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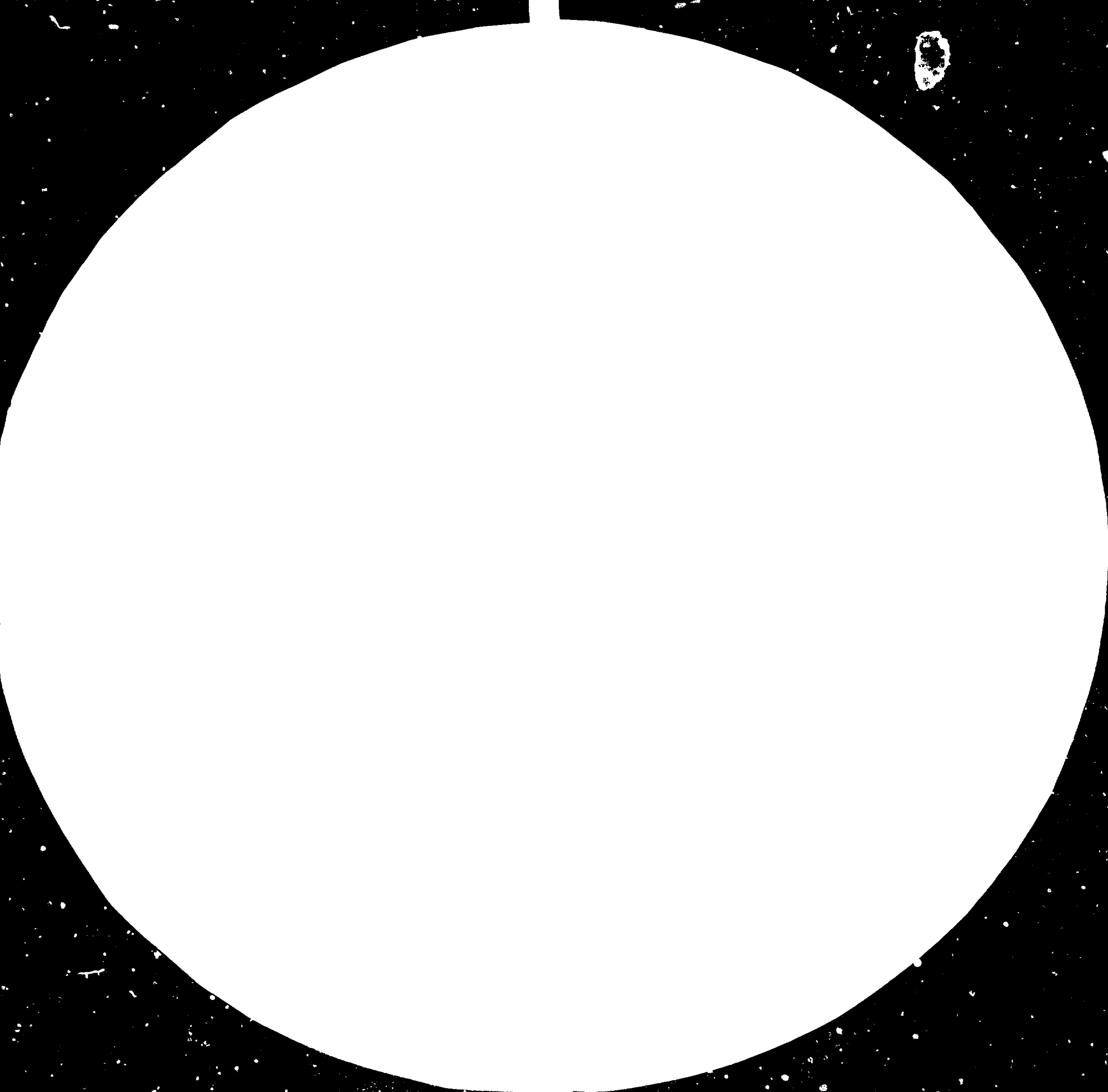

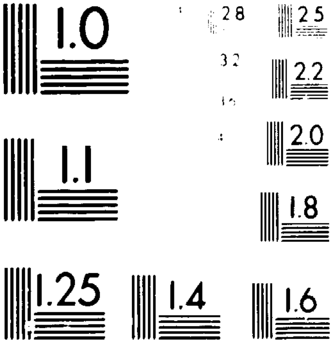

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WELDING PROCESSES AND THEIR APPLICATION, PRESENT STATUS*.

