Improving Productivity for Welded Constructions

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INTRODUCTION

Optimisation of productivity in a business is an essential phenomenon to make profits, in order to remain in business, with the ability to grow and expand, as well as to reward employees and equally the shareholders.

This concept of improving productivity equally applies today to the structural, fabrication or construction industry, in which welding operations are carried on, and also for any allied or parallel operations in all the fields covered by these industries.

Productivity in any field may be measured in terms of the output expressed in some way per input of resources. The measurement of output may be carried out in any convenient terms, but specifically by something that is easily understood and determined, reflecting adequately the work involved. The input resources, i.e. materials, capital equipment and human work may also be expressed by a common parameter in order to determine Productivity Index, which may be required as a direct measure of the rate of improvement in efficiency. Productivity rises or falls with changes in technology, with management skills, and with the quality, flow and availability of labour and capital resources in an organisation.

Considering these aspects of productivity, this paper has been written to highlight the basic and primary requirements for improving productivity in welded fabrications.

The analysis of the subjects covering the areas where major improvements are possible has been dealt with in the following pages.

A. CONCEPT AND MEASUREMENT OF PRODUCTIVITY

Productivity ratios are a tool that enable the management to analyse business situations and to monitor their performance at each and appropriate levels, by diagnosing the problem areas, providing a basis for evaluating and controlling the performance and also acting as an indicator for future planning.

The method of measuring productivity in welding also involves a system of 3 graded analysis consisting of the following :-

A.1 The welders' productivity measurement and control, termed as "Productivity measurement by ratios", which eventually includes measurement and reporting of work in welding operations.

A.2 The "Total cost productivity ratio" for comparing cost efficiency of welding operations and welded products.

A.3 The "Value-added productivity ratio", measuring the total value generated in the process of manufacture by welding operations and by welded products.

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A.1 PRODUCTIVITY MEASUREMENT BY RATIOS

This is a system of calculation of Productivity based on developing relationship amongst Total Productivity, Labour Productivity, Workers' Efficiency, Supervising Efficiency, Process Efficiency, Organisational/Capacity Efficiency etc. The control points and the causes of variance are also indicated in the relationship exposed.

Responsibility Area	——→Management + Supervisors + Workmen		Management		—		—		Management + Supervisors	
	A	=	B	×	C	×	D	×	E	
	Total Productivity		Standard Productivity Or Method Efficiency	×	Workers Efficiency	×	Supervising Efficiency	×	Organisational or Capacity Efficiency	
	Q/K	=	Q/S	×	S/M	×	M/L	×	L/K	

Where ; Q = Output in a suitable physical unit.

K = Total Input Hours
S = Standard Man Hours
M = Effective Input Hours L—b
L = Net Input Hours K—a
b = Time lost due to avoidable reasons like breakdown of equipment, repair work, shortage of items, defects of materials and parts, delays on various account etc.
a = Time lost due to unavoidable reasons, like omitted hours, e.g. recess, cleaning, maintenance, handling of materials etc.

Total Productivity,

$$A = \frac{Q}{K} = \frac{\text{Output}}{\text{Total Input Hours}}$$

Method Efficiency,

$$B = \frac{Q}{S} = \frac{\text{Output}}{\text{Standard Man Hours}}$$ — (e. g. Kg of weldment per standard man hour)

Workers Efficiency,

$$C = \frac{S}{M} = \frac{\text{Standard Man Hours}}{\text{Effective Input Hours}}$$

Supervising Efficiency,

$$D = \frac{M}{L} = \frac{\text{Effective Input Hours}}{\text{Net Input Hours}} = \frac{L-b}{L}$$

Capacity Efficiency,

$$E = \frac{L}{K} = \frac{\text{Net Input Hours}}{\text{Total Input Hours}} = \frac{K-a}{K}$$

Labour Productivity, $= \text{Workers Efficiency} \times \text{Supervising Efficiency} \times \text{Capacity Efficiency}$

$= \frac{S}{M} \times \frac{M}{L} \times \frac{L}{K}$

$= \frac{S}{K}$

$= \frac{\text{Standard Man Hours}}{\text{Total Input Hours}}$

Process Efficiency $= \text{Workers Efficiency} \times \text{Supervising Efficiency}$

$= \frac{S}{M} \times \frac{M}{L}$

$= \frac{S}{L}$

$= \frac{S}{K-a}$

$= \frac{\text{Standard Man Hours}}{(\text{Total Input Hours}) - (\text{Time lost due to unavoidable reasons})}$

Labour — Resource Efficiency $= \text{Supervising Efficiency} \times \text{Capacity Efficiency}$

$= \frac{M}{L} \times \frac{L}{K}$

$= \frac{M}{K}$

$= \frac{\text{Effective Input Hours}}{\text{Total Input Hours}}$

$= \frac{L-b}{K} = \frac{K-(a+b)}{K}$

$= \frac{(\text{Total Input Hours}) - \text{Time lost due to avoidable and unavoidable reasons})}{\text{Total Input Hours}}$

Overall/Total Productivity is a ratio of output to input and it indicates objective/physical substance, while labour productivity is a combined effect of factors such as workers' efficiency, rate of labour resource use and techno-organisational influence. The ratio of standard man hours to actual man hours is of a semi-sociological nature. Standard time is the value to be realised by a normal worker who has a normal skill and a normal will to work under normal conditions of work.

