Productivity in Welding

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1.0 INTRODUCTION :

Obtaining better quality products in larger quantity at a lesser cost is the best way to achieve higher productivity. For the past two decades, we have been seeing explosions in the use of new welding processes and the associated techniques. Now, there are not less than three or more number of acceptable alternative welding techniques to make a product. This increase in the variety of welding processes together with the general movement towards more sophisticated methods of production, accounting and control has led to a gradual change in emphasis in the decision making process from a simple selection of the welding process which is technically the most satisfactory, to the one which is also the most economical in a given situation. This clearly reveals the interrelationship between productivity and economy.

Improvement in productivity can be achieved either by widening the scope of application of the existing process or by additional resources keeping in mind the relative effect on cost. This effect on cost need not be over emphasised due to the fact that welding occupies 30% of total fabrication cost and time. Since the welding process itself is labour intensive, there are both human and non-human factors controlling productivity and economy. It is these non-human factors that can be easily controlled by suitable resources and techniques. To enrich these resources quite considerable amount of research has been carried out at our Welding Research Institute, Tiruchy. Some of the resources along with practical case studies are discussed in this article. The discussions presented here are limited to fusion welding processes only.

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2.0 RESOURCES :

The shaping of any product involves processing of the material under various stages like design, preparation, manufacture and finishing. In each of these individual stages, various techniques can be employed to improve productivity, contributing to the overall improved economy and reducing the unit cost. Since the design and manufacturing stages have larger influence on productivity, these two are discussed in detail here.

Productivity is directly influenced by the 'operating factor', the ratio between the net arc time and total time. Any attempt to improve the productivity is done either through obtaining a higher net arc time or by keeping the total time (net arc time+handling time) as minimum as possible. A corresponding check on the cost also is to be done. The following are some of the resources which dwell on this fact.

2.1 Design Stage :

A careful analysis at the design stage itself can bring about a considerable increase in productivity. Often an improper design warrants rework, bringing about heavy loss in total production cycle time and impairing the productivity. Some of the factors that need utmost attention are discussed in detail below :

2.1.1. Optimum Product Design :

An optimum design of a product should not only take care of the functional requirement but also productivity and economic aspects during the manufacture. This enables one to achieve a cheaper product. Every attempt should be made to reduce the cycle time, rejection and reworkrate, etc., in the design stage itself. Some of the procedures of significance are :

(i) use of lesser number of welded joints

(ii) proper location of welded joints

(iii) rationalisation of weld sizes

(a) Use of lesser number of welded joints :

This can be achieved by the use of standard rolled sections. By use of such standard sections, the number of welded joints are minimized, reducing the total manufacturing cycle time. It also minimizes rejection and correction, enabling achievement of higher productivity.

(b) Location of welded joints :

The location of any weld joint should be such that it occupies a lone stressed region. This makes the weld more effective and efficient in transmitting the loads. Moreover, it should also be located in an area having easy accessibility for the welder.

This point is not very uncommon to be missed by any designer which substantially decreases the arc time. This aspect should be particularly given attention in site welding applications wherein positioning may not be feasible. Moreover, from the distortion point of view, the location of the welds should be either on or as near as possible to the neutral axis of the component to minimise distortion. This will help in reducing the correction time.

(c) Rationalisation of weld sizes :

Wherever possible the designer should use rationalised weld sizes throughout the component. This reduces the number of welding procedures, sequences, frequent changes of electrodes, etc. Though the effect of this factor on productivity seems to be minor, it may become quite considerable in large weldments.

2.1.2. Process selection :

Many welding processes are available to join components of a weldment. Each has its own limitations in application, and proper selection is imperative. The common features and limitations of the more important welding processes are illustrated in table 1. Limitations are dictated by the materials being used, material thickness, joint design, welding position, welding procedure to be employed as well as the productivity of the process versus the capital cost for each application. When selecting a welding process it is important to consider the application. An improperly applied semi-automatic process having higher efficiency of deposition can be more costly than MMAW. It should also be noted that processes with higher initial capital cost can easily prove to be more economical. So if the productivity is increased to overcome the capital cost it can enhance economy. However, the criterion is the ability to keep the equipment in operation for a sufficient percentage of time.

To substantiate this fact, presented here is a case study wherein two processes-MMAW and Co_2 are compared in terms of both productivity as well as economy. The details are given in case study 1.

A glance through the case study reveals the following :

(i) The net arc time required for Co_2 welding is only one third that of manual metal arc welding.

