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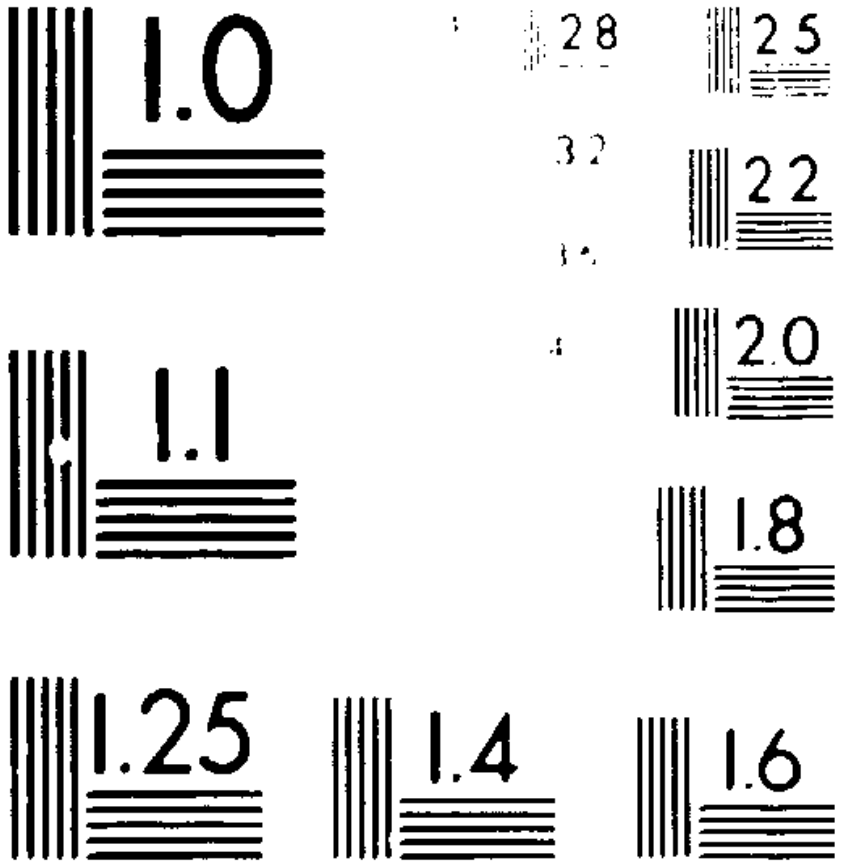

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Interregional Workshop on the Promotion of
Welding Technology in Developing Countries

Tiruchirapalli, India, 30 January - 4 February 1984

REPORT* (Workshop on promotion of welding technology).

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INTRODUCTION

Recognizing the technological self-reliance and appropriate infra-structure built up as essential factors for the balanced industrial growth, UNIDO, with the financial help of the United Nations Development Programme, has been promoting industrial research and development centres in various developing countries.

Welding plays a vital role in industrialization. Most of the modern technological industrial achievements over an extremely wide field from structural to nuclear fabrication have been made possible by developments in welding technology. It has become an irreplacable tool of fabrication industries and constitutes an important step towards industrial progress of a country.

The advances in the welding field are stupendous in advanced countries, thus contributing to their industrial revolution. In developing countries on the other hand, growth in welding itself has to cope up with insufficient infra-structure. There is a growing need for more R and D efforts in strengthening indigenous technology infrastructure for selection, adoption and assimilation of appropriate technology, from the developments made elsewhere, for advancement of industrial progress.

The Welding Research Institute, Tiruchirapalli, India, is one of the Large Scale Projects promoted by UNIDO/UNDP for boosting industrialization. The Institute is rendering yeoman service to the Indian industry by taking up applied research projects in the field of welding process, technology, consumables, machine development and metallurgical investigations. Consultancy and quality control services are being extended to various industries and specialized training in welding and applied fields are also being extended to all levels for enhancing the process of development.

The Interregional Workshop on Welding Technology held at the Welding Research Institute, Tiruchirapalli, India, from 30 January to 4 February 1984 showed ways and means of possible co-operation by the Institute with other developing countries in the field of training of manpower, exchange of know-how, collaborative research, for mutual benefit and establishment of similar/appropriate Institutes.

ORGANIZATION OF THE WORKSHOP

The Interregional Workshop on the Promotion of Welding Technology in Developing Countries was held at the Welding Research Institute, Tiruchirapalli, India, from 30 January to 4 February 1984. The Workshop was attended by 14 participants from 14 developing countries. UNIDO was represented by the Senior Interregional Adviser from Headquarters, Vienna and by the Senior Industrial Development Field Adviser, stationed at UNDP, New Delhi; the UNIDO Regional Adviser for Africa. stationed at the Economic Commission for Africa, Addis Ababa, participated as an observer. The list of participants is given in Annex I.

Opening Session

The Workshop was officially inaugurated on 30 January 1984 by Mr. K.L. Puri, Chairman and Managing Director, Bharat Heavy Electricals Ltd. (BHEL), who stressed the need for industrialization in developing countries to accelerate

the tempo of economic and social development. Considering the problems confronting and peculiar to developing countries in technological growth, Mr. Puri said that such workshops would give an opportunity for better understanding and better solutions in selection and adoption of appropriate technology through mutual co-operation among developing countries. Highlighting BHEL's involvement in the fulfilment of power requirements and the role of welding in fabrication sectors as a whole, he traced the systematic planning that has gone, in setting up of WRI. He was confident that the strong linkage that the Institute had established with the Indian industries had given confidence for the Institute to extend its assistance in any modest way to other developing countries in the region.

In his presidential address, Mr. E.S. Chandrasekaran, Group General Manager, BHEL, said that the siting of the Workshop at Trichy was very appropriate as it happened to be one of the biggest fabrication centres in India. It was that fact that had promoted the Government of India to set up the WRI under the aegis of BHEL. From a modest beginning through training of manpower the Institute had emerged as a full fledged industrial research centre catering to the various fabrication industries in India. Stressing the need for appropriate selection of technology and its absorption to suit to the environmental conditions, he explained the experience of BHEL and the progress it has made over the years in meeting the national power requirements and also its impressive share in exports.

Mr. Kamal Hussain, UNIDO Senior Industrial Development Field Adviser stationed at UNDP, New Delhi, mentioned in his key note address that UNIDO's endeavour to achieve a more equitable distribution between developed and developing countries could be largely realized through industrialization in developing countries. He drew attention to the Lima Declaration and Plan of Action for the developing countries to reach the target of 25% of industrial output of the whole world by the year 2000. Co-operation among developing countries was particularly stressed as a tool to self-sustained and self-generated growth at sub-regional, regional and interregional levels. He felt that Welding Research and Development Centres should be extended to other developing countries be it in the field of training or technical consultancy or in setting up of similar research centres, based on the experience gained through the operations of UNDP/UNIDO assisted project - WRI at Trichy.

Welcoming the delegates, Mr. R. Krishnamurthi, Head of Welding Research Institute, emphasized the vital role of welding in industrialization. He expected that the workshop would overcome the technological shortcomings in fabrication industries and could lead to concrete proposals for mutual technical co-operation in training of manpower and exchange of know-how.

Mr. B.R. Nijhawan, UNIDO Senior Interregional Adviser then conveyed the greetings of the Executive Director of UNIDO, Dr. Abd-El Rahman Khane, for the success of the Workshop and outlined its objectives. He particularly stressed the importance of the TCDC/ECDC scheme (technical and economic co-operation among developing countries) to reach technological self-reliance. The services of WRI would be decisive in three fields: technology of welding; development, design and manufacture of welding equipment and consumables (electrodes); and development of weldable alloys (e.g. welding of stainless steels). The final endeavour would be to establish a centre of co-operative research and development for the mutual benefit of the developing countries, in the metallurgical R + D fields. Preparatory activities would promote the

twinning arrangements amongst allied R + D centres in the developing countries covering metallurgical fields. He concluded by stressing that UNIDO would promote the establishment of Welding Research Institutes and centres of metallurgical technology in other developing countries.

