Study on Economics Between Twist Arc Narrow Gap and Tandem Submerged Arc Welding Processes

By R. VISWANATHAN* and R. VENKATESAN**

1.0 Introduction

1.1. The Japanese have recently introduced the Twist Arc Narrow Gap Welding Process for welding of thick plates, while the West continues their research and application on Tandem Submerged Arc Welding and Multiwire Submerged Arc Process.

Experimental studies carried out at the Welding Division of M/s. KOBE STEELS LIMITED, JAPAN indicate a vast potential for Twist Arc Welding Process application in heavy fabrication jobs.

This paper critically examines the productivity and economy aspects of the Twist Arc Welding Process compared to the more widely practised Tandem Submerged Arc Welding Process.

A comparison of variousele ments that go to the building up of the total Welding cost/metre length of a 135 mm. thick plate has been presented for objective cost studies.

2.0 Principles and Salient Features of the Processes

2.1. The Twist Arc Welding Process is basically gas shielded metal arc welding in which a twisted wire made of two inter-twined wires is used as a consumable filler wire. This process utilises the rotational movement of the arc, which is a characteristic feature of this process.

This process has been found most suited for Narrow Gap applications since the lack of fusion on the side wall grooves gets eliminated by the rotational movement of the arc.

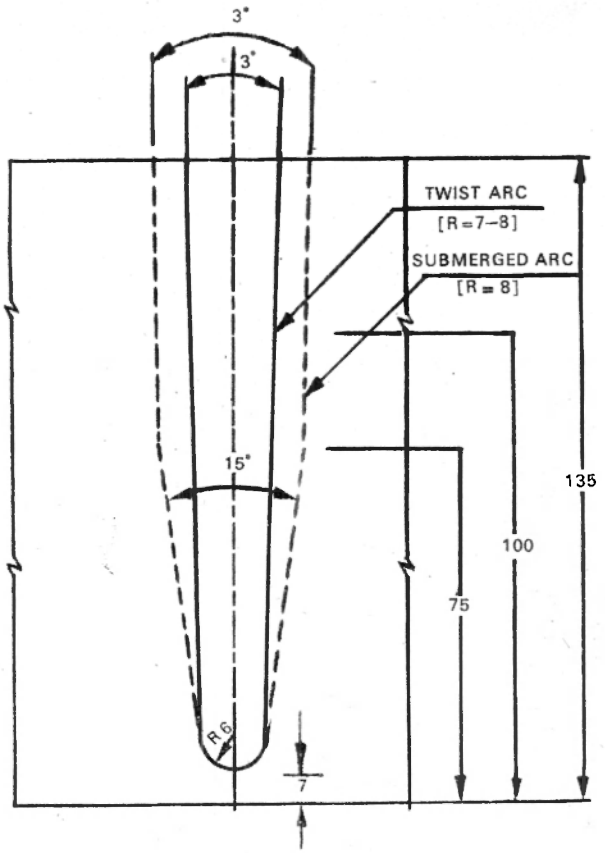


Fig. 1 Weld Groove Design.

* Manager/Operation Planning & Control/Nuclear.
** Senior Industrial Engineer,
Bharath Heavy Electricals Ltd./Tiruchirapalli.

2.2. The Tandem Submerged Arc Welding Process is being used for higher deposition rates with control on heat input not exceeding the prescribed limits of 20-25 KJ/Cm so as to ensure the required notch toughness values. The process is adoptable for welding thick plates with leading and trailing arcs.

3.0 Known Data for Study

3.1 A typical weld groove design for a plate butt weld 135 mm. thick is given in Fig. 1 for both Twist Arc Narrow Gap and Tandem SAW processes. A graphical representation between plate thickness and arcing time per metre length of weld is shown in Fig 2 for both Narrow Gap Twist Arc Process and single wire Submerged Arc Welding Process. The optimum welding conditions for the Twist Arc Process have been reported as 500-550 Amps, 32 V and a twist wire made up of two 2 mm wires.

