTING OF PIPE-LINE WELDED JOINTS

V. A. Troitskii, I. Ya. Shevchenko, V. E. Baldakov

Abstract

In the oil and gas industry, pipe fracture is most often the cause of short term and prolonged interruptions of pipeline operation. One of the causes of fracture can be low quality of the welded butt made in the shop or site. Very high quality of pipe welded joints are required for this purpose. Assessment of quality is done by ultrasonic and X-ray radiography techniques.

This document describes the equipment for automatic ultrasonic testing of pipe welded joints during their production and during pipeline mounting. Experimental datas comparing ultrasonic and X-ray techniques are highlighted in this document.

Doc : V-898-89

THE SET OF TRAINING DEVICES FOR WELDED JOINT ULTRASONIC INSPECTION OPERATORS

K. Bondarenko, A. K. Gurvich, B. Eskov

Abstract

This document deals with training devices for welded joint ultrasonic inspection operators. Reliability of work of a weld ultrasonic inspection operator depends on his skill and experience, intellectual and psycho physiological properties, efficient working conditions, duration of work etc. Reliability of work of the operator can be

improved by adding the operation with the training devices into his training programme to develop the above mentioned habits and properties. Typical training devices like IIK-155, HK-156 and IIK-157 are explained in this document.

IIW Commission XIII : Fatigue Testing

*Reported by - Dr. V. M. Radhakrishnan
Chairman, Indian Commission XIII*

Doc : XIII-1332-89

WORK IN PROGRESS ON FATIGUE STRENGTH OF WELDED JOINTS IN JAPAN.

K. Iida

Abstract

The author gives the details of the on-going research work in the area of fatigue of welded joints. They are broadly classified in the following manner.

- a. Low cycle fatigue strength :
 - Low cycle fatigue strength of butt welded joint with a backing plate.
 - Fatigue life of aluminium alloy pre-strained by bending.
 - Thermal fatigue strength estimation of solder joints of surface mount IC packages.
- b. High cycle fatigue strength :
 - Improvement of fatigue strength of fillet welded joints by TIG arc re-melting of weld toe.
 - Fatigue strength diagram of welded joints subjected to random load with Weibull distribution.
 - Fatigue strength of welded joints of stainless steel for the strut/foil of hydro-foil.
 - Fatigue assessment of orthotropic steel decks of box girder bridge.
 - Field measurement of service stress and fatigue life evaluated of bridges.
 - Fatigue damage calculation of bridges due to service load using fracture mechanics.
 - Fatigue test of 10 year weathered weldments.
 - Effects of thickness, width and residual stresses on fatigue strength.
 - Fatigue strength of tubular joint for offshore structure.
- c. Fatigue crack propagation.
 - Fatigue crack propagation properties in welded joints under compressive applied stresses.
 - Near threshold fatigue crack propagation in welded joints under random loading's.
 - Effect of heat treatment temperature on fatigue crack propagation properties of butt welded joints.
 - Surface fatigue crack growth behaviour in thin plate specimen.
 - Non-destructive measurement of welding residual stresses by acoustoelastic technique and prediction of fatigue crack growth.
 - Fatigue crack propagation under random loading.
 - Experimental estimation of probability distribution function of fatigue crack growth life.

Doc : XIII-1334-89

IMPROVEMENT OF WELDED JOINT FORMANCE BY EXPLOSION TREATMENT.

V. A. Titov, V. G. Petushkov, P. P. Mikheev and V. N. Malei

Abstract

The mechanism of stressed-strained state formation in metals after explosion treatment is analysed. The stress component ratio in the surface layer of metal after explosion treatment is also studied. Explosion treatment improves the fatigue life of T-joint of high strength steel and austenitic chromenickel steel at 77 K.

Doc : XIII-1335-89

FATIGUE RESISTANCE OF WELDED JOINTS UNDER COMBINED STRESS STATE.

N. A. Klykov

Abstract

In this paper Klykov obtains the fatigue strength condition on the basis of hypothesis about the independence of the ultimate amplitudes of the tangential stresses on the cycle asymmetry. A universal method of endurance limit calculation for combined stress state is developed, which does not require a knowledge of the experimental endurance limits and is obtained according to the metal strength characteristics.

Doc : XIII-1338-89

PROPOSED IIW ENQUIRY INTO THE CASES OF THE APPLICATION OF FITNESS - FOR - PURPOSE CRITERIA TO THE ASSESSMENT OF WELDED COMPONENTS AND STRUCTURES.

S. J. Maddox

Abstract

This is a draft of the possible format of an enquiry where fitness-for-purpose criteria have to be used in the assessment of the integrity of welded components and structures. The objective includes the following :

- a. To provide hard evidence of the economic benefits arising from fitness-for-purpose assessments.
- b. To highlight areas of weakness in the methods presently available and hence topics for further research.
- c. To identify areas of industry in which fitness-for-purpose is most widely used and hence, if necessary, enable future revisions of the IIW Guidelines to be tailored to suit those industries.
- d. To provide a catalogue of case studies of ways in which fitness-for-purpose assessments have been used to provide practical help to others and to increase confidence in the wider application of such methods.

The draft after careful review and vetting is to be adopted by IIW for the fit-for-purpose assessments in the various member countries.

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