Mr. M.K. Sridar, Technical Director, BHEL, referred to welding as a growing technology area and stressed the importance of maintenance welding and reclamation techniques, as material saving devices to bring down inflation. He pointed out that in the field of engineering industry, India ranked 10th in the world. He also referred to the large range of products that BHEL was producing and its activities in innovative fields such as production of solar power systems, energy conservation measures, battery operated vehicles and computer-based software. BHEL's willingness to share its know-how with other developing countries was expressed. This could take the form of co-operative R + D projects and acceptance of trainees.

Election of Officers

The Workshop elected Mr. R. Krishnamurthi as Chairman of the meeting. Messrs. H. Bassani, Argentina and Antonio Madeira, Jr., Mozambique, were elected Vice-Chairmen. Mr. Suryanto Mertoatmodjo, Indonesia, was elected Rapporteur.

Programme of the Workshop

During 10 technical sessions 12 lecture papers by Indian experts were presented to the participants. The list of the lecture papers is given in Annex II. Summaries are given in the text.

Apart from a visit to the Welding Research Institute, with demonstrations, the workshop participants visited a power plant manufacturing industry (BHEL), a sugar cane processing plant, a medium-scale process equipment manufacturing industry, a plant producing welding equipment, a plant producing welding consumables and a plant producing machine tools. The list of plant visits is contained in Annex III. The programme of the workshop is attached as Annex IV.

The participants were asked to prepare papers on the state-of-the-art of the welding industry, or related subjects, for their respective countries. Summaries of the country papers have been prepared and are attached as Annex V.

Technical Session I - Institution Building in a Developing Country - the case of the Welding Research Institute (WRI), Tiruchirapalli, India

The case study was introduced by Mr. R. Krishnamurthi, Head, Welding Research Institute, Tiruchirapalli, India.

Summary

The process of industrialization in a developing country has several unique characteristics and proceeds through different stages. Amongst the various inputs essential for a balanced growth of the industry are technology

and infra-structure. Generally, industrial growth commences in order to meet growing home-demand and begins with simple processing of agricultural and mineral commodities in a vast country like India. As the industrialization progresses the needs for advanced skills, newer technology inputs and basic facilities correspondingly require continual updating. Integrated planning at the national level is usually aimed at achieving these goals.

The paper studies the role of research institutions in industrial growth in developing countries. The Welding Research Institute at Tiruchirapalli, India, is an example of a typical service institution acting as a catalyst in technology transfer.

The decision for establishing WRI was taken in 1974 and as site Bharat Heavy Electricals Ltd. (BHEL) was chosen. The United Nations Development Programme approved a contribution of about 2 million US dollars to finance sophisticated equipment imports, training of WRI personnel outside India and deputation of foreign experts to the Institute, whilst the Indian Government contribution covered all indigenously manufactured equipment. BHEL's infrastructure was crucial in quick establishment of facilities of WRI. Other salient features of WRI's success are: complete autonomy in project implementation; linkages with UN and availability of resources, expert advice and training opportunities; R + D projects primarily as sponsored research assuring user implementation possibilities; training programmes covering the entire spectrum of skills; basic research; and linkages with national and international bodies and core sector industries in India.

The future activities of WRI are aimed at horizontal integration, to be achieved through: continuous tie-ups of long term nature for scientific co-operation with leading welding institutes in the world; effecting appropriate technology know-how transfer; and setting up liaison centres at different parts of India.

Discussion

A number of questions on the organization and operation of WRI were posed. It was explained that the pilot plant could produce 40 electrodes per minute which were propagated in the industries.

Answering the question regarding the promotional activities of WRI the participants were informed that even before establishing the Institute, WRI staff visited 26 manufacturing plants in the country to inform them about contemplated facilities. Every three years from 1979, this advertising campaign was repeated and about 100 plants visited with very good results. The private sector welding equipment and welding consumable manufacturing industry and international companies have since realized that WRI was no competitor but rather an independent institution that could provide even advice to them. Requests for advice have been received with regard to working and fabrication programmes and testing of electrodes. An exchange of trainees is taking place and a representative from a private sector consumable company is a member of the WRI Advisory Committee. Tests on behalf of Indian Standards Institution have been carried out while assuring the Application of codes, specifications and standards.

Training at WRI could take place up to any required level, according to requests from the industry, such as to the level required for qualification by external inspection agencies as well apart that of WRI. Performance of the trainees is assessed every week. Theoretical training is supported by slides.

Questioned about the profitability and financial viability of a Welding Research Institute, the Director, WRI, informed that R + D work may depending upon the area of work normally only pay back after 10-15 years or so. Therefore immediate financial viability could not be expected. Policy of respective groups in R + D promotion also becomes relevant. However, the industry would, in the long term, benefit through an enhanced number of skilled welders and through the possibility of obtaining indigenous advice and consultancy. R and D projects and "trouble-shooting" activities requested by clients are charged to them at the actual cost on a "no profit/no loss" basis.

A number of participants confirmed the interest of their respective countries in setting up similar institutions, possibly with UNDP/UNIDO assistance.

Technical Session II - Welding processes and their applications present status

The paper was presented by Mr. K. Sampath, WRI, India.

Summary

The availability of so many fusion welding processes has vastly aided the design engineers to improve functional values and utility of various engineering products and also to lower their costs. These processes continue to be exploited in their various forms and modifications thereof.

The very fact that there are so many fusion welding processes also suggests that there are many advantages and disadvantages in each of these and one has to thoroughly understand the capabilities and pitfalls to derive maximum benefit in his chosen application.

Selection of the correct welding process from the available welding processes have a direct effect on profitability. A logical and a systematic approach is often required to examine the details of the joint, performance characteristics of the welding processes. Typical case studies for selection of appropriate processes have been presented:

i) Difficult conditions of weld joint as in lithium storage batteries - microplasma selected;

ii) Joining of stiffeners to panels in shipbuilding - gravity welding and auto-contact welding recommended;

iii) Change in position facilities use of alternative process;

iv) Bead profile figures in process selection for fatigue conditions;

v) Hot wire additions for improving toughness;

vi) Dilutions dictating process employed;

vii) Varying gaps deciding the process.

Discussion

Various technical questions were raised such as about the flux cored wire welding which came to market about 5 years ago. Only 5% of welding is done by this sophisticated process. The Mexican participant informed that they had abandoned to use this process since good mechanical properties could not be reached and the fumes were hazardeous to health.

Regarding the application of the electroslag method it was pointed out that the process cannot produce refined grains except through postweld heat treatment. The process had been applied on certain materials up to 200 mm. In some cases postweld heat treatment may even be eliminated, depending on the basic materials joined and service conditions.

The total amount of weld metal deposit in India is estimated at 56 - 60,000 metric tons per year. The figure is related to a 11.5 million ton steel consumption of which about 10 million tons are produced in the country. 99.5% of welding consumables are produced in India and only special requirements such as for nuclear power plants are imported. Maintenance welding is carried out in India. The representative from the Republic of Korea informed that his country produced about 80,000 tons per year of welding consumables.

Technical Session III - Welding consumables - An overview

This paper was prepared by Messrs. K. Narasimhan, D.V.R. Varma, A.K. Garg and A. Raja and presented by Mr. K. Narasimhan, Welding Research Institute, Tiruchirapalli, India.

Summary

Welding plays an important role in the manufacture and erection of power plant equipment, petro-chemical, fertilizer, ship-building and aircraft industries. The amount of welding done is quite high and a number of welding processes are being used to weld a variety of materials under different conditions. A wide range of consumables are available and selection has to be done carefully depending on the material that is being welded. The paper describes the available consumables process-wise, their classification and application. In particular, the following subjects are covered:

- Manual metal arc welding consumables, coating materials and their function, classification of electrodes by coating and based on materials being welded;
- Systems of electrode classification with detailed description of American Welding Society Classification and British Standard Classification;
- Testing of electrodes;
- Storage of electrodes;
- Manufacture of electrodes (analysis and procurement of raw materials, wire straightening and cutting, mixing, extrusion, baking and packing of electrodes).