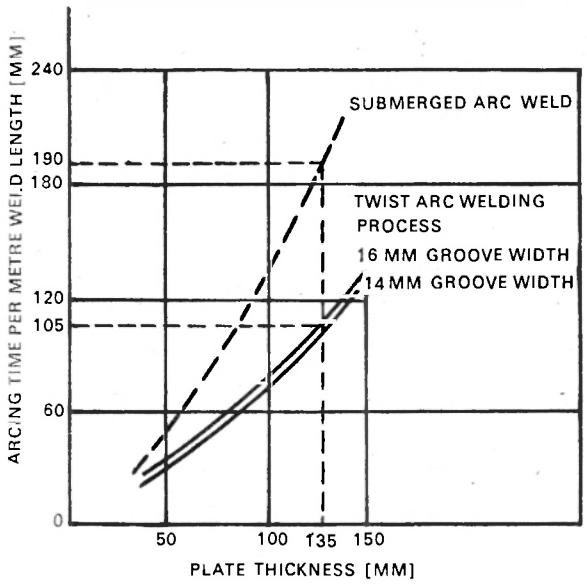
And as for proper shielding, when the flow is 5-10 litres/min. for the inner shielding gas and 50 litres min. for the outer shielding gas with "in gap type" nozzle, the best shielding property is obtained. Near the surface of the plates, when the thickness to be welded is around 50 mm., "box type" shielding is recommended. Fig. 3 represents the relations between shielding gas flow rate and gas shielding property for such purposes. With these data, the further part of this paper presents the analysis done.

4.0 Comparison of Twist Arc Welding and Tandem Submerged Auto Welding

4.1 *Deposition Rate* : From the data available, the rate of deposition works out to an average of 275 gms/min. (i.e. 16.5 kgs/hour) for tandem SAW and 175 gms/min, (i.e. 10 kgs/hour) for Twist Arc Welding.

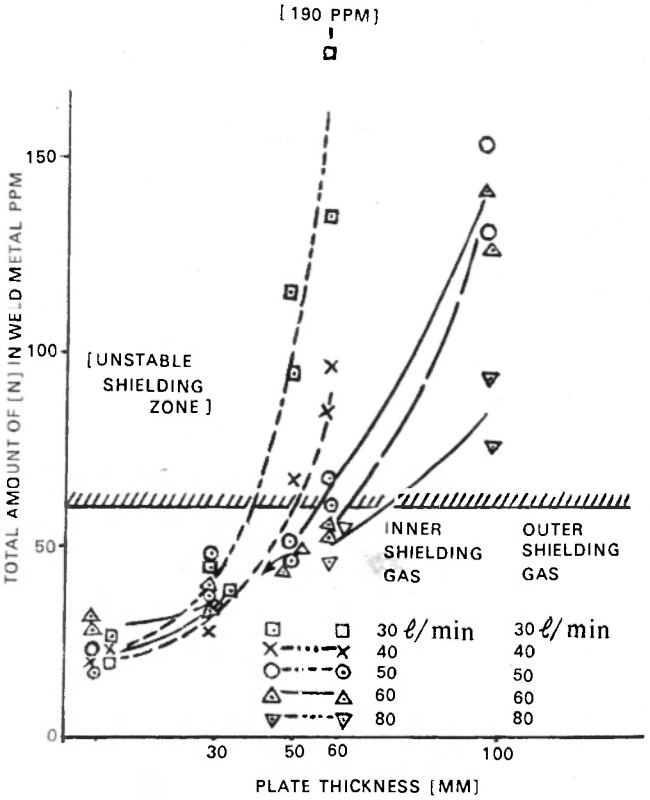
4.2 *Arcing Time* : For the type of groove shown in Fig. 1, Twist Arc Welding works out to be more economical from the point of view of arcing time. Referring to Fig. 2, it can be seen that for plate thickness of more than 50 mm., arcing time/metre is less compared to Submerged Arc Welding. The difference increases in larger proportion with the increase in plate thickness. Considering a 135 mm. plate as an example for our study, the arc time per metre of weld is as follows :

Twist Arc Welding	:	105 Arc mins./Metre
Sub-Auto Welding with single wire	:	190 Arc mins./Metre
Tandem Sub-Auto Welding with two wires	:	95 Arc mins./Metre (i.e. 190÷2=95)



COMPARISON OF ARCING TIME

Fig. 2



RELATIONS BETWEEN SHIELDING GASFLOW RATE AND GAS SHIELDING PROPERTY [BOX TYPE]

Fig. 3

Due to process limitation, for the initial 25 mm thickness, single wire SAW is considered. For the remaining thickness, Tandem SAW is assumed.

In that case the arcing time per metre length of weld by Tandem SAW would be 115 mins. (i.e.

$$\left\{\frac{25}{135}\times 190\right\} + \left\{\frac{110}{135}\times 95\right\} = 113 \text{ mins})$$

as against 105 arc mins./metre by Twist Arc Welding.

4.3 *Metal Deposition Requirement* : Referring to Fig. 1 for the given cross section area, Tandem SAW metal deposition requirement is 60% (approx.) more than that of Twist Arc Welding.