A.2 TOTAL COST PRODUCTIVITY RATIO

Total cost productivity is defined as a ratio between the total output of welders at constant prices and the corresponding total cost at constant prices. The concept of total cost productivity is based on the fact that the performance of any economic activity is influenced both by the productive efforts and by the prevailing market force. The total cost productivity ratio measures the productive effect, which is the sum of the effect like

technical change, scale of production, productive efficiency etc. The total cost productivity may be calculated at constant prices.

Total cost productivity of welded constructions, (i.e.) assessment of the cost efficiency of the final product, when expressed in ratio, should be minimum unity.

A2.1 Computation of Total Cost Productivity :

Value of Output and Aggregate Input (Rs.)

FIGURES AT CURRENT PRICE

	Material Input		Labour Input	Quantity	Total Cost	Total Price	Quantity
Year — 1	a_0	+	b_0	Q_0	PP_{01}	P_{01}	q_0
Year — 2	a_1	+	b_1	Q_1	PP_{11}	P_{11}	q_1

FIGURES AT CONSTANT PRICES

	Material Input		Labour Input	Quantity	Total Cost	Total Price	Quantity
Year — 1	q_{00}	+	b_{00}	Q_0	PP_{00}	P_{00}	q_0
Year — 2	q_{10}	+	b_{10}	Q_1	PP_{10}	P_{10}	q_1

(a) Total Cost Productivity Year 1 $= \dfrac{P_{00}\ q_0}{PP_{00}\ Q_0}$

(b) —do— Year 2 $= \dfrac{P_{10}\ q_1}{PP_{10}\ Q_1}$

(c) Index of total cost Productivity $= \dfrac{P_{10}\ q_1}{PP_{10}\ Q_1} \div \dfrac{P_{00}\ q_0}{PP_{00}\ Q_0}$

Total cost productivity of welded constructions, e.i. assessment of the cost efficiency of the final product, when expressed in ratio, should be minimum unity.

A.3 VALUE ADDED PRODUCTIVITY RATIO

The value added is the combination of various elements of the production value in a manufacturing organisation, that is, depreciation, labour cost, net profit, interest, taxes, etc., which means production value less material cost. Value added is usually influenced by fall or rise in price of materials, power, fuel, and equipment, which are ingredients for production. Value added is the value created in the production process. Value added is a broader concept than net profit. The value added concept provides a sound basis for performance evaluation.

For the purpose of productivity measurement, the following Indices based on value added concept are utilised :

(a) $\dfrac{\text{Value added}}{\text{No. of workers}} = \dfrac{VA}{W}$

(b) $\dfrac{\text{Value Added}}{\text{Total Capital}} \times 100 = \dfrac{VA}{TC} \times 100$

(c) $\dfrac{\text{Value Added}}{\text{Net Sales}} \times 100 = \dfrac{VA}{NS} \times 100$

Since, value added
= Sales — (Materials + Power + Fuel Consumption)
Or VA = Sales — Throughput,

we may depend on another ratio, i.e.

(d) $\dfrac{\text{Value added}}{\text{Material consumption (Throughput)}} = \dfrac{VA}{MC}$

The higher the value of this ratio, the greater is the output produced by the group/firm.

A.4 COURSES OF ACTION FOR DEVELOPING A REPORTING SYSTEM

(a) To introduce a personwise "Daily Time Card" for booking daily hours against job numbers and other cost codes for omitted man hours and also other avoidable and unavoidable lost time.

(b) To introduce machinewise 'Machine Detail Cards', for booking of daily hours of machine working and idleness due to breakdown etc.

(c) To introduce machinewise 'Machine History Cards' for preventive maintenance and controlling machine down time.

(d) To introduce 'Job Cards' for specifying the work content and for clearly defining the work boundaries along with the responsibilities of each agent like welders/forefront supervisors, indicating priority and delivery time of the job—i.e. pinpointing milestones.

(e) To standardise sectionwise and levelwise 'Span of Control' of supervisors.

(f) To communicate periodical productivity indices/ workers' efficiency figures to respective working groups for creating consciousness/awareness in order to infuse greater participation.

(g) To calculate productwise, cost elementwise, groupwise actual costs.