Special chapters are devoted to gas metal arc welding electrodes (GMAW); sub-merged arc welding consumables and production of fluxes for these. Reference is also made to consumables for TIG welding.

Discussion

The paper was well received by the participants. The questions raised mainly related to moisture pick-up by the electrodes, proper storage of electrodes and how to improve slag detachability. With regard to the latter it was suggested to obtain assurance from the manufacturer to avoid such occurences and to ensure proper baking. A storage temperature with a deviation of +/- 10 °C from the outside temperature can be tolerated and the humidity should be in the range of 50 - 60%. Electrical heating devices or infrared lamps may help to ease the storage problem. In particularly affected areas (monsoon climate, etc.) vaccum packing should be applied. Cellulose electrodes should have a moisture content of 4-5%.

A participant inquired about the minimum economic capacity for an electrode fabrication plant. He was informed by the Director, WRI that for a virgin market a plant producing only one ton a day might be viable but the viability can be arrived at after analysing the market potential and the infra-structure available in a country besides examination of other factors.

Questions were raised whether argon or helium was to be preferred. Whilst helium was considered better for application in tube to tube welding, in most of the cases argon could be used. The latter is cheaper to obtain in India and should be so in all developing countries.

During the general discussion of the paper, it was stated that no welding machines or equipment was available in Africa. Only 2 or 3 overseas companies in North Africa produced electrodes. Countries like Ethiopia and Tanzania were reportedly interested in starting electrode production soon; Uganda has also expressed interest. As such, WRI should take a leading role in developing the welding industry of Africa. WRI fully agreed to provide assistance whenever necessary. First of all some basic data should be made available to them such as on the availability of raw materials and intended government policies. Whilst the import of ready-mix fluxes was certainly more economic in the beginning, early self-sufficiency was recommended in order to become independent of technology. WRI expressed their willingness to support and train African welding staff and also help in testing materials, electrodes and welds.

It was considered highly desirable by the participants to have a case study prepared on the Indian experience in the manufacture of welding consumables, which was started from scratch some 20 years ago. An elaborate study was considered desirable, to be prepared under Contract with UNIDO.

Technical Session IV - Integrated Human Resource Development

The paper was presented by Mr. B. Pullat, WRI, India.

Summary

In his lecture the author presented the steps taken at the Welding Research Institute for training of manpower and knowledge dissemination.

Reliance on self-generated technology is visualized largely through building up adequate strength of welding personnel in all the three levels, viz. engineers, supervisors and welders.

Welding engineers should comprehend themselves closely, the optimum properties of the weldment, keeping economy in mind. Practically oriented training of the engineering graduates is the only way by which it is possible.

A technically sound supervisory team is to be maintained by any organization in order to assist internal developmental schemes, at all times.

Orientation training and qualification of welders are to be reckoned in view of implementing the technology to such constructions demanding high workmanship.

Various welding personnel should be exposed from time to time to courses in contemporary welding process and practices and also on future welding trends.

Procedure and performance qualifications are to be rightly understood and resorted to while undertaking coded constructions.

Monitoring of approved welding procedures and scheduling of procedure and welder requalifications are to be enforced as and when warranted.

The welder's performance test has to be limited only to verify his ability to deposit mechanically sound weld metal and the requirements of metallurgical compatibility are to be attributed to the welding process characteristics.

Discussion

Timely planning of training programmes was considered most important. Measures should be taken in order to prevent that freshly trained staff would seek other employment possibilities. As an example it was mentioned that at WRI an engineer had to sign a fixed-term appointment of a minimum of 5 years, with a penalty payment of a few thousand rupees when giving notice before this time limit.

It was stated that training at WRI was open to everybody and was considered to be the lowest in cost in the world. The training fee was about US $ 135 per week for highly skilled welders trained to various code requirements and this may vary depending on the test requirements.

The UNIDO representative also pointed out the possibilities for candidates from developing countries to have training undertaken under the auspices of UNIDO. In-plant training programmes, group training, as well as individual fellowship training could possibly be arranged, subject to the availability of necessary financing.

It was suggested that a group of trainees should be kept below 15 in order to ensure maximum benefit of practical training. He also informed that WRI experts were undertaking in-plant training outside the Institute. In such cases more emphasis was given to theoretical training as the necessary facilities for practical training were not always available for all subjects outside the institute.

It was pointed out that a Manual on welding technologies had been prepared with ECA/UNIDC assistance for the Maltese Government and translated into the local language from English. It was suggested that similar instruction booklets be prepared and made available in local languages, such as Suaheli for certain African countries.

Technical Session IV - Information management and dissemination at the Welding Research Institute, Tiruchirapalli, India

The paper was prepared by Messrs. M. Balasubramanian and B. Pullat and presented to the Workshop by Mr. M. Balasubramanian.

Summary

The Institute has attached great importance to technology dissemination and human resource development. The Institute receives about 32 journals and publications covering welding and its allied areas. The dissemination of information is effectively done through a computerized information storage and retrieval system (Weld-in-Search System) which gives easy access to present developments in the welding industry field. Users of information are classified as follows: browsers (interested in no specific topic); users interested in specific topics; users interested in first hand information or recent developments. The Weld-in-Search system records documents by reference number, title, authors, source of documents, key words (max. 12).

Through its journal KEYWORDS, WRI is periodically disseminating information on recent trends and development in welding and makes it available to all industries. Thus, WRI, in a modest way, caters to the welding information needs of India.

Discussion

Participants expressed interest in obtaining lists with titles of international journals. WRI subscribes to all English journals. Translations were reportedly not made. By then about 13,000 articles had been codified to be put on line with the main computer of BHEL.

WRI reportedly was the cheapest access to information. For 50 articles they charge only about 30 rupees. For hard copy paper Rs. 1.50 per page is charged. Computer usage amounts to 400 Rs. per hour.

A suggestion was made by a participant to record prices of electrodes from various supplier companies. WRI informed that some information on the subject was already available which could be made available to participants upon request.

It was suggested that publications of the Indian Standards Institute be made available to the African countries. Reportedly, Africa at that time only used about 9 varieties of steels. The Indian standards could appropriately be adapted. A list of journals and addresses was handed over to all the participants.

Technical Session V - An overview of Engineering Materials for welded structures and metallurgical problems in Fabrication Industry Part I

The paper was presented by Mr. R. Veeraraghavan, WRI, India.

Summary

Welding applications are varied and diverse. The applications personnel are often confronted with many welding technological and metallurgical problems, leading to laying down of productivity time and energy and increased cost due to wastage of materials and consumables. To avoid or at least diminish these problems it is necessary to understand the metallurgical problems encountered during welding fabrication. Two aspects of materials weldability should be considered: 1) choice of specific materials for every welded component in terms of the weldment/material behaviour for the specific application; and 2) choice of fabrication technology, methods and parameters to produce a sound, defect-free joint.

The paper considers the core engineering materials used in fabrication industries such as for pressure vessels and boilers, shipbuilding, transport industry (railroad and road transport) materials welded for building and bridges application, aircraft industry, materials for storage and tank fabrication. Subsequently, the requirements during welding for these materials are analysed. In this connexion special attention is given to fabrication weldability, including hot cracking, cold cracking, restraint cracking, reheat cracking, lamellar, tearing and weld porosities.

The paper reports on the "weldability package" developed at WRI which consists of raw material testing, hot cracking tests, cold cracking tests and restraint cracking tests. Service weldability is also an important task carried out by WRI. Examples of weldability evaluation are given.

Discussion

A number of technical questions were posed. These centered around the experience gained with die and tool steel welding and testing of metals and finished welded products. The example of a boiler drum was given, where each plate or sheet would be tested separately and where testing would take place in each consecutive stage of work. When welding the drum, a sample weld is made at the same time on a plate of the same batch, which would be tested at the final stages after undergoing all the heat treatment operations; based on the mechanical tests results, the drum would be accepted apart from conducting a number of NDT methods.

