Concept of Equivalent Welding Applied to Work Measurement of Heavy Fabricated Vessel

By S. R. MUNGEKAR*

INTRODUCTION

What is a "fair day's work"? A production standard is an answer to the question and the field of work measurement provides methodology and rationale for determining a fair day's work for different jobs. Production standard indicates the time allowed for producing a unit of work. However, in a heavy fabricated vessel the main problem is to decide the unit of work, and in addition to the problem of deciding the unit of work, the plain fact is that for such type of work the foremen, supervisors and managers have their own standards in their mind based on their own actual experience and knowledge, which do not tally with each other and then the problem of having production standard becomes serious.

The paper presents the concept of equivalent welding which was tried for establishing the rate for measuring daily shop performance and for all practical purposes the method was found useful under the prevailing situation to all concerned.

This paper is unusual in the sense that it is an attempt to supply a summary of efforts made and methodology used on a common sense basis for deciding the standard for the fair day's work. With the exception of certain information the whole material is original in the sense that it is a presentation of facts and problems experienced in handling an assignment of completing the welding of a nuclear vessel in the scheduled period. The major material for construction of the vessel was 1½" (38 mm) stainless steel of 304 L type and the total welding length involved was 1085′ (325 metres). The probability of completing 1085′ of welding in scheduled period was mainly based on whether we can establish, measure and maintain the rate of welding per day so that ultimately 1085, of welding is over in a given time. To find out this rate of welding, concept of equivalent welding was used.

Some of the opinions, ways and methods may, perhaps, in some instances be open to challenge by the scientific purist, but the author submits that, within various limitations the concept of measuring the output on the basis of equivalent welding completed per day has fulfilled the purpose for which it was intended.

BACKGROUND OF THE PROBLEM

In spite of the great advances in computer and automation technology, manual labour at various levels is still predominant today and therefore understanding and handling the human element plays an important role and decides the success or failure of the project. The human element involved in the work measurement and establishing production standards is therefore difficult even in the workshops where product, operations and methods are more or less standardised. From

* Superintendent, Fabrication Division, Walchandnagar Industries Limited, Walchandnagar.

this point of view, the measurement in the nuclear fabrication, where the manufacturing technology and other concerned aspects are yet to reach a recognising stage, is difficult to establish if all the concerned staff and workers are not clear about the purpose and the method of work measurement. The other aspect involved in such work is the treatment given by the management to the workers and staff working in such specialised and important work. Management is not very much keen on the productivity in these sections, in the sense that the concerned staff can work freely and maintain the quality by way of improving the working methods. However, this has got some limit. When things start going out of schedule considerably, the situation and approach start taking a different turn. The contract and planning engineers start getting pressure from the customer and the same is in turn passed on to the workshops. The staff working on such jobs have more or less enjoyed the full freedom in working up to the time and once they start getting pressure for the delivery, the matter starts rolling in higher circles and then the management starts thinking about the rate of work in this field too.

Who can solve the problem of establishing and measuring the rate of output? The normal practice is to involve an industrial engineer having experience in work measurement, because the staff working in workshop on such job is normally trained in fabrication or machining or welding technology and therefore the approach and attitude and knowledge required for work measurement is seldom found amongst this staff. However, we decided to find out the answer to the problem of deciding the unit and measuring the rate of output without involving the staff specialised in the work measurement field and basis on which the shop engineers and supervisors completed this work of work measurement was nothing but common sense.

Main Requirements

The first and foremost thing necessary to establish and use the work measurement was that it should be simple enough so that an average worker can understand his performance at the end of the shift.

The second main requirement was that it should be useful to the ultimate aim of reaching our target in scheduled time.

Variables

In all, 13 variables were considered out of many variables on shop floor and, in general, in the total project. These 13 variables are listed in Table I. Other variables were not considered to simplify the method of work measurement.

The main variable for measuring the welding in metres/min was the difference in weld geometry.

It goes without saying that the different welding preparations will have different welding rates in metres/min basis. To sort out this difference, all welding preparations were given a suitable factor, so that they can be compared with a standard welding preparation. This factor was named as weld equivalent factor. The preparation which was selected as standard for comparison is as shown in Fig. 1. The weld equivalent factor for various welding preparations are shown in table II Col. (4).