by

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WELDING PROCESSES AND THEIR APPLICATION - PRESENT STATUS

1.0 INTRODUCTION

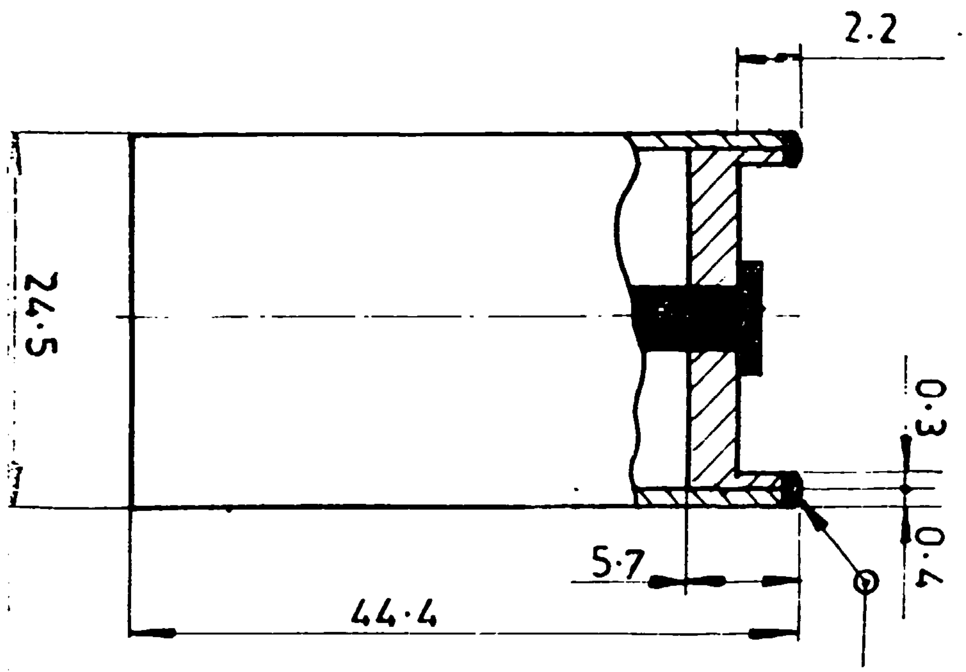
Today India occupies a pride of place among the developing countries of the world. A larger share of the pride goes to the early start of the planning process in the country. Since her Independence, India has built up a strong network of capital intensive yet basic infrastructural industries by a careful administration of five year plans. For example, the just concluding sixth plan has provided for quantum jump in power generation capacity, a larger outlay for exploration and tapping of offshore and onshore oilfields, installation of higher capacity refineries and expansion of existing capacities of petrochemical plants besides modernisation of machine tool industry, improvement in railway rolling stock, facilities for ship construction and containerisation of ports.

These types of industrial equipment need to serve in different service conditions such as higher operating pressure and temperatures, irradiation, high pressure hydrogen and corrosion. These service conditions pose special restrictions on the choice of materials with their different degrees of weldability. Again the economic need to fabricate higher unit sizes also imposes many challenges - challenges in the critical assessment of various metal joining methods and in ensuring higher levels of productivity. These challenges have largely been met by several contributions to the exploitation of fusion welding processes and today these welding processes have come to stay as a perfect gift to the fabrication industry. Selection of the correct welding process from the available welding processes has a direct effect on profit. A logical and a systematic approach is often required to examine the details of the joint, performance characteristics of the welding processes in terms of operator factor, duty cycle, deposition rate, joint completion rate and on-the-job factors like shop or site fabrication, position of welding, fit-up, mismatch etc., before one can select the right process. We discuss below certain case studies that highlight the application of the above themes in selection of appropriate welding process.

2.0 CASE-1 - DIFFICULT CONDITIONS OF WELD JOINT IN LITHIUM STORAGE BATTERIES

In the making of lithium storage batteries, a lid has to be joined by welding to a slender body made of stainless steel. The lid encloses in the body certain chemicals used in storage batteries and these chemicals are potentially explosive in nature. A welding procedure had to be developed that would just fuse the 0.4 mm thick stainless steel lid on to the body, but would not heat it considerably even 5 mm below the joint line, lest a condition conductive for explosion to take place may occur.

Considering the joint requirements, one would opt for high heat input process like TIG, Plasma or Microplasma. Microplasma was selected as it gives a controlled arc with constricted parallel shape. The component was clamped in position in a rotating fixture. The fixture also contained a water cooling arrangement which cooled the assembly adequately so that its content did not reach ignition conditions while welding. Since the joint was only 0.8 mm thick, there was also no need to introduce a filler.