Other questions related to the different levels of heat flow in the welded part and how the change of heat flow e.g. from 2-3 dimensional may affect the weld.

Discussions about the latest theory on lamellar tearing, applicability of inplant test results to actual fabricator's use in choice of process and parameters, etc. were held.

Technical Session V - An overview of engineering materials for welded structures and metallurgical problems in fabrication industry Part II

The paper was presented by Mr. S. Suresh, WRI, India.

Summary

Besides metallurgical aspects, when one considers the strength of a structure that is welded, several additional factors are involved, the most important of which are occurrence of weld defects, residual stress and distortion.

In the conventional analysis of the tensile strength, fatigue strength, the buckling strength, etc. of a material, idealistic conditions of material and structure are assumed. However, a realistic welded structure is inhomogeneous, comprising of the weld, the HAZ and the unaffected parent material zone, contains various types of defects, carries initial residual stress and has initial distortion.

The paper describes the effects of these imperfections on the service performance along with the appropriate procedures that are to be followed to overcome these problems during fabrication to achieve a sound weld. A large portion of the paper is devoted to the sources of weld defects, their consequences and fabrication techniques and procedures to minimize weld defects. Factors that influence residual stresses, their effects and possibilities for stress relief treatment are emphasized. Effects of distortions produced in fabricated structures are analysed together with the factors influencing them and possibilities of minimizing distortion.

The paper concludes that welded structures are by no means free of problems although they are economical and versatile. Hence in order to design a sound welded structure, it is essential, to have an adequate design, proper selection of materials, adequate equipment and proper welding procedures, good workmanship and strict quality control.

Discussion

The participants were particularly interested in learning more about the possibilities for minimizing residual stresses. The vibrational treatment was considered to be disadvantageous in case of presence of cracks in the material in which case they might propagate or, at least, the chances for propagating are higher.

Inquiries were made on the calculation of distortion.

Sub-assemblies were considered to be preferential, to be put together with a few welds.

Information was sought whether the welding of bogies was an acceptable process. The participants were informed that no shortfalls would be expected in applying the process. In fact 2 plants in India had recently introduced it.

Regarding the welding of boilers it was mentioned that a weld may even make them stronger. Figures of 1.2 times more strength could be reached. A too high amount of weld material would, however, cause reduction in fatigue strength.

Notches in welded parts would be very dangerous, therefore it was very important to effectively clean and polish the weld surface.

For inspecting welds in bridge construction it was considered necessary to carry out in situ non-destructive tests.

Technical Session VI - Appropriate welding techniques for maintenance
by Mr. R. Krishnamurthi, Head, Welding Research Institute, India

Summary

For any industry today, fitness to withstand the restraints posed due to diminishing finances, competition, technological advancements and catastrophic breakdown is a must. Within the available resources it is relatively easy to combat the threats posed by breakdowns. With due care, the least one can do is to increase the cycle time between the recurring breakdowns. The precautionary measures taken to achieve the goal is commonly called in engineering management as "maintenance management".

The importance of maintenance welding is stressed in the paper. As a case the hardfacing of sugar mill crusher rollers is given. For this purpose WRI has developed special electrodes in order to save considerable imports. They are now applied in a number of sugar mills all over India.

The technique of "hot arc" weld surfacing is explained. It can be adopted by welders with little skill also. The paper also explains an in-situ repair of hydrogenerator runners and the constraints posed to it. The welding procedure would have to be carefully selected as well as the filler material. The paper gives a few examples of such welding, including plasma application, surface treatment, plasma spraying and the areas for its application as well as plasma surfacing.

Discussion

Participants were informed that out of the 350 sugar mills in the country, nearly 50% have been covered by WRI services. This strong interest was mainly due to promotional efforts and demonstrations organized by WRI for sugar mills in the region. WRI had supplied about 1.5 tons of their specially developed welding electrodes to the sugar mills within the last half a year.

Complying with a request from the Indonesian participant, the plasma spraying technique was explained. Preheating was considered a border case. In application, the technique was classified to have its place between arc welding and laser welding. Surface preparation to remove all oxides and particularly grease was considered to be of special importance. Shot blasting or grit blasting is very essential.

Certain fluxes were available in the world market for welding on rusted material.

The case of master gear welding in an African cement mill was brought up. Mild steel welding inside and hard surface treatment outside was suggested.

It was pointed out that in many cases when the clients considered the welding electrodes to cause failures, the failures were actually due to improper parameters and lack of skills. Welding transformers were often not available in the desired quality.

For hot shears welding, Zimbabwe initially used hot die steel which was later substituted with chrome-molybdenum steel hardfaced with stellite, which brought down costs substantially.

Technical Session VII - Productivity and Quality through mechanization and use of high productive processes and techniques in welding

The paper was presented by Mr. S. Suresh, WRI, India.

Summary

The lecture brought out the fact that productivity and quality which are two inseparably linked aspects, can be achieved only through mechanization and use of high productive processes and techniques. Suggestions regarding how mechanization can be attempted in a developing country are elucidated. Case studies on mechanization of:

i) A simple gas welding process for stelliting of valve seats and wedges;

ii) A turbine spindle plasma arc surfacing; and

iii) A welding process for transformer casing through semi-automatic CO_2 welding

are presented in the paper.

Employment of high productive processes and techniques are also discussed, like: gravity/auto contact welding; one side welding and one side SAW; narrow-gap and quasi narrow-gap; twin torch CO_2 welding; flux cored arc process; and hot wire process.

The paper concludes that mechanization is a sure way of achieving higher productivity without a compromise on quality. However, the extent of mechanization is to be decided based on the investment potential, the labour rates, and conditions prevailing locally and the type of demand envisaged. As far as developing countries are concerned it will be most appropriate if mechanization is attempted in a phased manner going in for low cost automation and subsequently towards higher levels of mechanization including use of robots. By this way, many finer aspects of mechanization and associated needs would be getting established resulting in higher levels of productivity in the longer run.

Discussion

The discussion centered around actual quality control measures applied to raise the productivity of welded products whilst balancing the mechanization efforts with local resources of personnel and technology. In the case of developing countries, ad hoc mechanization may not yield optimum results.

Technical Session VIII - Welding processes and applications - future trends (Solid phase welding processes)

The paper was presented by Mr. Ramesh Sarma, WRI, India.

Summary

Solid phase welding process can be classified as a modern welding process. This process has a distinct advantage and edge over the conventional processes being used nowadays. The process parameters are repeatable over a period of time and good joint quality can be assured at all times. Most of the processes have a very short welding cycle and hence a very high rate of production can be achieved. Dissimilar metals can be easily welded and do not pose problems as that encountered in conventional processes. Friction welding is one of the solid phase welding processes which can be fully automated and the parameters can be controlled with use of computers.

The main solid phase welding processes now in use are: friction welding, explosive welding, ultrasonic welding, MIAB welding and diffusion welding.

In case of friction welding, case studies on the following are presented: cover assembly for check valves for power plants; foundation bolt for boiler structures; transition joint between low alloy steel and stainless steel; rod to rod welding between HSS and medium carbon steel for drill bits.

In explosive welding, tube to tube plates (brass to brass and brass to steel) explosive welding has been identified. Ultrasonic welding for combinations of Al to Al, Cu to Al and Cu to Cu for various product forms (foils, wires, etc.) are described.

Discussion

The participants expressed keen interest in the subject. One participant asked for photo micrographs for the welded joints. During the visit to WRI participants were given the opportunity to observe explosive and friction welding processes in operation.

An inquiry was made into the types of explosives used. It was explained that either nitro-glycerin based explosives or ammonium nitrate based explosives were applied.

Technical Session VIII - Welding processes and applications - future trends (resistance, electron beam and laser welding)

The paper was presented by Mr. S. Muthukrishnan, Welding Research Institute, India.