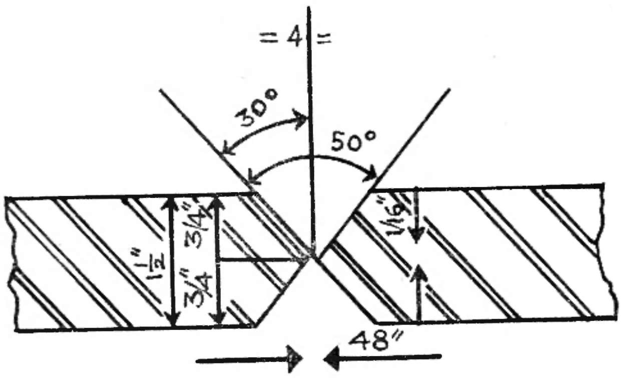

Fig. 1

The weld equivalent factor was proportional to the time required for completing a unit length of weld. The factor used for converting all weld joints into a standard joint was named as equivalent factor and to decide this equivalent factor was the first step towards work measurement.

Data Collection

To decide the time required for welding a unit length of weld of different preparations, time study was taken when we welded many test plates for procedure and performance qualification of welders. Realising that test plate conditions and job conditions do not tally, data was also collected while welding a few joints on job itself in the beginning stage. This data helped us in realising the practical problems and deciding weld equivalent factor more precisely.

Difference in Test Plate Welding and Job Welding

As explained earlier, three variables as far as working conditions are concerned are applied to job only. In order to decide the weightages of the working condition

TABLE 1

I. Welding Processes	II. Welding Position	III. Accessibility
1. M.M.A.	6. 1 G-Down-hand	11. Normal
2. TIG	7. 2 G-Horizontal	12. Restraint
3. TIG + M.M.A.	8. 3 G-Vertical	13. Awkward
4. TIG + MIG	9. 4 G-Overhead	
5. TIG + MIG + M.M.A.	10. 5 G-All Position	

factor, it was necessary to decide the position and assembly stage in which a particular joint will be welded. To decide the welding position and the stage of welding for achieving dimensional requirements by minimising distortion, it requires meticulous efforts in deciding the manufacturing procedure. The problems become more difficult when the full depth of a welding preparation is filled in two or more stages. Considering the time required for turning such a heavy job requiring two cranes coupled by connecting beam, the sequence of welding was carefully planned so that frequent changes in welding sequence are avoided.

Computation of Total Welding Time and Welder's Performance

Referring table II, let us say that we have to complete 550′ of welding and 6 welders are at our disposal. The welding time for welding a unit length i.e. 1′ of standard preparation is taken as 10 hours.

TABLE II
Dump Tank Assembly Welding

Type of Joint	*Joint No.*	*Total Weld length in Dump-Tank*	*Weld Equ. factor*	*Total Equ. weld length*	*Equ. Welding Comp*	*Equ. Welding remaining*
1	2	3	4	5	6	7
A + B.	W12, 21, 10	293.5'	1.5	200'	115'	85'
C	W6, 7, 30, 31	210'	0.85	250'	79'	171'
D	W1	2.5'	1.0	2.5'	2'	0.5'
E	W36	10'	1.4	7'	—	7'
F	W14, 13 19, 26	80'	1.55	51.5'	10'	41.5'
G	W8, 17, 24	56'	1.55	36'	7.5'	28.5'
H	W25, 27	13.5'	2	6.5	—	6.5'
	Total	665.5'		553.5'	213.5'	340.0'

(A) Welding performance factor is 7/10=0.7 (assuming 7 hours working in 8 hours shift. Remaining one hour is spared for personal needs, routine check-up and clearing of tools).

(B) Duration required for completing 550′ of equivalent with 6 welders, will be:

$$= \frac{\text{Total welding to be done}}{\text{Equivalent welding which can be completed per day by 6 welders.}}$$

$$= \frac{550'}{0.7 \times 6} = \frac{550'}{4.2}$$

say 5.5 months.