Sketch-1

3.0 CASE-2 - JOINING OF STIFFENERS TO PANELS IN SHIPBUILDING

Shipbuilding requires a large number of huge panels. These panels are stiffened using transverse members. These members are 4 to 5 metres long and are joined to the panels by horizontal fillet welding. If a welder has to do these joints, one after the other, it would require considerable time. Instead, if it were so arranged that a welder can look after 4 or 5 welding stations simultaneously, then it would considerably increase productivity. In a low cost automation method called gravity welding, high productivity per welder is achieved by mechanically feeding an extra long high deposition rate electrode on a slide and as the electrode burns away, the welder moves down the slide under gravity. Because of the slope of the slide this downward movement is accompanied by a component of movement along the joint line. A variation of this method called auto-contact welding uses a spring to move the electrode tip along the joint length.

Operator using four gravity welding machines simultaneously to weld stiffeners to plating in a shipyard

Photo-1

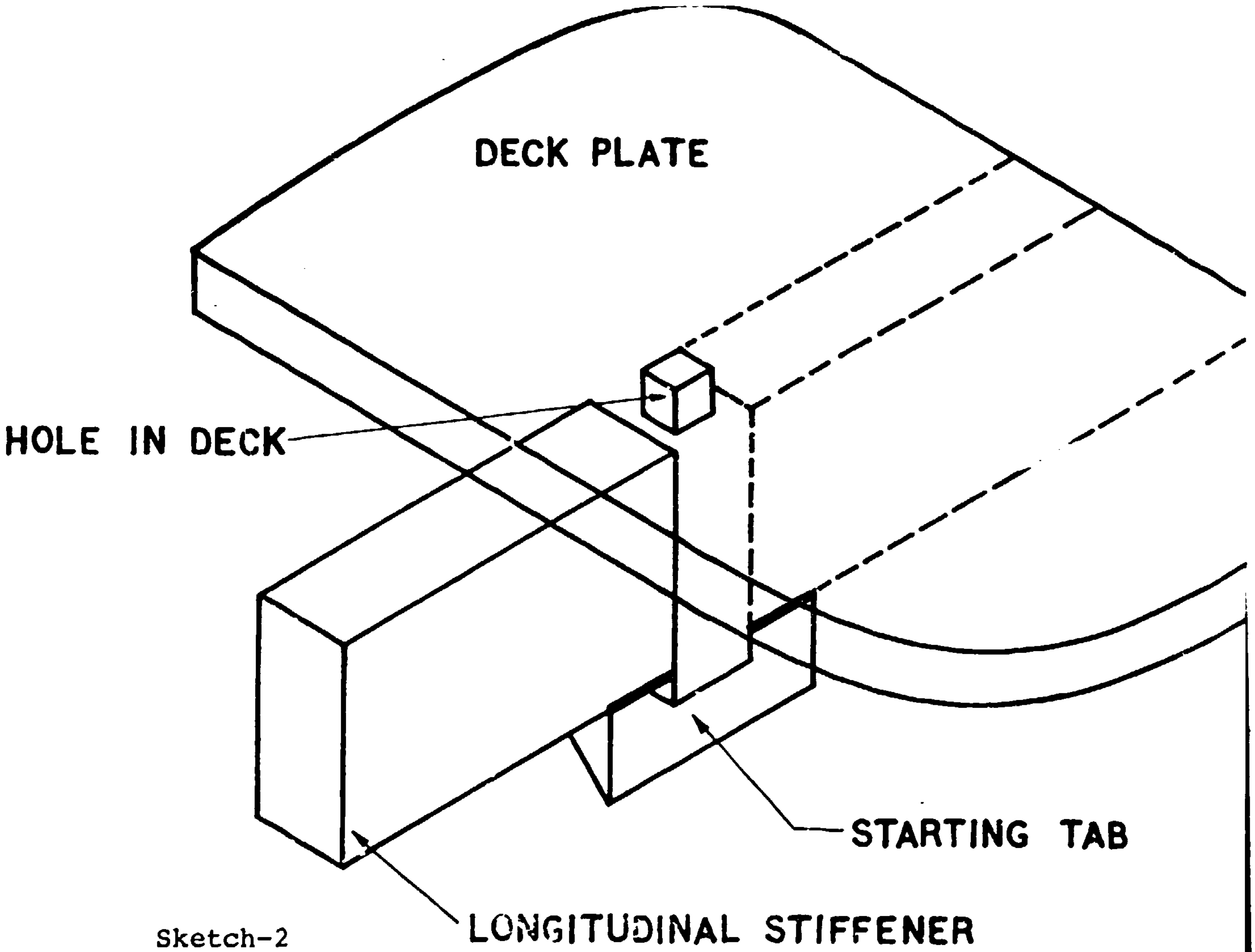
These are two innovations, wherein a welder's productivity is increased 4 to 5 times, by simply taking the feeding job out of the welder and instead asking him to look after many stations in a 'leap-frog' manner.