Summary

The present trend in manufacturing industries is to introduce more and more modern welding processes in order to improve the reliability and increase the production rate of the products. A thorough understanding of these new technologies will help welding engineers to identify the scope of their applications, for increased productivity. The paper highlights the following aspects of resistance, electron beam and laser welding: the resistance welding process has been fully exploited by the automobile, aircraft, railroad, electronics and consumer goods industries. The modern trend in this process is to improve the consistency and reliability of the welded product through the usage of in-process quality monitoring and correction system. The studies conducted and the monitors and correction systems developed at WRI are discussed.

Electron beam welding process has now become a common tool for the fabrication of nuclear, aircraft and other critical applications. It is also being used for the fabrication of pressure vessels and automobile components. Salient features of this process and typical examples are highlighted in the paper.

Laser metal working is one of the recent techniques with many closely competing applications with electron beam welding. Laser being a light source can be easily deflected using mirrors to divert the beam to any inaccessible area for welding or cutting. Unlike electron beam welding a laser metal working process does not require vacuum chamber. The basic laser theory and its various metal working capabilities viz. welding, cutting, hardening and drilling are described in the paper.

Technical Session IX - Quality assurance of fabricated components

The paper was presented by Mr. J.R. Bhatia, WRI, India.

Summary

Quality assurance is an integrated quality system on which the final product reliability depends. It is aimed at creating built-up quality from the beginning of design, through all the phases of planning, manufacture, final product acceptance and most important, to provide the customer with a product which performs as per its intended service. Checks are carried out for conformity with specifications through quality control procedures as laid out in the assurance system. Today, as much as 70% of all manufacturing is by way of fabrication in India as against only 30% about 30 years back. Even the most sophisticated equipments like pressure vessels, pipelines, oil exploration vessels, use fabrication to a large extent.

The paper stresses the importance of reliable metal joining techniques to achieve quality welded components at economic cost. Non-destructive testing methods are listed, together with their particular fields of application. These are radiography, ultrasonics, magnetic particle and penetrants. Suggestions for their application are given.

The paper also reports on evaluation, grading and removal of defects and the importance to determine the depth and orientation of any imperfection is stressed so as to assess its importance and to assist in its removal.

The author gives special emphasis to the need for training and qualification of personnel to carry out the tests as per the given procedure. Usually, the quality control engineer should bear in mind that quality shall be maintained at economic cost by carrying out inspection at suitable stages. Unless quality is built-in, the product reliability cannot be assured.

Discussion

The questions posed by the participants mainly related to the various advantages and limitations of the proposed testing methods.

Interest was also attached to the classification of any imperfections detected in welds.

Technical Session X - Institute - Industry - Interaction - A collaborative effort in problem solving

The paper was presented by Mr. D.R. Karnik, WRI, India.

Summary

The technological state of the art decides the socio-economic scenario in a given country. Inadequacy of suitable industrialization in developing countries exists with regards to choice of technologies, assimilation and

appropriate transfer of the alternatives. These impediments are mainly due to lack of comprehensive data base and developmental support at the national level.

The paper stresses the role of UNDP and UNIDO in their endeavours of promoting existing infrastructure and to adapt transferred know-how as well as to promote R and D at the national and regional level.

The case study of WRI and its interaction with industries is being outlined. The Institute has been establishing strong bond with the industries mainly through 3 channels: education, information dissemination and consultancy.

The WRI has been and is successfully entering into commercialization of R and D efforts, such as for pulsed welding module, hot wire systems, resistance welding instrumentation, hard facing consumables, etc. Promotional visits to the industry are undertaken by WRI staff, with a slide presentation to apprise them about the capabilities and facilities available.

For the benefit of participants from developing countries which are considering the establishment of a similar institute, 2 project documents (project concepts) are attached to the paper and were handed out to the participants. If requested through official channels by the respective Government, UNDP/UNIDO assistance might be considered, provided the necessary financing can be allocated.

Recommendations

The following recommendations were made during the deliberations of the Workshop:

1. The Welding Research Institute (WRI) should prepare a comprehensive paper on "Case study of the Indian experience for the growth of the welding/electrodes/flux industry" highlighting its growth over the last decade or two and in particular:

   (a) Raw materials, their indigenous availability and processing, their imports (including their progressive decline) quality and quantity wise and their value in terms of Indian currency and foreign exchange;

   (b) Current status of the industry based on small scale and on integrated larger scale operations;

   (c) Future plans and projections of the industry;

   (d) The role which WRI has played and will continue to play in respect of (a), (b) and (c) above and further, in training technical and skilled personnel for the industry and in the applications of appropriate technology for the growth of the welding industry in the country;

(e) This case study may provide the guidelines and serve as a "model" to the extent possible for the growth and future development of the welding industry in other developing countries;

(f) WRI should analyse the possibility of providing technical assistance through UNIDO or bilaterally in the above fields to other developing countries including training/in-plant group training through UNIDO's technical assistance programme and financing based on TCDC/ECDC concepts and parameters.

2. UNIDO should reproduce/publish this WRI paper/document for wide circulation in order to promote the growth of the welding industry in the developing countries with UNIDO and WRI's active participation and assistance.

3. A case should be made out for regional co-operation and establishment of a Regional Centre for Applied Research and Development at the WRI; UNIDO could initiate an action-oriented programme on a regional basis for the benefit of ESCAP countries.

4. On the interregional basis and platform, UNIDO may organize a Workshop on the welding industry in Africa, jointly with an appropriate host country/centre, to effectively promote the interregional co-operation and assistance in multiple fields of welding technology.

5. WRI should be rostered in UNIDO as a top level Institute/Organization to undertake contractual projects for UNIDO in promoting the growth of the welding industry in developing countries; WRI could further provide technical experts to UNIDO for assignments in the above fields in developing countries on request.

6. WRI may prepare an "Annual Report" each year highlighting its R and D facilities/activities for wide circulation besides a Quarterly Technical Journal, if possible, within its financial and technical resources. WRI could also prepare from time to time "Monographs" on typical technological and commercial facets of the welding industry; UNIDO could assist WRI in promoting these activities for the benefit of the developing countries including the setting-up of computerized documentation facilities at the WRI.

7. WRI could assist UNIDO in formulating and implementing technical assistance projects in the developing countries including the preparation of Project Documents based on WRI and UNIDO experience (small scale and relatively larger scale projects) depending upon the status of the developing country concerned and scope of activities envisaged.

8. UNIDO may take steps towards promoting "Twinning" arrangements and operations between the WRI and sister institutions in other developing countries for mutual technical assistance and benefits.

9. WRI could develop Welding Extension Services based inter alia on Mobile Technical Assistance Units for technical assistance to small scale sector industries within the country.

10. WRI should be considered by UNIDO as a full-fledged Training and Technical Consultancy Centre for providing training to technical/skilled personnel from other developing countries including Demonstration Scale expositions and Technical Consultancy/Advisory Services for the growth of the welding industry in the developing/third world countries.

Annex I

WORKSHOP ON PROMOTION OF WELDING TECHNOLOGY IN DEVELOPING COUNTRIES

TIRUCHIRAPALLI, INDIA 30 JANUARY TO 4 FEBRUARY 1984

LIST OF PARTICIPANTS

Country	Name, Position	Contact address of participant
ARGENTINA	Hector E. Bassani Chief of Welding Area Instituto Argentino de Siderurgia	Pasaje Carlos Maria Della Paolera 226 1104 Buenos Aires
BRAZIL	Leonardo Uller Head of the Unity of Programs in Materials Technology	Instituto Nacional de Tecnologia Secretaria De Tecnologia Industrial Ministerio Da Industria Edo Comercio Av. Venezuela 82, Sala 608 20081 Rio de Janeiro R.J.
INDONESIA	Suryanto Mertoatmodjo Assistant Manager for Central Workshop	P.T. Krakatau Steel CILEGON
IRAN	Said Sahraian Vice Manager	QC Dept. of Machine Sazi Arak Arak (Iran)
IRAQ	Abdul Hakem S. Mahmod Head of Main Workshop in the Eng. Dept.	Ray State Establishment P.O. Box 11230 Banks, Baghdad
KENYA	I.S. Odera Mechanical Engineer Projects Officer	Industrial Promotion Dept. Industrial Development Organization Ministry of Industry P.O. Box 30418 Nairobi
KOREA Rep.of	Sun-Hyo Hwang Head Welding Research Div.	Ship Research Station Korea Institute of Machinery and Metals P.O.Box 1 Daedeog Science Town Chungnam
MADAGASCAR	Emmanuel Randria Harvel General Manager	Societe Industrielle pour le Developpement du Machinisme Agricole (SIDEMA) P.O. Box 14 Antananarivo