(ii) The number of units to be manufactured or the weight of metal deposited per hour can be increased by 200% by using the Co_2 welding process.

(iii) The cost per kilogramme of weld metal deposited works out to be 25% less in Co_2 application.

(iv) Considering the MMAW process, productivity can be increased by use of larger diameter, higher deposition efficiency, iron powder electrodes and by providing one or more helpers to the welder. In the former case 100% increase in productivity with 5% reduction in cost can be achieved and in the latter case 21% increase in productivity with a marginal reduction in cost. So comparing these facts, the Co_2 welding process is superior in terms of productivity and economy.

TABLE-1 CHARACTERISTICS OF CERTAIN WELDING PROCESSES

	Process	*Range of Current (Amps)*	*Arc Shielding method*	*Deposition Rate (Kg/Hr)*	*Thickness Weldable (mm)*	*Operating Consideration*	*Welding position*
Manual Metal Arc	Class 2, 3 rutile electrodes	Upto 500	—	Upto 5	3mm to any thickness	Labour intensive	All positions
	Class 6 Basic Electrodes	-do-	—	-do-	-do-	Flexible in operation	-do-
	High yield Electrodes (Iron powder)	-do-	—	Upto 6.5	-do-	-do-	Downhand and Horizontal Vertical
Fusarc		200 to 1200	—	1.5 - 10	10mm to any thickness	Long weld runs recommended	-do-
Gas Metal Arc	Spray-transfer type	250 - 900	Co_2 or Argon	3 - 7.5	5mm to any thickness	Good quality labour required	Downhand Horizontal-Vertical
	Dip transfer type	50 - 200	Co_2	0.5 - 5	2 - 15	Requires maintenance	All positions
	Pulsed Arc Welding	50 - 300	Argon or $Ar + Co_2$	0.5 - 7	1.5 - 40	-do-	-do-
Gas Tungsten Arc		40 - 200	Argon or Helium	Slow completion rate	0.5 - 4	-do-	-do-
Sub-merged Arc	Single wire	200 - 1200	—	1.5 - 15	3mm to any thickness	Long weld runs recommended	Downhand Horizontal Vertical
	3 arcs in tandem	-do-	—	Upto 35	15-25 in a single pass	-do-	-do-
	Electro-slag	300 - 700	—	5 - 22.5 per elec. wire	12mm to any thickness	Restarts are difficult if the equipment breaks down during welding.	Vertically up

CASE STUDY I

Product Analysis : Side wall of a MS tank (4650 × 3000 × 6 mm thick) Fig. 1
Objective : Substitution of Co_2 welding process for MMAW for improving productivity

	Procedure details	Existing method		Proposed method
1.	Process	Manual metal arc		MAG (Co_2)
2.	Parameters	110 Amps 20 V DC		265 Amps 24 V DC
3.	Welding speed	0.15 m/min		3.35 m/min
4.	Welding size	6 mm fillet - 23 m 6 mm butt - 13 m		6 mm fillet - 23 m 6 mm butt - 13 m
5.	Number of passes	One		One
6.	Weight of weld metal to be deposited	7.143 Kg		7.143 Kg
7.	Weight of consumables required	11.421 Kg		7.682 Kg
8.	Consumable specification	E60 class size 5 - 450		E60 class size 1.2 wire
9.	Wire feed	—		3 m/min
	TIME DETAILS			
10.	Net arc time	364 min		110.4 min
11.	Handling time	1052 min		414.24 min
12.	Total time	1416 min		524.64 min
13.	Equipment cost	Rs. 6.30		Rs. 5.4
	Maintenance at 2%	Rs. 0.126		Rs. 0.108
	Total	Rs. 6.426		Rs. 5.508
14.	Field cost			
	Electrode cost at Rs. 5/Kg	Rs. 57.10	Wire	Rs. 76.80
			Gas	Rs. 6.60
	Power	Rs. 2.70	Power	Rs. 1.15
	Total	Rs. 59.80		Rs. 84.55
15.	Labour cost	Rs. 94.40		Rs. 35.00
	TOTAL COST	Rs. 160.00		Rs. 120.00

INFERENCES

Process	*Deposition rate (kg/hr)*	*Arc time required (min)*	*Total welding time (min)*	*Total cost (Rs.)*	*Cost/kg of weld metal deposited (Rs.)*
MMAW	1.2	364	1416	160/-	22.4
Co_2	4.0	110.4	524.64	120/-	16.8

(v) Further, Co_2 welding being a deep penetrant process, the fillet weld size can also be reduced by about 2mm (for the same loading conditions) which brings 26% reduction in weld metal requirement as well as 43% reduction in arc time.