(h) To calculate needed 'Deflator' for input factors and output factors for assessing the rates of 'output at constant price' to 'total cost at constant price'.

(i) To calculate and analyse the total cost productivity index, as well as value added productivity index".

(j) To make productwise accounting for reflecting the causes of variance by incorporating detailed job numbering labour hours booking, material accounting, etc. in order to rationalise planning and budgeting process.

(k) To develop an independent accounting system by product/group/shop to evaluate the performance of multiple activities and also the comparative economy between them.

(l) To use a computer for developing estimation of standards based on rationalisation, in order to make it possible to compare the actual performance both in physical and monetary terms, by the economic, useful and timely information, accurately and quickly processed for management information system.

B. MEASURES FOR IMPROVING PRODUCTIVITY

How can maximum productivity with available resources be achieved in welding ?

In every case it is the result of the action carried out by management of an organisation, with the cooperation of the willing workmen/welders, backed up by technical and scientific improvements in the field of welding. Any improvement in the productivity of labour in welding may be assigned to the better planning of work by management and at shop floor or due to greater skills attained by welders through training and association, and also due to improved design and technology and so on. Productivity may be improved by the following steps.

B.1 Improving Productivity by Innovative Measures.

B.2 Improving Productivity by Control Measures.

B.3 Improving Productivity by Motivation Techniques.

B.1 Improving Productivity by Innovative Measures :

The productivity in welding operation may be improved by innovative measures by substituting existing practices with developed methods and practices. This includes import substitution, selection of electrodes and consumables, standardisation, variety reduction, improved technology, high yield machines, design and sequence of welding operations, process research, capital budgeting and investment anaylsis.

B.2 Improving Productivity by Control Measures

The productivity in welding may also be improved by introducing checks and control mechanisms on existing practices of welding for reduction of costs by material control, process control, quality control, reduction of waste/scrap, prevention of excess consumption, control of breakdown of equipments etc. Some of these are highlighted here.

For improving any control on the existing practices, the detail knowledge of the equipment and its operations are a must for the individuals operation in this area. In view of this, based on the operational details of each type of welding equipment and machine, two types of analyses are to be carried out, i.e. 'Risk Analysis' and 'Operation Evaluation'.

B.3 Improving Productivity by Motivation Techniques :

The productivity in welding may again be improved by introducing suitable motivating techniques to enthuse human elements at work by group/individual incentive schemes for welders, payment of rewards, proper methods of selection and training, practical personnel policy etc. Some of these are mentioned here.

B.3.1 Financial Incentive Schemes :

Welders are to be covered under any financial incentive scheme as direct workmen only whose efficiency should be calculated either :

(a) in a group of welders or amongst co-workers of other trades

Or

(b) as an individual welder

Or

(c) as an individual welder, under a group cum individual incentive scheme.

The pre-requisites for any of these schemes are :

(A) Standard time for a welding job, either based on job standard, synthetic elemental data, analytical estimation, or M.T.M.

(B) Record keeping of output and input data, with all details and proper certification/checks.

(C) Record keeping of consumable consumed with proper checks.

(D) Rate of incentive payment, as laid down in the incentive scheme designed.

In the group incentive scheme, the standard hours produced by the welders in an incentive period, either in the welding group or in a group alongwith co-workers of structural trades, are generally summed up together, which when divided by the total input hours of the workmen in that group, during that period gives the productivity index of the group.

In individual incentive scheme, the sole standard hours produced by a single welder in an incentive period is taken into consideration, for being divided by his input hours, during that period, for calculation of his productivity index or workers efficiency index as the case may be.

In individual cum group incentive scheme, the incentive points earned by a group is proportionately shared amongst the group members based on the size-wise no. of electrodes consumed/Kg. of weldment deposited by individual welders.

A suitable penalty is generally imposed for wastage of electrodes, higher consumption of electrodes, quality of welding etc. which becomes applicable to individual welders.

B.3.2 Cash Awards for Welders :

Based on the individual efficiency index of a welder and qualitative assessment by his supervisor, a cash reward is awarded to some ranked welders every month in many organisations, in order to maintain high motivation amongst the welders.

B.3.3 Training :

Suitable training schemes should be introduced not only for maintaining skill of welders, but also for imparting higher skills/higher knowledge/higher education to each and every welder of an organisation. This system keeps them active and enthusiasitic for ever and makes a welder dedicated to his work and organisation.

C. CONCLUSION

How can maximum productivity with available resources be achieved in welding ?

Having discussed the background and classifications, we may now pass on to the economics of welding, involving functions of various departments of an organisation.