Country	Name, position	Contact address of participant
MEXICO	Francisco Esparza H. General Co-ordinator of Research	National University of Mexico P.O. Box 394 54700 Cuautitlan Izcalli Edo. de Mexico
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THAILAND	Boonsong Sangtong Mechanical Engineer	Thailand Institute of Scientific and Technological Research 196, Phaholyothin Rd. Bangkhen, Bangkok 10900
ZIMBABWE	Colin Alfred Waters Chief Metallurgist	ZISCO Steel P. Bag 2, Redcliff
INDIA	R. Krishnamurthi Head	Welding Research Institute Tiruchirapalli 620 014
UNIDO	B.R. Nijhawan Senior Interregional Adviser	Metallurgical Industries Section P.O. Box 300 A-1400 Vienna, Austria
	A.K. Mitra Regional Adviser for Africa	c/o Economic Commission for Africa Addis Ababa, Ethiopia
	G. Hynek, Research Assistant	Metallurgical Industries Section P.O. Box 300 A-1400 Vienna, Austria
	Kamal Hussain Senior Industrial Development Field Adviser (part-time attendance)	c/o United Nations Development Programme New Delhi, India

Annex II

List of lecture papers presented to the Workshop

Title of paper	Authors
Institution Building in a Developing Country - the case of Welding Research Institute	R. Krishnamurthi Head, WRI
Welding processes and their applications - Present status	K. Sampath Senior Development Eng.
Welding consumables - An overview	K. Narasimhan D.V.R. Varma A.K. Garg A. Raja Senior Development Eng.
Integrated approach to human resource development	B. Pullat Senior Development Eng.
Information management and dissemination at the WRI	M. Balasubramanian Development Eng.
An overview of engineering materials for welded structures and metallurgical problems in fabrication industry Part I	R. Veeraraghavan Senior Development Eng.
An overview of engineering materials for welded structures and metallurgical problems in fabrication industry Part II	S. Suresh Senior Development Eng.
Appropriate welding techniques for maintenance	R. Krishnamurthi Head, WRI
Productivity and quality through mechanization and use of high productive processes and techniques in welding	S. Suresh Senior Development Eng.
Welding processes and applications - future trends (solid phase welding)	Ramesh Sarma Senior Development Eng.
Welding processes and applications - future trends (resistance, electron beam and laser welding)	S. Muthukrishnan Senior Development Eng.
Quality assurance of fabricated components	J.R. Bhatia Senior Development Eng.
Institute-Industry - Interaction A collaborative effort in problem solving	D.R. Karnik Senior Development Eng.
Reclamation of a set of cogging mill rolls by welding	C.A. Waters Chief Metallurgist Zimbabwe Iron and Steel Co.

Industrial visits

Date	Industry/institution	Address	Products manufactured/work on	Specific areas and demonstration
31.1.84	Bharat Heavy Electricals Ltd.	Tiruchirapalli 620 014	High pressure boilers for utility and process industries; valves and fittings for high pressure and temperature applications, boilerhouse auxiliaries	Boiler production (plate formed pipes, boiler drum, waterwalls of other tubular products) and quality assurance department
1.2.84	Kaveri Engineering Industries	Senthanneerpuram Tiruchirapalli 62001	Pressure vessels, boilers and other engineering components	Demonstrations in pulsed TIG welding machine developed by WRI, India
1.2.84	Kothari Sugars Ltd.	Kattur (New Lalgudi)	Sugar manufacture	Hardfacing of crusning roller teeth as mounted on lathe as well as hardfacing on crushing roller while sugarcane crushing was on. The HF electrode was developed by WRI, India
2.2.84	Welding Research Institute	Tiruchirapalli 620 014	Training of welders and welding engineers. Research in welding processes, welding metallurgy, weldability evaluation, welding machine development, documentation of information	
4.2.84	Kirloskar Electric Co. Ltd.	P.O. Box 317 Bangalore 560 055	manufacture of welding equipments	
4.2.84	Weldcraft Pvt. Ltd.	60, Industrial Suburb II stage Thumkur Road Bangalore 560 022	manufacture of welding electrodes	
4.2.84	Hindustan Machine Tools Ltd.	17, Ali Asker Road Bangalore 560 052	Manufacture of machine tools	

INTER-REGIONAL WORKSHOP ON WELDING TECHNOLOGY TO BE HELD AT WELDING RESEARCH INSTITUTE, TIRUCHY, INDIA

(30 JAN 1984 - 04 FEB 1984)

P R O G R A M M E

30 JAN 1984 (Monday)	1130 - 1230 Hrs	INAUGURAL SESSION
	1400 - 1530 Hrs	TECHNICAL SESSION I INSTITUTION BUILDING IN A DEVELOPING COUNTRY - A CASE STUDY
	1545 - 1715 Hrs	TECHNICAL SESSION II WELDING PROCESSES AND APPLICATION - PRESENT STATUS
31 JAN 1984 (Tuesday)	0830 - 1015 Hrs	TECHNICAL SESSION III WELDING CONSUMABLES - AN OVER VIEW
	1045 - 1230 Hrs	TECHNICAL SESSION IV INTEGRATED APPROACH TO HUMAN RESOURCE DEVELOPMENT AND WELDING INFORMATION MANAGEMENT - A WRI APPROACH
	VISIT TO POWER PLANT MANUFACTURING INDUSTRY	
01 FEB 1984 (Wednesday)	0830 - 1015 Hrs	TECHNICAL SESSION V METALLURGY FOR FABRICATION INDUSTRY
	1045 - 1230 Hrs	TECHNICAL SESSION VI MAINTENANCE WELDING - A TECHNO-ECONOMIC ANALYSIS
	1330 - 1500 Hrs	TECHNICAL SESSION VII PRODUCTIVITY AND QUALITY THROUGH MECHANISATION

	1515 Hrs	VISIT TO A MEDIUM-SCALE PROCESS EQUIPMENT MANUFACTURING INDUSTRY
	1730 Hrs	VISIT TO SUGAR INDUSTRY - AN EXAMPLE OF INSTITUTE-INDUSTRY INTERACTION
02 FEB 1984 (Thursday)	0830 - 1015 Hrs	TECHNICAL SESSION VIII WELDING PROCESSES AND APPLICATION - FUTURE TRENDS
	1045 - 1230 Hrs	TECHNICAL SESSION IX ROLE OF QUALITY ASSURANCE AND CONTROL IN WELDING FABRICATION
	1330 Hrs	VISIT TO WRI/DEMONSTRATION
03 FEB 1984 (Friday)	0830 - 1015 Hrs	TECHNICAL SESSION X INSTITUTE-INDUSTRY INTERACTION - A COLLABORATIVE EFFORT IN PROBLEM SOLVING
	1045 - 1230 Hrs	TECHNICAL SESSION XI PRESENTATION BY THE PARTICIPANTS
	1230 - 1315 Hrs	LUNCH BREAK
	1330 - 1500 Hrs	TECHNICAL SESSION XII PRESENTATION BY THE PARTICIPANTS
	1515 - 1600 Hrs	CONCLUDING SESSION
	1730 Hrs	DEPARTURE FOR BANGALORE
	1955 Hrs	ARRIVAL AT BANGALORE
04 FEB 1984 (Saturday)	0900 Hrs	VISIT TO WELDING EQUIPMENT INDUSTRY
	1130 Hrs	VISIT TO WELDING CONSUMABLE INDUSTRY

The welding technology in Argentina - Present situation and ideas for a future development

The paper was presented by Mr. H.E. Bassani, Chief of Welding Dept., Instituto Argentino de Siderurgia (IAS)

Summary

A number of institutions organize high-level welding courses including the IAS. Technological R + D is carried out with numerous projects and various research centres and universities with the aid of the planning secretariat. The various institutes are co-operating with each other.