In other words, for every one kg. of metal deposit by Twist Arc Welding, the Tandem SAW requires 1.6 kgs. of weld metal.

Hence, for our 135 mm. thick plate example, the weld metal requirement by Twist Arc welding would be 16.1 kgs./metre (area of cross section 2050 mm² ref. Fig. 1 and specific gravity of steel taken as 7.85 gms/cc) as against a 25.2 kgs/metre weld metal by Tandem SAW Process.

4.4 *Verification of amount of Metal Deposit* : Taking into consideration the two known factors :

(a) Deposition Rate and

(b) Arcing Time/Metre

the above total weld metal deposition can be verified for its veracity.

Twist Arc Welding Process :

Arcing Time/Metre	...	105 mins,
Deposition Rate	...	10 kgs/hour
Amount of Deposit/Metre	...	17.5 kgs.

Saw and Tandem Saw Process :

SAW Arcing Time/Metre	:	36 mins.
Deposition Rate	:	8 kgs/hour
Tandem SAW Arcing Time/ Metre	:	77 mins.
Deposition Rate	:	16.5 kgs/hour

∴ Total Deposition by both SAW and Tandem SAW/Metre

$$= \left\{16.5 \times \frac{77}{60}\right\} + \left\{8 \times \frac{36}{60}\right\}$$

$$= 26.1 \text{ kgs.}$$

These values tally fairly well with all the worked out, assumed and known values.

5.0 Requirement of Consumables

consumable requirements per metre length of weld for the 135 mm. thick plate by the above processes are as follows :

5.1 *Saw and Tandem Saw* : Amount of weld metal deposit 25.2 kgs. Assuming weld metal to flux ratio as 1.3 the flux requirement is 32 kgs. considering a 95% transfer efficiency,

Wire requirement is 26 kgs. and
Flux requirement is 32 kgs.

5.2 *Twist Arc Welding Process* : Amount of weld metal deposit is 16.1 kgs. Shielding gas for Twist Arc Welding Process is a mixture of Argon and CO_2 in the ratio of 80 : 20.

Referring to Fig. 3, Shielding gas requirement for the top 50 mm. thickness works out to 120 litres/minute for both inner and outer shielding. For the remaining thickness the shielding gas requirement is 8 litres + 50 litres respectively for both inner and outer shielding. The shielding gas requirement is less due to advantages of having "in gap nozzle" for deep groove and the nozzle arrangement inherent with the process.

Hence, the average requirement of shielding gas works out to 90 litres/min. (i.e. 120+58=178÷2).

Arcing Time/Metre by Twist Arc Process is 103 mins.

∴ The amount of shielding gas required per metre length works out to 9270 litres (i.e. 90 litres × 103 mins).

Assuming 10% as wastage the total requirement is 10,197 litres or 10.2m³ of shielding gas which is made up 8.1 m³ of Argon and 2.1 m³ of CO_2.

Estimated consumable requirement for Twist Arc Welding Process :

(a) Filler Wire 16.8 kgs. (with 95% transfer effiiciency) and

(b) Shielding gas 10.2 m³/metre made up of a mixture of Argon gas 8.1 m³ and CO_2 gas 2.1 m³)

6.0 Total Welding Time/Metre Length of Weld

6.1 In the case of SAW and Tandem SAW, the Arc Time Factor or the weld time factor is around 1.8, whereas based on a fair judgement, this factor may be around 1.2 to 1.3 in the case of Twist Arc Welding. This increase in ATF (Arc Time Factor) in the case of SAW is mainly due to the cleaning-slag removal requirement after each pass.

∴ Estimated Total Welding Time per metre for,

(a) SAW+Tandem SAW=205 mins. (i.e. 113 Arc. Min.×1.8 ATF)

(b) Twist Arc Welding=126 mins. (i.e. 105 Arc Min.×1.25 ATF)

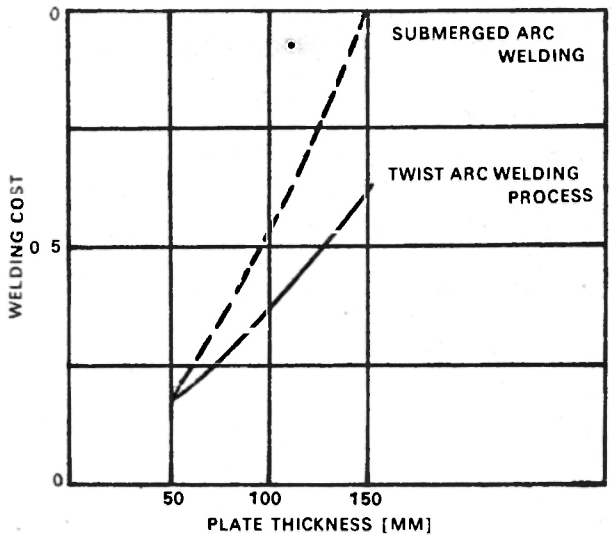
This total welding time has considerable effect on the overhead expenses and manufacturing cycle time.