4.0 CASE-3 - CHANGE IN POSITION FACILITIES USE OF ALTERNATE PROCESS

Mechanised welding is preferred for joining materials with simple joint geometries like straight line, circle, or curves with good accessibility. Mechanised welding gives joints of repeatable quality and for the same reason deficiency in quality can easily be correlated and corrected.

In shipbuilding it is often required to join under-deck longitudinal stiffeners to themselves and on to the panel. This joint is made at the erection stage, at the dry docks. It requires matching the longitudinals making suitable edge preparations and welding in the overhead position. It used to be a classical example for an unproductive joint, till a new design was introduced.

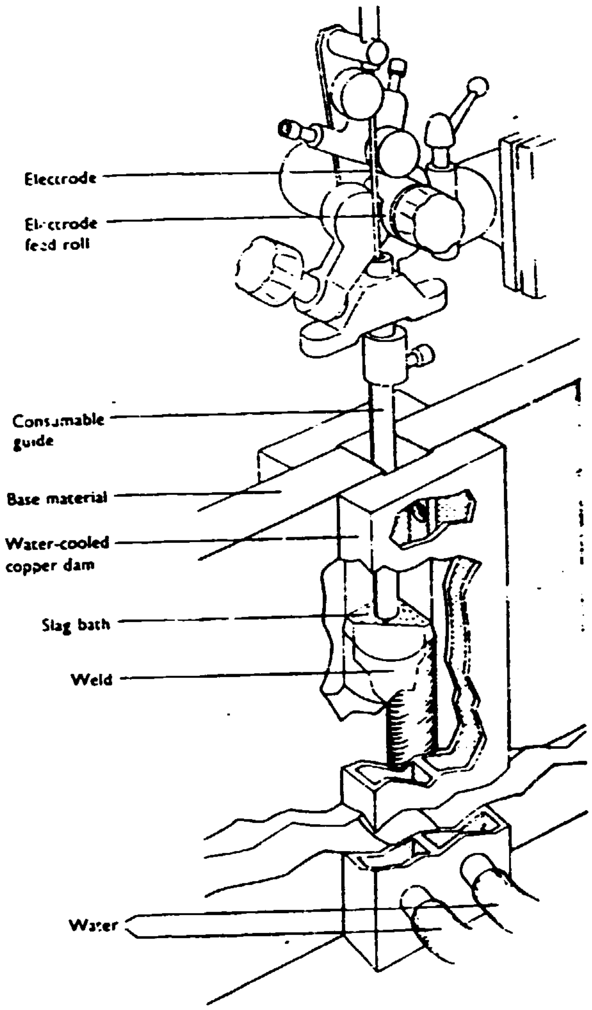
In the new design a hole is bored on the deck plate at the place where the longitudinals meet just below. A starting block is attached to the longitudinals and the joint gap between the longitudinals is enclosed by water-cooled copper shoes. A consumable guide electrode is inserted through the hole in the deck, and the welding arc is initiated on the starting block and the welding is completed in quick succession using special purpose machines. The consumable guide electrodes are available in different sizes like 8 mm, 12 mm etc, and facilitate different welding gaps. The operation is so simple the welder has to adjust only the voltage of the AC drooping characteristic power source.



Sketch-2

SKETCH OF THE JOINT DESIGN USED FOR CONSUMABLE GUIDE WELDING OF STIFFENERS THROUGH DECK PLATE

High welding currents can be conveniently used in downhand position as the molten pool will be self supporting in this position. If welding costs are taken as 100% in downhand position for shielded metal arc welding, it rises to 165% in the horizontal position and to 294% in the



Consumable welding with a tubular steel guide.

Sketch-3

overhead position. The increases are due to factors like size and type of electrodes, arc time factor, skill level required for different positions etc. In most applications, if the joint can be positioned for downhand welding, then larger economies can be easily realised.

One side welding techniques are simple methods to do welding in downhand position where job repositioning is difficult or require more time. These technique use different types of backing to cover the reverse side of the joint preparation, support the molten puddle and form neat underbead shapes free from notches and undercuts. Glass has been used as a backing material along with resistively melted insert (RMI) additions to a CO_2 welding technique to obtain defect free weld quality. These backing require less time to fit up, facilitate welding in different positions and at different current levels and provide good control of the welding operation. Moreover, these glass backings are also quite cheap.