The paper particularly describes the activities of the Undersecretariat of Science and Technology (SUBCYT) and the IAS.

SUBCYT deals primarily with the elaboration of scientific and technological policies; the development, updating and determination of standards, intervenes with scientific and technological consultancy, and takes care of scholarships, loans and subsidies for science and technology work.

The IAS is a private non-profit association with the basic aim of serving the steel industry in the country through the undertaking of R + D projects. 6 sectors are covered: raw materials and materials, reduction, steelmaking, rolling, energy and welding. The IAS takes care of the welding sector since 1981. Todate the following work commissions have been formed: hand arc welding; inspection, testing and control of welds; behaviour of metals subject to welding; residual stress; pressure vessels, boilers, pipes;electric welding processes, with gaseous or flux protection; fatigue testing.

A short description of other centres dealing with welding is also given. In particular, the following are cited: Comision Nacional de Energia Atomica, Comision de Investigaciones Cientificas de la Provincia de Buenos Aires, Instituto de Investigaciones Cientificas y Tecnicas de las Fuerzas Armadas, Instituto de Investigaciones Aeronauticas y Especiales de la Fuerza Aerea Argentina, Instituto Nacional de Tecnologia Industrial. The Sociedad Mixta Siderurgia Argentina (SOMISA)has set up welding training courses. Manufacturers of consumables and components are also listed. The most important consumable manufacturers are Conarco Alambres y Soldaduras S.A.

The experience gained hitherto allows to make plans for enlarging its scope. New equipment will, however, have to be procured. Implementation of international refresher courses for skilled welding staff is considered essential. In the future, the IAS would seek the support of international experts for the purpose as well as for planning and development of the welding sector in order to increase local capabilities to actively participate in joint activities of investigation and development at the international level, particularly with other developing countries.

Welding R + D in Brazil - Interregional Co-operation with Latin America

The paper was presented by Mr. Leonardo Uller, Head of the Unity of Programs in Materials Technology of the National Institute of Technology, Rio de Janeiro, Brazil.

Summary

The paper describes the state of the art of welding research and development in Brazil, also taking into consideration the ways and means of promoting technology exchange, focussing on the possibilities of interregional co-operation in Latin America. Since 1975,four Latin American Congresses in welding have been held whilst Brazil has organized 9 annual welding meetings so far; the 10th being planned for October 1984. Technology transfer is effectively taking place through exchange of experience at these meetings, through discussions and dissemination of papers.

In 1979 the Brazilian Association of Non-destructive Testing and the Brazilian Welding Association were founded. They promote short courses, seminars and programmes in welding fields and disseminate printed information. In 1979, the Foundation for Brazilian Welding Technology was created and a reference laboratory was established at the National Institute of Technology. Their mandate is promotion of adaptation, generation and development of welding technology through human resource development, documentation, R + D and eventually quality certification.

Contracts and agreements in the welding area are limited because, as a rule, the welding technology is included in the basic contracts for construction, fabrication or equipment manufacture.

The importance of integrated research projects is stressed. The paper refers to the creation of the Latin American Metallurgical Association and its 8 working groups including one on welding, covering countries like Argentina, Brazil, Chile and Venezuela.

In the author's opinion, technological integration in the welding field should be aimed at the establishment of companies with regional technology and capital and a Latin American Welding Research Institute.

Country paper on welding activities: Indonesia

The paper was presented by Mr. Suryanto Mertoatmodjo from P.T. Krakatau Steel, Cilegon, Indonesia

Summary

As the Second Five Years Development Planning began in 1974, synchronising with the oil-boom market, Indonesia started to strengthen the industrialization stage from the agricultural base. The main target in the Third Five Year Plan in the industrial field was to establish a strong industrial base as a starting stage for the Fourth Five Year Planning starting in April 1984, aimed at self-sufficiency in manufacturing machine components.

The availability of infrastructural factors has to be increased. The need for skill development in welding technology is urgently required for rapid industrialization.

The need for establishing a strong body in welding technique which could co-ordinate all activities from training up to several areas of industry should be recognized and implementation take place as soon as possible.

Welding activities are expected to grow rapidly towards self-sufficiency; therefore there is also urgent need for studying the feasibility of expanding the welding consumables manufacturing and welding machinery industry.

Country paper on welding - Iran

The paper was presented by Mr. Said Sahraian, Vice-Manager of Quality Control Dept., Machine Sazi Arak

Summary

Iran fully recognizes the need for R + D as a means to industrial growth. The Machine Building Plant of ARAK (MAS) was erected in 1968. Technology transfer from industrialized countries which has been practiced in the past has recently been stopped. The plant is now building up suitable technology through own efforts. MSA has a technical training center with full facilities including 14 workshops. 2 workshops are reserved for welding purposes. A central laboratory provides testing facilities, carries out R + D and produces small structures.

MSA applies a variety of welding processes for the production of pressure vessels, steam boilers, bridges, etc. Weld joints are tested including with NDT and DT methods. Within MSA a pilot plant has been established which supplements the efforts of the Technical Training Center and provides 6 month courses for staff of the plant. For higher technical education MSA is establishing an advanced technical education center which will provide 4 - 5 year programmes for students. Construction for an R + D center will start in spring 1984.

The company is eager to co-operate and exchange programmes with other countries, particularly developing countries in order to share their experience.

Industrial Development in Iraq

The paper was prepared by Mr. A.H.S. Mahmoud, Head of Workshop, Rayon State Establishment, Babylon, Iraq

The period 1968-1980 is considered impulsive development of the Iraqi industry and various plants and fundamental projects were founded. At the same time, engineering faculties and polytechnical institutes with modernized technical equipment and instruments were established in order to attain the planned national technology standard.

Most factories in Iraq consider welding technology as being crucial for industrial development and modern equipment is being used. Such welding equipment and techniques include:

1. Electrode welding equipment:

   (a) Manual metal arc;
   (b) Automatic welding;
   (c) Spot welding;
   (d) Argon welding;

2. Oxy-acetylene:

   (a) Manual oxygen welding;
   (b) Oxy-acetylene for cutting;
   (c) Spray type transfer.

Country Paper: Kenya
The paper was prepared and presented by Mr. I.S. Odera, Dept. of Industries, Ministry of Industry and Commerce, Nairobi, Kenya

Summary

Kenya has a moderately developed metals and engineering sector. The country imports semi-finished raw materials in the form of hot rolled coils and plate, cold rolled coils, billets, wire rod and scrap metal. Spare parts and capital goods are also mostly imported. The first cold rolling mill started operation in September 1983, with a capacity of 120,000 tpy. Non-flat products manufacture reaches about 180,000 tpy, based on local or imported scrap. Capacity of the foundries in the country is about 7,500 tpy.

A study conducted on the Kenyan metal working and engineering industries in 1978 revealed that welding was the most widely used technique, mostly done in its simpliest form, manual electric arc welding. Only in a few cases gas shielded arc welding is also applied. Welding is mostly applied in the motor vehicle industry, the manufacture of agricultural machinery, manufacture of plant machinery and equipment, manufacture of structural metal products and manufacture of furniture.

The motor vehicle industry comprises 3 large assembly plants and 2 smaller ones, applying electric arc welding and spot welding. There are a large number of vehicle body builders in the country, 16 of them fairly large.

Manufacture of agricultural equipment takes place at the large, medium and small scale and varies from sophisticated power tools to animal drawn implements and handtools.

Several plants have embarked on the manufacture of plant machinery and equipment. Stainless steel piping fabrication has started. Small capacity boilers, cranes and LPG cylinders are also manufactured. High frequency welding techniques are applied for rectangular and round tubular product fabrication from metal sheet.

There is one leading R and D institute in the country, the Kenya Industrial Research and Development Institute which caters for the manufacturing industry as a whole.