Now, let us assume that as per schedule we can get only 3 months for completing 550′ of welding then,

Welding (Equivalent) to be completed, per month= 550/3.

Equivalent welding to be completed per day (assuming 25-days working in a month).

$$= \frac{550}{3 \times 25} = 7.3'$$

$$\text{Number of welders necessary} = \frac{7.3}{0.7} = 10.$$

This means that if we employ 10 welders per day and if the welding performance factor of each welder is maintained to 0.7 then we can complete the welding work in the schedule time. Now depending upon the number of qualified welders available and the other necessary equipments, welders can be engaged for extra work in suitable shifts.

Measuring the Rate of Output of Each Welder

Having decided the unit and amount of weld length required to be completed per welder per shift, it is now necessary to measure the actual output. As explained earlier, the welders are working under 13 variable conditions and the measurable quantity was the number of runs and their length deposited by a welder under a particular working condition.

For example say that welder 'A' has deposited two TIG runs and one MMA run welding preparation No. 1 in Fig. 1 in 1G position having a joint length of 10′. This means he has done 10 + 10 = 20′ of TIG welding and 10′ of MMA welding. Now in order to find out the rate of output we must compare the time taken for this 20′ of TIG welding and 10′ of MMA welding with the standard rate. The standard rate of welding was found out for each process in various positions as mentioned in Table III (figures in Table III do not represent the actual data).

TABLE III

Welding Rate Running Feet of Weld Run (Feet/Welder/Shift) of An Average Welder

Process *Position*	*1G*	*2G*	*3G*	*4G*	*5G*
TIG	25	20	15	10	10
MIG	40	30	—	—	—
M.M.A.	30	25	15	15	15

From this table, we can find out the welders' performance and the equivalent welding completed as mentioned below:

(1) Welder performance for TIG welding

$$= \frac{20}{25} = 0.8$$

(2) Welder performance for MMA welding

$$= \frac{10}{30} = 0.33$$

Performance of welder 'A' = 0.8+0.33 = 1.13

Welding Equivalent
Performance = Welder Performance × 0.7
= 1.13 ×0.7
= 0.791.

For Welder 'A'

(1) Welding Performance = 1.13
(2) Equivalent Welding Performance = 0.791.

Once the welder and supervisor know the method of finding out the performance using Table III, the only problem remains to find out the possible solution to genuine problems like power failure, no purging gas etc., whenever total performance does not fully tally with scheduled output.

Reporting

All the above mentioned work was recorded and reported to concerned authorities in the proforma shown in Annexure 1.

ANNEXURE I

Dump Tank. Rapp II Sub/Min Assembly Daily Welding Performance Sheet

S. No.	*Welder*	*Engaged on parts*	*Jt. No.*	*Welding Completed*	*Welder Perform-mance*	*Equivalent Welding Performance*
1	2	3	4	5	6	7
1. PNK						
2. IRJ						
3. DID						
4. DDB						
5. SJY						
6. CRD						

This way of reporting was found out to be most convenient for all departments and purchasers also.

Motivation

For all the welders, col. No. 6 in the Table II is an index of their overall performance. It was observed that the welder who was generally accepted as giving maximum output showed highest performance, and the welder whose performance was generally treated as below average was ranked last as per column 6. However, the overall effect of recording daily performance forced the workers to try for more output and the welders who were giving average good output were motivated by getting credit over other colleagues and further improved their performance.

SUMMARY

The whole purpose of this paper is to explain the solution which was tried on shop floor for establishing a unit of measurement and measuring the rate of output, for completing welding operation of a heavy fabricated vessel in the scheduled period.

The major steps were,

(1) To convert the total welding length of various types into a standard welding length which was described as equivalent welding length.

(2) To decide the welding performance factor.

(3) To collect the data indicating how much length of a welding run a welder should weld for various processes and in various positions to produce a standard output per shift basis (Table III).

(4) To decide the factor for working condition allowance.

(5) To report the performance in a tabulated form as shown in Annexure 1.

ACKNOWLEDGEMENTS

The author is thankful to all those who have helped in collecting the data and preparing this paper.