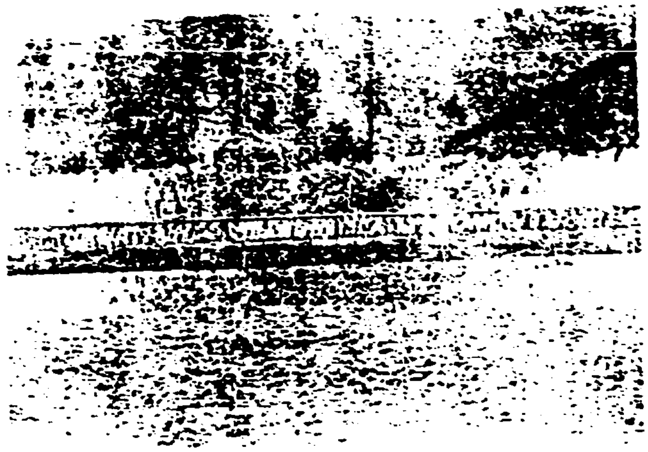
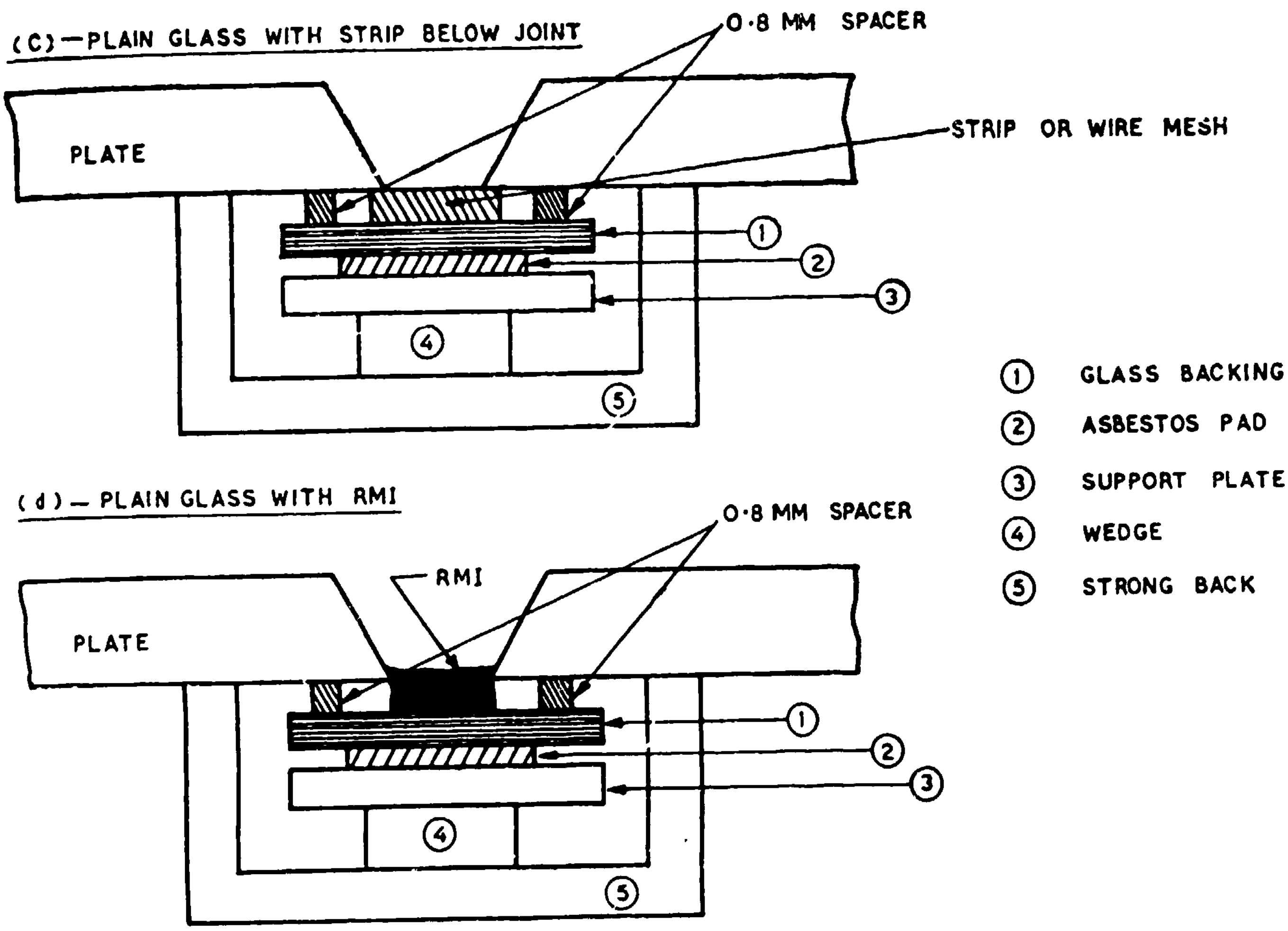