From the foregoing conclusions it is clear that a considerable amount of improvement in productivity can be achieved by selecting the higher deposition and deeper penetrant process. However, as high as 8 to 12 Kg per hour deposition rate can be easily achieved by Co_2 welding for larger thickness welding

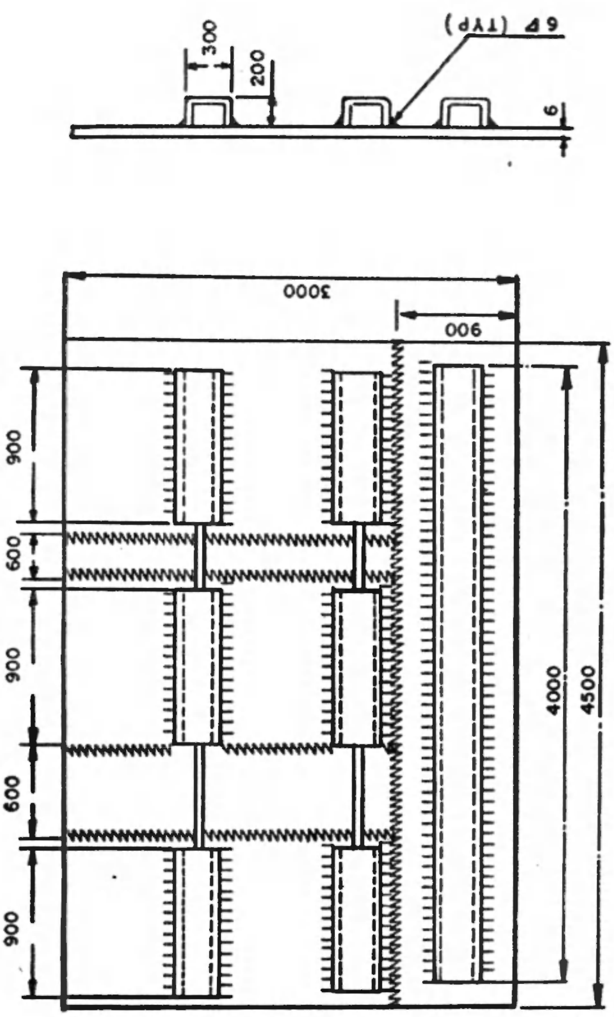

Fig. 1. Case Study I.

applications bringing down the unit cost to a greater extent.

The unit process cost (total cost per metre or kilogramme of weld) is a function of the amount of welding carried out per working period and duty cycle. For a given practical duty cycle, the typical relationship between the unit process cost and the amount of welding is shown in Fig. 2. It can be seen that the unit process cost initially decreases sharply with increase in utilisation and then tends to a limiting value which can be considered a constant for the process in question. These values can be used to predict the welding rate above which any particular process is the most economical, to select the cheapest welding process for a fixed production rate required. Similar graphs should be prepared (depending upon the existing local conditions) for the particular applications of interest, to guide one when to change the process.

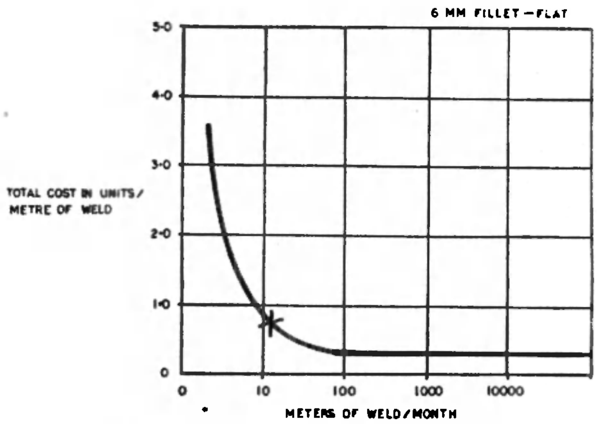

Fig. 2. Relationship between fillet length and cost.