7.0 Welding Equipment

7.1 Even though the Twist Arc Welding equipment cost in our country is yet to be known, we can safely assume that the overall cost may be atleast comparable with if not cheaper than that of the Tandem SAW equipment. This is mainly because Tandem SAW requires two power sources while Twist Arc Welding needs one only.

8.0 Summary

8.1 The cost curves on Fig. 4 show the overall economy of the Twist Arc Process. These curves represent the Japanese conditions. However, considering the various factors (Ref. Table 1), which influence the overall cost, the authors believe that there may not be an appreciable variation in our country too.



COMPARISON OF WELDING COST

Fig. 4

9.0 Conclusion

It is quite obvious from the above analysis that the Twist Arc welding Process would lead to lower consumption of welding consumables, lesser time of welding and more significantly less probabilities of weld defect. Considering the growth potential for heavy fabrication industries especially in Power and Fertilizers Sectors in the coming years, the proper exploitation of this technique will go a long way in effecting overall economy.

Table 1 Comparison of various elements in building up the total cost/metre length of weld

PROCESSES : TWIST ARC NARROW GAP & TANDEM SAW.
PLATE THICKNESS : 135 mm.

Sl. No.	Element	Twist Arc Narrow Gap	Tandem SAW
1.	Power	500 Amp. 32 V. for 105 Minutes	600 Amp. 32 V 2 Nos. × 77 Mins.+ 1 No. × 36 Mins.
2.	Arcing Time	105 Mins.	113 Mins.
3.	Total Welding Time	126 Mins.	205 Mins.
4.	Consumables	16.8 kgs. of Twist wire 8.1 m^3 of Argon and	26 kg. of wire
		2.1 m^3 of CO_2 gas	32 kg. of flux
5.	Equipment Capital Cost	Single power Source	Two Power Sources

10.0 Acknowledgement

The authors express their thanks to Dr. Tomokazu Godai, Mr. Yogi Ogata, Mr. Toshisada Kashimura of Technical Department (Welding Division) of KOBE STEEL LIMITED JAPAN for the valuable points discussed during their recent visit to India. The authors are grateful to BHEL Management for their kind permission to publish this Paper.

References

1. Twist Arc Welding Process for Narrow Gap Welding— Dr. Tomokazu Godai, Mr. Yogi Ogata, Mr. Toshisada Kashimura of KOBE STEEL LTD., JAPAN—Paper presented at the "WELDING-81', Seminar, Tiruchirapalli, January, 1981.
2. Tandem Submerged Arc Welding Studies conducted at B.H.E.L., Tiruchirapalli.
3. Submerged Arc Welding combining increased Deposition Rates with improved mechanical properties- Mr. P. S. Viswanath, Mr. S. V. Nadkarni of Advani Oerlikon Limited, Bombay and Dr. H. Baach, welding Industries, Oerlikon Buehrle Limited, Zurich, Switzerland-Paper presented at the "WELDING-1981" Seminar, Tiruchirapalli. January, 1981.

DECLARATION OF OWNERSHIP

The Registration of Newspapers (Central Rules) 1956.

Statement about ownership and other particulars about newspaper : Indian Welding Journal (English).

FORM IV

1.	Place of publication	48/1, Diamond Harbour Road, Calcutta-27.
2.	Periodicity of its publication	Quarterly
3.	Printer's Name Nationality Address	S. V. Sambamurti Indian 48/1, Diamond Harbour Road, Calcutta-27.
4.	Publisher's Name Nationality Address	S. V. Sambamurti Indian 48/1, Diamond Harbour Road, Calcutta-27.
5.	Editor's Name Nationality Address	S. V. Sambamurti Indian 48/1, Diamond Harbour Road, Calcutta-27.
6.	Name and address of individual who owns the newspaper and partners, shareholders holding more than one per cent of the capital.	The Indian Institute of Welding, 48/1, Diamond Harbour Road, Cal-27.

I, S. V. Sambamurti hereby declare that the particulars given above are true to the best of my knowledge and belief.

Sd/- S. V. Sambamurti