Photo-4

Resistively melted wire insert
placed in the root gap top view

Backing Set-up



Sketch-5

5.0 CASE-4 - BEAD PROFILE MATTERS IN WHEEL WELDING

Truck wheels are made by joining two circular discs, one fitting inside the other. The joint is a fillet weld, one each on either side. Between the two fillets there is a considerable space that remains unfilled. In severe dynamic conditions, this unfilled portion can act as a notch and cause damage. For this reason, the fillet weld dimensions are closely controlled and deviations are not allowed.

To obtain desirable bead shape, i.e., ratio of bead width to depth of penetration, three different welding techniques were tried out at the same welding speed. Flux cored arc welding was found to fill the bill,
gave a good penetration and the flux took care of spreading and slow coding of the bead to give a large bead width.

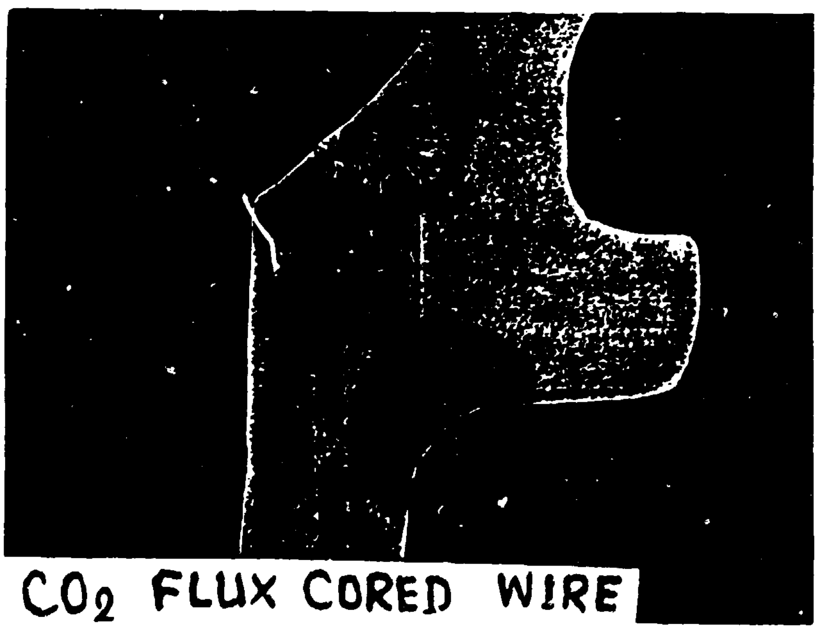


Photo-2

TABLE-1

Process	Inside Weld					Outside Weld				
	Current	Vol-tage	B	D	B/D	Curr-ent	Vol-tage	B	D	B/D
Fuse Arc	800-900	36	12.5	7	1.78	820-900	36	12.5	6	2.1
SAW	750-800	36	13.0	7	1.85	650-700	34	12.1	8.5	1.4
FCAW	380-400	34	6.4	5	1.28	380-400	34	5.7	7.5	0.76

6.0 CASE-5 - HOT WIRE ADDITION IMPROVES NOTCH TOUGHNESS

For a process that is a boon to downhand welding, submerged arc welding process further lent itself for considerable development to cater to the needs of high productivity. The multiwire tandem SAW process gives increased deposition rates at considerable high total heat input. They also require considerable capital expenditure in equipment and controls. Whereas the hot wire SAW gives increased deposition rate at rather low heat input with little extra capital investment. While a particular minimum heat input is required to avoid hydrogen cracking in low alloy steels, the net low heat input that is possible with hot wire SAW ensures a higher notch toughness in the heat affected zone, next to the weld metal. Thus when used with the quenched and tempered steels, hot wire SAW not only improves weld productivity and notch toughness but also results in use of less filler metal as smaller sections of QT steels can replace larger sections of mild or high tensile steels for a given load conditions.

TABLE-2

TYPICAL PARAMETER SELECTION FOR HOT WIRE SUBMERGED ARC WELDING OF NAVY Q1, QUENCHED & TEMPERED STEEL.