2.1.3. Choice of edge preparations :

The volume or the weight of weld metal deposited has a direct influence on the productivity and cost of welding. Many kinds of edge preparations viz., single Vee, double Vee, single-U, double-U, level, J,K, etc. are available to join two edges of a component. For a component, a double vee edge preparation requires only 50% of the weld metal comparing that of a single Vee preparation. This results in 50% reduction in arc time, apart from savings in weld metal. However, the cost and time of edge preparations should not be ignored. Analyzing the fabrication aspects, it need not be emphasized that a single Vee edge preparation is going to result in heavy distortion in thicker sections. This may warrant correction and rework which will have adverse effect on productivity. Very often it may increase the production time by 100% or more. To illustrate these facts a case study (No. 2) is presented here which clearly highlights the relative effect of the edge preparation on productivity using MMAW process.

2.1.4. Optimisation of weld sizes :

An optimum size of the weld is the smallest weld size that effectively meets the design load requirements. This provides the minimum size of the weld to carry the designed loads which minimizes quantity of weld metal, improving the productivity and economy. To substantiate this fact is shown the escalation in the cost with different fillet sizes carrying the same load, in fig. 4.

Moreover to achieve economy in weld production, what is wanted on the production floor is speed in metre

CASE STUDY 2

Product analysis : Fabrication of top cover of a tank (5000 × 3000 × 12 mm thick) shown in figure 3

Objective : Change of edge preparation to decrease WM consumption and increase productivity

	Details	Existing design	Proposed design
1.	Process	MMAW	MMAW
2.	Edge preparation	Nil	Double vee edge preparation
3.	Welding procedure	One side welding with sealing run on the otherside	Welded from both sides alternately
4.	Weight of weld metal to be deposited	10.32 Kg	9.5 Kg
5.	No. of passes	4	6
6.	Weight of consumables required	17.2 Kg	15.9 Kg
7.	Net arc time	*380 min	*322 min
8.	Handling time (inclusive of preparation time)	826 min	759 min
9.	Total time	1206 min	1081 min
	COST DETAILS		
10.	Equipment cost	Negligible	Negligible
11.	Fixed cost	Electrode cost Rs. 135/- Power cost —	Electrode cost Rs. 125/- Power cost —
12.	Labour cost	Rs. 80/-	Rs. 72 + 812†
13.	Rework cost	Rs. 1301/-	—
14.	TOTAL COST	Rs. 1516/-	Rs. 1009/-

Note : *Operating factor is taken as 3
†Preparation cost for double vece

INFERENCES

Procedure	*Wt. of weld metal deposited* *Kg*	*Wt. of consumables* *Kg*	*Arc time* *Min*	*Total time* *Min*	*Total cost/panel* *Rs.*
Existing	10.32	17.2	380	1206	1516
Proposed	9.5	15.9	322	1081	1009

CONCLUSION

At superficial sight the existing method seems to be economical. Actually the economy gets adversely affected to a tune of 30% due to the increase in total time. This increase in total time is contributed by the time spent on correction of distortion at the manufacturing stage. Hence, though double vee preparation seems to be time consuming it is more economical.

per hour in producing welds. This can be represented by the following equation,

$$\text{Speed}\ \frac{(m)}{(hr)} = \frac{\text{Deposition rate (Kg/hr)}}{\text{Size of weld (Kg/m)}}$$

The welding engineer selects the welding process and the procedure that determine kilogrammes of weld metal deposited per hour, the numerator of this equation. Usually everything possible is done to increase the numerator (i.e. deposition rate) and make it as large as

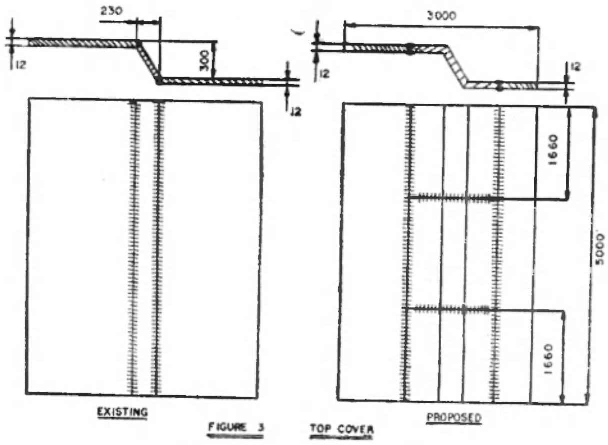

Fig. 3. Case Study II.