C.1 Drawing and Design Office :

It is the duty of the designer, in consultation with welding technologists/welding engineer to be specific in his requirements. A standard system of symbols

has to be followed ; size, length and type of weld preparations are to be marked on the drawings always. Therefore at the design stage, the precise form of joint should be determined and specified based on the available equipments/processes to be used for required welding, unless a standardised process of welding is followed in a particular organisation. In an organisation where both resistance and fusion arc welding are prevalent, the joints are to be specifically marked and identified for each type of welding on the drawings always. One matter additional to the basic form of joint should be determined at this stage if the joint is a progressive fusion type, namely, the need for a backing bar. A backing bar can be put behind an open butt type weld that is being welded from one side and the weld completed right through on to the bar, so that penetration is kept uniform on the under side, overheating is prevented, and defects are avoided.

Now a days it is also the practice that the size and specification of manual arc welding electrodes are mentioned on the drawing along with the preheating temperature if required, differentiating both manual and submerged arc welding.

Total volume of weldment involved with respect to the total tonnage of the fabrication is also mentioned by the designers on the drawing in order to control over or under depositons of weldment.

C.2 Process Planning Deptt/Welding Technology Deptt.

While underlining the economic process, the process planners also mention the economic methods of welding in terms of cost, specifying the use of jigs, fixtures and turn tables/rotators which are subsequently to be developed.

C.3 Purchase Deptt :

Welding equipment and consumables occupy a major portion of the total purchase. In order to maintain an uninterrupted supply of electrodes etc. against a reasonable price for quality expected, the purchase deptt. has to play a greater role today since there are a lot of brands, sizes and supplies in the market.

C.4 Stores Deptt :

Electrodes and other consumables are generally stored as stock items. Volume of stock and proper storing also plays a role in maintaining optimum welding cost. Electrodes should generally be kept at specified temperature in stores and they have a definite shelf life, as such over stocking may lead to wastage and increase in cost.

C.5 Production Planning and Control Deptt :

Proper loading of jobs to welders/welding Section may improve welders, productivity, otherwise for non-availability of jobs the overall performance of such a skilled section involving many highcost equipments may become poor.

C.6 Inspection Deptt :

Welding involves rigorous destructive and non-destructive inspection procedures in order to maintain a standard quality level. On the job inspection, ensuring timely guidance to the welding section may reduce rework, rectification and rejections. Labour and material loss on account of lack of proper/timely inspection adds to the cost.

C.7 Maintenance Deptt :

Welding transformers, rectifiers, etc. need periodic and preventive maintenance in order to work safely, satisfactorily as per their capacity and to have proper life. Frequent breakdown and poor performance of welding sets, reduces quality of work, increases costs in leaps and bounds. TIG/MIG/Plasma etc. are very sensitive equipments requiring timely and regular attention from the maintenance deptt, in order to make full utilisation of their investment. Any sacrifice will bring down the efficiency of these equipments and of the related welding section drastically.

C.8 Industrial Engg. Deptt :

The following are basically the functions of IE Deptt. which affects economy in welding on the whole.

(a) Standardisation of process, time, manpower and development of norms.

(b) Standardisation of equipments.

(c) Standardisation of cables, electrodes and other consumables, and development of consumption norms.

(d) Measurement of productivity of welders.

(e) Measurement of consumption ratios with respect to standards developed regarding cables, and electrodes specifically.

(f) Assessment of requirements of equipments and consumables with respect to the planned output of welded fabrication.

(g) Development of means for reducing rejection/rework of fabricated items and wastages of consumables specially electrodes.

(h) Running of Incentive scheme for welders to increase productivity.

C.9 Shopfloor/Welders/Welding Deptt :

In fact major economy is related to the efficient performance of the workmen of welding department in all aspects of welding. They are as follows :-

1. Maintaining proper size of weld preparations. Increase in weld preparation increases volume of weld and may cause distortion also.

2. Reducing the habit of over deposition of weld metal.

3. Making use of only proper current and size of electrodes in manual metal arc welding.

4. Proper cleaning of slags and contaminants.

5. Maintaining exact ratio of wire and flux in submerged arc welding, thereby stopping excess consumption of flux.

6. Stopping wastages of electrodes from the excessive stub loss.

7. Using higher sizes of electrodes wherever possible thereby increasing deposition rates.

8. Using mostly down hand position of welding thereby increasing deposition rates and reducing chances of weld faults.

9. Using mostly automatic welding wherever possible thereby increasing deposition rates.

10. Using proper methods and proportion of gas/filler in TIG/MIG welding thereby increasing efficiency of the machines.

11. Maintaining transformers and welding sets (AUTO) in condition thereby increasing deposition rates and utilisation of welders.

12. Using only required type/brand of electrodes thereby restricting the higher weldment cost/Kg.

13. Using properly the cables and other accessories in order to achieve the desired life.

14. Increasing productivity thereby reducing labour costs.

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