Main Wire 4 mm Ø			Hot Wire 2 mm Ø		Deposition Rate Kg/Hr.
Volts V	Wire Feed Rate m/min	Curr-ent A	Wire Feed Rate m/min	Current A	
29	1.1	600	3.35	300	11.4
30	0.86	500	3.35	300	10.1
30	1.1	600	3.6	350	11.8
31	1.1	600	3.6	240	10.4
33	0.86	500	3.6	350	10.5

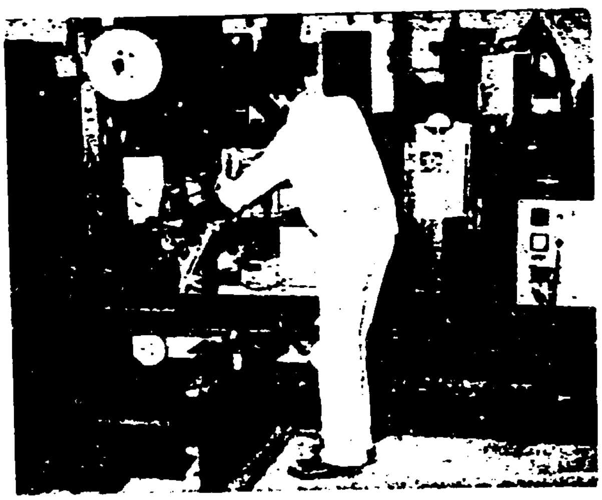


Photo-3

HOT WIRE SUBMERGED ARC WELDING SETUP

7.0 CASE-6 - MATERIALS ALSO DICTATE PROCESS SELECTION

A material like aluminum forms readily a strongly adherent oxide layer. This oxide is an insulator and has also a high melting point that aluminum itself. If aluminum has to be fusion welded, this oxide layer has to be effectively removed. This is sought to be automatically done by an electronic way, by opting for a process like MIG welding. Alternatively DCRP - TIG welding may be selected.

However, it leads to excessive heating of the tungsten electrode. This is again off-set by going in for AC-TIG welding. This, however, leads to a problem of partial rectification and transformer saturation and de-rating. All these have gone to the development of AC-TIG welding with capacitor bank to neutralise the effect of partial rectification.

8.0 CASE-7 - SURFACING REQUIREMENTS LIMIT PROCESS SELECTION

Surfacing is normally done on one material with another material to give particular properties like corrosion resistance, wear resistance, etc. These types of material combinations introduce certain metallurgical problems. These problems are best minimised by going in for low dilution welding methods like Plasma-MIG, Strip Cladding SAW and Electroslag surfacing.

Dilution control is achieved either by current (density) control in a non-consumable electrode process like TIG or by metal transfer control in a consumable electrode process like spray transfer MIG welding or plasma-MIG welding.

9.0 CASE-8 - NARROW GAPS HAVE COME TO STAY

The amount of weld metal required to make a joint depends on edge preparation. Square edge preparation requires more metal than single-V preparations which require more metal than double-V. The trend goes to quasi narrow gap and ends at different narrow gap techniques.

These narrow gap techniques require sleek welding head which can go deep into the narrow gap and do welding. Again the welding arc must also be suitably oscillated to obtain side wall fusion. In these techniques the deposition rate of the process does not increase but the joint completion rate is high as the volume of weld metal required to fill the narrow joint gap is low.

TABLE-3

Comparison of joint completion rate by Electrogas welding for various edge preparations on 25mm butt weld in vertical position:

Edge Preparation	WM/Unit length of joint Kg/m	WS mm/min	JCR m/hr
Square	4.17	66	3.99
Single-V	2.31	89	5.33
Narrowgap	1.58	99	5.94

10.0 CASE-9 - ON THE JOB FACTORS ALSO MATTER

Often fabricators must endeavour to ensure good fitups and reduce fitup gaps to avoid depositing excess weld metal. On the one hand organising for good fitup would reduce the handling of excess consumables and give tangible cost reduction. On the other hand the cost of improving fitup should not be high, then the product cost may go up.