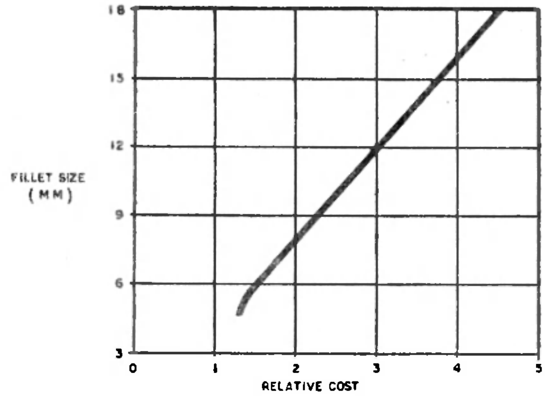

Fig. 4. Relationship between fillet size and cost.

possible to achieve higher productivity. But the denominator is where the real cost reduction can be made.

The larger the kilogrammes of weldmetal per metre, the greater the effect in reducing the values of numerator and hence the lower the welding speed. It is the weldment design engineer who determines this controlling value of the denominator. This kilogramme of weld metal per metre run is dependent on weld size, joint configuration etc.

The weld size required to carry a specific load depends on the strength of the weld metal and nature and amount of forces coming on the weld. The strength of the weld metal is governed by the strength of the consumables used. So by selecting a consumable having higher strength, the weld size gets reduced to carry the same load. Moreover, the cross sectional area of a fillet weld generally varies as the square of the fillet size. For example making a 8 mm leg size fillet weld when a 6mm weld is desired, increases the leg by 25% but the area is increased by 56%. The amount of reinforcement also is difficult to control. So the reduction in weld size can be advantageously used to reduce the arc time and cost to enhance productivity. This fact is illustrated through case study number 3

2.2. Manufacturing stage :

Achieving higher productivity and controlling fabrication cost is a formidable task. It affects everyone from the welder to the management. The consequences of error in fabrication are even more formidable. Probably the greatest trouble in welding is the rectification of a mistake which not only means repetition of the job but also means clearing out the faulty joint usually by laborious chipping, to make it ready for rewelding. So troubles sorted out in the shop are invariably costly. Changes may be impossible if materials for the job are already in stock or mating parts are already finished. Hence the concern of the shop floor personnel should be to increase productivity and control fabrication cost. This applies not only to shop but also to site conditions.

2.2.1. Any fabrication of weldment involves edge preparation of components, fit up & assembly, welding, heat treatment, inspection and finishing. Of these the first four factors are discussed in detail below :

(a) **Assembly procedure :** The overall assembly procedures adopted to fabricate a weldment influence the production cycle time to a considerable extent. Each of the assembly procedures available ts associated with its relative effect on distortion etc. Usually two methods of assembly procedures are adopted for fabricating a component.

1. Restrained assembly procedure—in which the different component members are present to the overall dimension and welded together.

2. Unrestrained assembly procedure—in which the whole component is broken up into smaller welded sub-assemblies and welding them together.

Out of these the latter procedure is highly productive since,

(i) it requires lesser production cycle time,

CASE STUDY 3

Product analysis : Lifting attachment welding as shown in figure 5

Objective : Choice of higher strength weld consumable to reduce fillet weld size to improve economy

Procedure details	Existing method	Proposed method
1 Process	MMAW	MMAW
2. Type of weld	Fillet	Fillet
3. Length of the weld	1200 mm	1200 mm
4. Forces coming on the weld	560.5 Kg/cm of weld	560.5 Kg/cm of weld
5. Consumables used	E60 class	E70 class Iron powder type
6. Actual size of fillet required	16 mm	14 mm
7. Weight of weld metal required	1.2 Kg	0.96 Kg
8. Weight of consumables required	1.9 Kg	1.44 Kg
TIME		
9. Surfacing time required	30 min	18 min
10. Handling time required	60 min	36 min
11. Total time	90 min	54 min
COST		
12. Equipment cost	Rs. 0.53	Rs 0.32
13. Fixed cost		
Electrode cost	Rs. 13.30	Rs. 12.96
Power cost	Rs. 0.18	Rs. 0.15
Total	Rs. 13.48	Rs.. 13.11
14. Labour & Overhead	Rs. 6.00	Rs. 3.60
15. TOTAL	Rs. 19.48	Rs. 16.71

INFERENCES

Procedure	*Wt. of weld metal deposited Kg*	*Wt. of consumables Kg*	*Arc time Min*	*Total time Min*	*Total cost/panel Rs.*
E60	1.2	1.9	30	90	19.48
E70	0.96	1.44	18	54	16.71

CONCLUSION

The reduction in weld size amounting to 12.5% increases the productivity by 40% along with a reduction of 14% in total cost.