2 companies in Kenya produce welding consumables (welding electrodes mainly for mild steel components and welding gases).

It is expected that welding will have a large potential in Kenya particularly when the oil pipeline running from Mombasa to Nairobi will be extended westwards to Kisumu.

Welding technology in the Republic of Korea

The paper was presented by Mr. Sun-Hyo Hwang, Head, Welding Research Division, Ship Research Station, Korea Institute of Machinery and Metals.

Summary

South Korea is a nation with large population density and small natural resources. This is the reason for urgent industrialization through technical upgrading. The welding technology is labour and technical knowledge intensive. The present South Korean welding technology is mainly depending on labour, not on technical know-how.

Most of the important heavy industries like the iron and steel industry have an inseparable relation to welding technology. Until now the country depends on the advanced foreign know-how for the solution of welding problems. The demand for development the welding industry is expected to increase fast and therefore the welding technology should be boosted up as soon as possible.

In South Korea there are 8 research institutes operated by government support and a number of others by industries. Among the governmental research institutes only the Korea Institute of Machinery and Metals has a welding research group. KIMM is now planning to build up a welding research centre from its welding research group. Among the research institutes in industries, Hyundae Heavy Industry is the only company with a welding research institute.

At the end of 1982 the Korean welding society was founded. Its members are now 800 and are composed of mainly engineers from industry.

In order to improve welding technology it is necessary to increase research activities in universities, in research institutes and in industries and also to train more welding engineers. Expansion of the activities of the Korean Welding Society, build-up of welding research departments in universities and technical colleges, as well as in institutes and industries would be necessary.

The current use and research of welding technology in Mexico

The paper was presented by Mr. Francisco Esparza Herrada, Head of Master Program in Metal-Mechanical Engineering, Centre of Adaptation of Technology, Cuautitlan Izcalli, Mexico

Summary

Mexico, as a medium development country, has a strong dependence on other countries; in the specific case of welding, the dependence is basically from: USA, Switzerland, West Germany and Sweden: the autonomous development efforts consist only in some power sources manufacturers with very little impact on the market. Most of the welding jobs are carried out by manual arc (about 80%), with submerged arc, MIG, flux-cored and TIG, following in this order. Only some large factories are using plasma cutting and welding, electroslag and powder surfacing.

The codes, normes and inspection are also in the hands of transnational companies like American Shipping Bureau or LLoyd's Register of Shipping and the AWS standards and the procedures in welding from ASME or the company who sells the technology are almost exclusively followed. The teaching and training of welders normally is carried out through the traditional system of "apprenticeship in the shop", and only in recent times the government has established a system of technical schools where the people can learn welding, mainly manual arc; nevertheless, no single university or polytechnical institute offers a career in welding engineering and only recently a master degree in metal mechanical engineering was established which has in its curriculum welding metallurgy and selection of welding consumables and processes.

Almost all producers of welding consumables and equipment impart courses on the subject but, of course, these are mainly oriented towards sale of products and not to improve the technology. R + D is very limited and only in the most recent years Mexico is trying to systematize it in the Center of Technology Adaptation.

Welding Technology in Nigeria

The paper was prepared and presented by Mr. R. Kilanko, Assistant Superviser, Federal Institute of Industrial Research

Summary

Welding trade was established at the Government Trade Centre in Nigeria in 1950. Initially, students were only trained to the grade of trade test certificate. In 1963 ILO assisted the country and since then students can take exams in all trades and enrol in welding technician courses. Welding facilities in the country are now being expanded and equipment requirements in the future will include equipment for TIG welding, gas shield metal arc welding, submerged arc welding, electroslag process, atomic hydrogen process and a number of others.

In the paper the author gives a rating for 145 welding workshops in Nigeria that he visited. Common faults, mainly due to unskilled workers, can be found in porosity and non-resistance to wear. There are about 100 welding companies in Nigeria, mostly foreign owned. About 14o firms are engaged in commercial welding business.

Electrodes come mainly from Europe, which is a burden on the balance of payments. Plans for expansion/modernization of the plant of a local electrode supplier exist. However, a lot remains to be done in updating technical skills and know-how.

Preparatory plan for setting up of a metal and engineering industry clinic within the Existing Foundry and Mechanical Workshop

The paper was presented by Mr. Mohamed Ali Dahir, General Manager of Foundry and Mechanical Workshop, Mogadiscio, Somalia.

Summary

In Somalia there is a growing foundation for Metal Engineering works according to the rapid expansion of the national industrialization plan. Many factories in th country started to establish metal and engineering workshops for local manufacture of metal sections, spare parts and to carry out repair and maintenance.

There are more than 200 medium and small workshops existing in Mogadiscio, owned by public and private sector which are involved in metal fabrication. The national university, faculty of engineering and teachers technical faculty and various polytechnical and vocational training centres are also involved in developing the metal and engineering works.

The Foundry and Mechanical Workshop (FMW) established by Somalia with UNDP/UMIDO assistance was carrying out during the last 4 years research programmes on introduction to the local market of new products which had previously not been manufactured locally. In 1982 trial products were exposed at the national fair which would be developed later on. The Government has realized the need for preparatory plan for setting up of a Metal and Engineering Clinic within the existing FMW with the immediate objectives of carrying out applied research in metal and engineering work, to serve as a centre for know-how dissemination, to render consultancy services and to act as a training centre.

The services of UNDP/UNIDO will be requested in the implementation of the proposed programme.

Country Report - Welding in Thailand

prepared and presented by Mr. Boonsong Sangtong, Thailand Institute of Scientific and Technological Research, Bangkok

Summary

There is no single institute which has included welding as its main activity. Welding know-how is obtaind through study tours undertaken by private and government officials to companies abroad. At the Thai Industrial Standards Institute (TISI) standardization programme to control quality of industrial products is being implemented. Many standards relate to welding equipment such as electric arc welding rods, electric cables for welding machines, etc. Training in welding is carried out by the Institute for Skill Development, the Industrial Service Division, the Vocational Education Department.

Testing laboratories for weldment tests but also general tests are incorporated in the following institutes: Thailand Institute of Scientific and Technological Research (TISTR), Department of Science Service, and Academic Institute.

The paper gives a description of the TISTR which undertakes research projects in various fields; it is responsible for testing of industrial standards, repair and calibration of scientific apparatuses and procurement of scientific information. Inspection, examination and certification of pressure vessels is undertaken. A NDT laboratory is in the planning stage.

Welding State-of-the-art in Zimbabwe

The paper was presented by Mr. Colin Alfred Waters, Chief Metallurgist, ZISCO (Zimbabwe Iron and Steel Company), Zimbabwe.

Summary

Zimbabwe is the most industrialized country in the sub-region with a well developed infra-structure. The economy is based mainly on the mining and agricultural industries which are supported by a primary integrated iron and steel industry; secondary metal industries; foundries; metal extraction and refining plants; motor vehicle assembly plants; vehicle body and rolling stock fabricators; structural and constructional engineers; sheet metal fabricators; agricultural products processing factories and refineries; chemical plants; power generation and distribution networks. All these industries utilise welding to a greater or lesser degree and at various levels of sophistication.

Great emphasis is placed on education and training. Theoretical apprenticeship training is provided on a block release system by Government Polytechnical Colleges. Practical training is the responsibility of individual companies. The local company which supplies welding equipment and consumables has established,in 1970, a School of Welding. The South African Institute of Welding has two branches in the country. Weld testing is carried out by the Standards Association of Central Africa and by a private inspection services company.

The processes and techniques applied are mainly gas and electrode arc welding, semi-automatic and automatic welding, MIG and TIG welding. A unique process called Cyber-TIG welding has been developed by a private company. Resistance welding is applied for spot and butt welding; sub-merged arc welding for fabrication of boilers and pressure vessels. Ohter applied processes include metal arc spraying, induction brazing, plasma cutting and thermit welding.

The company that has established the Welding School produces welding consumables including industrial gases and electrodes with a finished product capacity of more than 400 tons permonth.