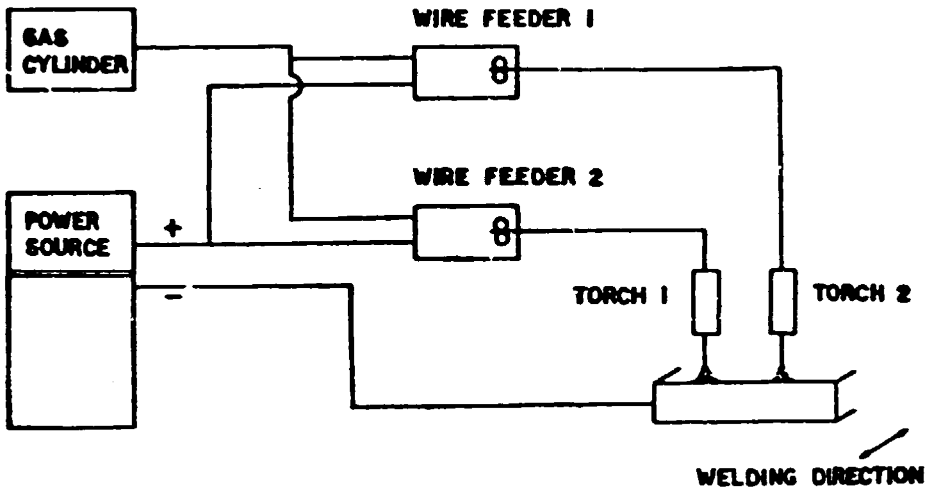
The latter point has led to the development of welding processes that can tolerate appreciable variations in gap width. Semiautomatic cored wire MIG welding, for example, can tolerate fitup gaps than most mechanised processes. It can tolerate gaps upto 3mm, if the joint design has an adequate root face. Twin wire welding consisting of a single power source that feeds two wires simultaneously into the same weld pool can also be used to weld poorly fit joint gaps.

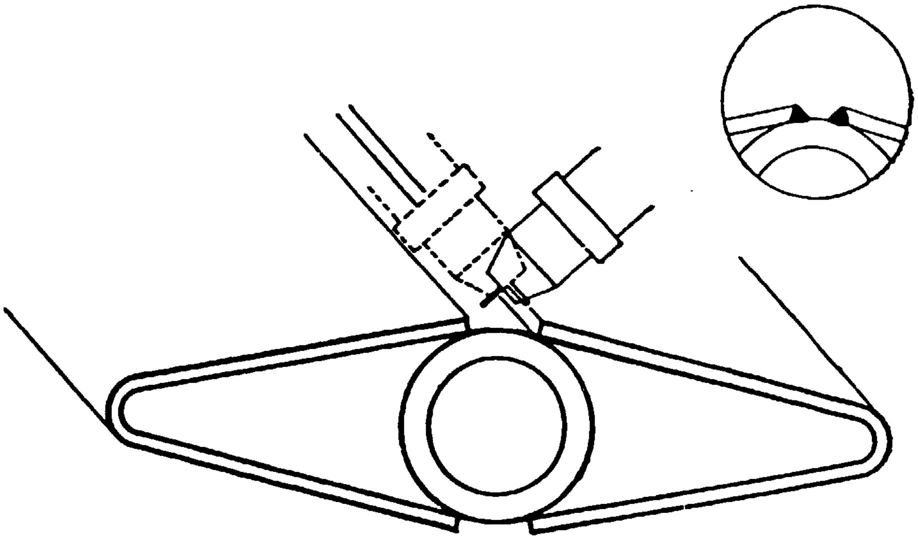
And where there are parallel joint lines separated by a distance, twin arc welding wherein welding is done simultaneously at different places can also be used to one's advantage.

TABLE-4

Welding Process	Setting Time (mins)	Arcing Time (mins)	Weld Cleaning Time (mins)	Total Time (mins)	% Saving in Time
CO_2 Welding	28	10	4	42	-
Twin Arc CO_2 welding	14	5	2	21	50%

TWIN TORCH WELDING SCHEMATIC DIAGRAM 2





FLAPPER BLADE

Sketch- 6 & 7

Another factor is the frequent breakdown of equipment not only major failures but also, for example, the necessity to clean repeatedly the gas nozzles of CO_2 welding equipment because of spatter. In this connection, it may be worthwhile to choose equipment which has a good record for reliability and serviceability.

Semi-automatic CO_2 welding equipment with automatic choke control to reduce spatter is a newer development that has significantly reduced the unproductive time lost in spatter removal. It also minimises to that extent the need to educate the welder to choose appropriate choke level for different welding currents.

11.0 CONCLUSION

The availability of so many fusion welding processes have 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.

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.

It may not be out of place to mention that fusion welding processes produce hazardous fumes, ultra-violet radiations which are harmful for injurious to the welder/operator and one needs to be trained in the art of welding and in the practices and procedures of safety. Suitable exercises in process selection and procedure application may well mean that all is well that ends Fusion Welded !