(ii) it minimises correction time in the assembly stage since distortion gets corrected in the sub-assembly stage itself. And hence no carry over of distortion to the final stage,

(iii) it is more economical.

(b) **Fit up :**

The fiitting up of components for welding is an important stage which needs considerable attention. Mostly the fit-up time exceeds the welding time and it is quite likely to get increased further due to many procedures like improperly prepared

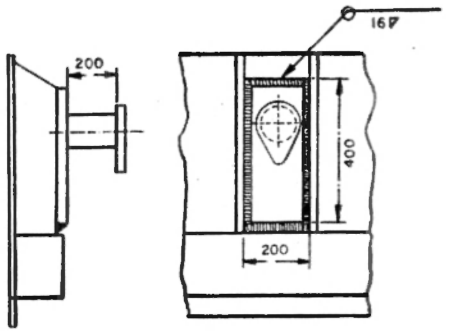

Fig. 5. Case Study III.

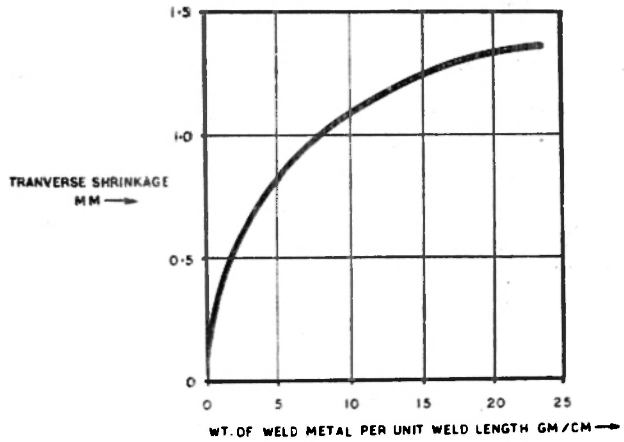

Fig. 6. Relationship between Transverse Shrinkage versus weight of weld metal.

edges, use of under dimensioned parts, use of improper clamps, wedges etc. These improper procedures force the shop floor man to assemble the components with excessive root gaps. As a result the joint grooves are filled with more metal than required contributing to overwelding. This overwelding affects the total time and weld metal consumption which are summarised in Table 2. This increased weld metal increases the shrinkage resulting in heavy distortion. The proportional effect of the amount of weld metal and root gap on distortion can be appreciated by the graph (Fig. 6) shown. Further, correction takes quite a substantial amount of time increasing the total welding time for the weldment. Moreover, it is also noteworthy that the aforesaid procedures can very easily nullify the good effects of properly chosen edge preparations, welding sequences etc. Hence a lot of precautions are to be observed in this fit up stage. Some of them are :

1. Tack welding procedures especially for thin plate fabrication.
2. Building up of underdimensioned components and component edges.
3. Use of temporary stays and stiffeners etc.

(c) **Deposition techniques :**

The deposition technique adopted to fill a joint groove is often done only with a view to improve the deposition rates. The effect of the deposition technique on distortion control is usually ignored. In fact some of the sequential welding techniques can quite effectively control distortion minimizing the total weld time enhancing productivity. Mostly the fabrication personnel notice the severity of correction time involved only after fabrication. Hence though they achieved a higher deposition rate the overall productivity still remains low. Some of the weld sequencing techniques that could be practised are : block techniques like back

TABLE-2 EFFECTS OF OVERWELDING

Joint Required	*Joint produced*	*Increase in Welding Time*	*Increase in Electrode consumption*
5mm leg length H-V fillet	6mm leg length H-V fillet	78%	78%
8mm leg length H-V fillet	9mm leg length H-V fillet	31%	31%
60° single Vee butt with 3mm root gap in 25mm thick plate	As required except root gap increased to 6mm	17%	17%

step, staggered step and alternate welding of double grooved joints etc. These block welding techniques are more effective to control distortion in thin walled fabrications wherein it is likely to result in heavy distortion. The alternate side welding of double grooved joints controls distortion in a better way minimising total distortion. Though considerable time is lost in turning the heavy component members each time the total welding time gets reduced due to lesser time spent in distortion correction. Hence, though sequential welding techniques are slower, they result in higher productivity and use of such techniques should be resorted to the maximum extent. Multi operators working on the same job sequentially also help to improve productivity.

2.2.2. Automation :

Automation is directing the welding gun or the work by a mechanical apparatus and not by the hand of welding operator although a welder may be on hand to watch and to make minor adjustments. Further, welding controls may be automatic enough to embrace the whole operation including loading and unloading the work, control of all weld variables, torch position and even inspection.

Productivity in an automatic process is usually 3 to 4 times that of manual operation since the human aspect viz., operator skill and fatigue is very much re-

CASE STUDY 4

Productivity analysis : Hard surfacing of Stellite over carbon and alloy steel material. (Ref. fig 7)

Objective : Comparison between semi automation of gas stelliting and manual gas stelliting.

Details	Manual stelliting	Semi automatic stelliting
1. Surfacing speed	15 mm/min	30 mm/min
2. Deposition rate	1 Kg/hr	2 Kg/hr
3. Dilution	15% to 25%	5% to 8%
4. Weight of metal deposited	1.0 Kg	0.6 Kg
5. Weight of consumables required	1.3 Kg	0.66 Kg
TIME DETAILS		
6. Arc time	120 min	40 min
7. Handling time	240 min	40 min
8. Total time	360 min	80 min
COST DETAILS		
9. Fixed cost		
Equipment	Rs. 1.40	1.80
Filler Rod	Rs. 520.00	264.00
Gas	—	—
Power	—	0.55
TOTAL	Rs. 521.4	266.35
10. Labour Cost	Rs. 18.60	4.13
11. TOTAL COST	Rs. 540.00	270.48

Process	*Deposition rate Kg/hr*	*Surfacing time min*	*Total time min*	*Total cost Rs.*	*Cost of metal deposited per Kg*
Manual	1	120	360	540	540
Semi automatic	2	40	80	270.48	410

CONCLUSION

It is seen that the productivity is increased by 66% in semi automatic operation along with the reduction of 24% in cost per Kg of metal deposited. This is due to the reduction in surfacing time and operator fatigue, as well as lesser dilution.

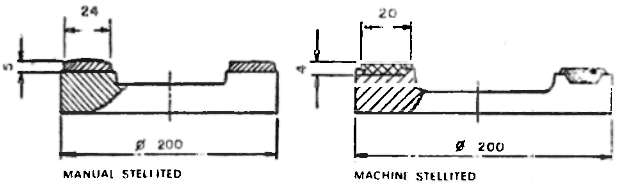

Fig. 7. Comparison between manual and machine stelliting.

duced. This is more so in performing intricate jobs at difficult locations and inconvenient environments. It even makes possible a single operator controlling multi welding heads. It yields consistent, good quality welds at reduced arc time and operating factor contributing to higher productivity. So for full advantage in high production mechanisation must be integrated into the production line.

Automating usually costs a lot for welding equipment, controls and fixtures. Hence while attempting automation it should be borne in mind to check whether it justifies the cost. It pays in circumstances when,

(i) a large number of identical parts are to be welded ;

(ii) there is scarcity of skilled (qualified) labour ;

(iii) labour costs are high ;

(iv) the form of the workpiece is complex, the welding position is difficult, welding environments are inconvenient and working conditions are rougher making hand welding difficult if not impossible.

Technologists incorporate mechanisation over many stages. Often it is impractical to find a way to weld the entire fabrication automatically but one should aim for the greatest amount of automation in standard assemblies. As a first phase, mechanisation was attempted in one of the welding process viz., gas. This was aimed at reducing operator fatigue and skill and increasing welding speed to improve productivity. The details of the results are given in case study no. 4.

2.2.3. Positioneering in welding :

Positioneering has become indispensable in the present day's demand of increased production or productivity. Positioneering is moving the work to the arc through positioners as well as moving the arc to the work through manipulators. Positioneering is done to improve accessibility, to increase the welding speed and to reduce operator fatigue. All these above factors contribute to the overall increase in productivity. Or in other words it reduces the handling time, increasing the duty cycle or operating factor. It also considerably reduces the man power requirements contributing to higher economy.

Positioneering a weldment is done either by using a crane or a welding positioner. The latter is more economical since it involves lesser cost per hour of operation, requires less time to position and can be done by the welder himself. A weldment is positioned (i) for the people and (ii) for the assembly.

(i) **Positioning for people :** Every out of position welding has disadvantages like lower deposition rate, higher production cost and operator fatigue. This is mainly caused by inconvenient welding position as well as inaccessibility to the joint. Further preheated environments also cause inconvenience to the welder resulting in operator fatigue. This considerably affects the skill of the operator affecting the productivity and quality. A rework on poor quality welds again swallows up much time impairing the productivity. Hence every effort should be made to keep the position convenient for the welder while he performs the welding. This ensures achievement of higher productivity.

(ii) **Positioning to increase the production rate :**

The deposition rate of any welding process depends on the position of welding. This is due to the effect of gravity on the molten metal pool. To be precise downhand welding is 3 to 4 times faster than overhead welding. Moreover, it facilitates the use of larger currents and larger diameter electrodes. This results in larger deposition rates reducing the net arc time required to deposit a given quantity of weld metal. Again positioning the job to a downhand position from an out of position through a positioner reduces the handling time contributing to the reduction in the total welding time. So in effect we achieve a higher operating factor by using such facilities along with our standard welding systems. The capital investment on these additional facilities is neutralized by the increased productivity resulting in better economy. Positioning can also be done either to facilitate inspection or maintenance. The main savings achieved are through the handling time reduction that contributes to improved productivity.

Apart from the positioners and manipulators a lot of other toolings and fixtures are also utilised to position the jobs as well as the arc. Some of them are orbital rotating head fixtures for tube and pipe welding, pipe fitting clamps, mechanised gas bevelling and cutting fixtures, weld weavers etc. These toolings increase production to the tune of 200% to 400% increasing overall productivity.

2.2.4. Developing new processes and techniques :

Technological advancements being a vital necessity in present day's circumstances, welding technologists, have been in constant search for newer processes. Such efforts have been mostly focussed only towards highly productive and economical processes. In tune with this, Welding Research Institute has been associated for the past few years with development of techniques like hot wire techniques, multi electrode techniques, one sided welding etc.

The hot wire technique is a combination of a heat source (either TIG or SAW) with a separately added resistance heated filler wire. This technique has been applied to two of the welding processes viz. TIG and SAW. The appreciable advantages that can be achieved are :

(i) Two to three times increased deposition rates with a proportionally less additional heat input.

(ii) Relatively less dilution warranting lesser weld metal improving the economy. The study over productivity aspects of this hot wire TIG applied to some of the components is described in detail.

Multi electrode or wire technique involves use of more than welding head (nozzle) for depositing the weld metal. This technique can be very conveniently employed to submerged arc welding having two to three welding heads in tandem. The heads could be either powered by a single power source or by means of a multi power source. Since the welding speed achieved is twice or thrice that of singlewire submerged arewelding, productivity is increased by 250% along with 45% reduction in unit cost. Hence this multi electrode technique is another technique which can be thought of for improvement in productivity.

These processes and technology developments aid the management to exploit existing technology to the fullest extent for achievement of better returns. Hence such developments should be always encouraged to achieve overall productivity and economy.

The studies were conducted on a mechanised hot wire TIG welding machine developed at our Welding Research Institute. The productivity of stainless steel surfacing by hot wire TIG process was compared with cold wire process. Stainless steel was surfaced over carbon steel wedge plate. A 360 amps power source with a water cooled torch and a mechanically fed, resistance heated filler wire were used for the study. The influence of the additional equipment cost and energy consumption on deposition rate is illustrated in Table 3.

A glance through the table reveals the following :

(i) Though the hot wire addition involves an additional expenditure towards equipment and power about 15%, the resulting increase in productivity is 200%.

(ii) A study conducted in similar lines on hot wire submerged arc welding showed that an additional investment of about 25% towards equipment and power yielded 15% increase in productivity. This was also done on the hot wire submerged arc welding machine developed at our Institute.

TABLE-3

Process	*Equipment Cost (Rs.)*	*Energy Consumption (Kwh)*	*Wt. of Metal deposited (Kg.)*	*Deposition rate (Kg/hr)*	*Surfacing time (mints)*	*Total time (mints)*	*Total cost (Rs.)*
Cold wire TIG	30,000	5	0.4	1	24	32.4	29.26
Hot wire TIG	35,000	6	0.4	3	6.8	9.52	29.00

3.0 CONCLUSION

Each of the aforesaid resources and techniques contributes to productivity by varying extents. Depending upon the existing local conditions one has to decide the choice and use of the appropriate technique that suits ones condition. However, an overall increase in productivity and economy can only be achieved if all the techniques at every stage of manufacture are adhered to after considering the pros and cons.

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