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Suggested Cost Minimization Techniques By Using Work Study Method At Powder Spray Painting Industry

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Abstract— The aim of this case study is to minimize the cost of the production in a spray powder line. The coating operation is the bottleneck point in modular furniture industries. For minimize the wastage of the powder by avoiding overspray painting on the article and improved the quality of the coating by using work study methodology. Many companies across the world are engaged in adopting work study (motion study and work measurement) are examination of humane work in all its contexts and which lead systematically to the investigation of all factors which effect the efficiency of the situation being reviewed, in order to seek improvements. Today the industries with all their complexities and modernization naturally demand a more systematic approach like the work study in its present form. This work suggest the best and most efficient way of using available resources, minimizing the operation, task duplication cost, scheduling and sequencing task and improved the production rate**.**

Keywords— Flow process chart, sequencing operation, Work study, powder coating booth.

I. INTRODUCTION

THE powder coating operation are widely use in industries to performing painting operation on the different article as per customer's demands. The powder coating is by far the youngest of the surface finishing techniques in common use today. Powder coating is the technique of applying dry paint to a part. The final cured coating is the same as a wet paint. In normal wet painting such as house paints, the solids are in suspension in a liquid carrier, which must evaporate before the solid paint coating is produced. The coating operations are performed in spray booth. The spray booth forms a coating space which at bottom bounded by powder collection means. But some of the powder particle is spread in the atmosphere causes the air pollution, for restricted the powder particle best powder coating booth are selected or redesign the existing booth and improves the technique (method) by using work study.

The work study is a generic term for those techniques, particularly method study and work measurement, which are used in examination of human work in all its contexts, and which lead systematically to the investigation of all factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement. The two major techniques of work study is **-** Method study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs. Next one is Work measurement is the application of techniques designed to established the time for a qualified worker to carry out a specified job at a defined level of performance [1]. Therefore, for reducing costs, different models of the product must often be paint on the same line. To observe the effect of different parameters on total cost of finished goods, a comparison is carried out between existing and improved method based on a cost minimization approach. The objectives of this case study are as follows;

- The main objective of this project is to present the cost model and compare the performance of present and improved method with respect to cost savings. Costs are included, ordering cost of parts, holding cost of parts, line setup cost for each article, holding cost of goods.
- The second objective is to keep the constant consumption of each article in the spray painting line.

II. WORK STUDY METHODOLOGY

It is a closed loop process that eliminated the unproductive steps, often focuses on new measurements, and applied technology for continuous improvement. Methodology took places in essential seven stages in the application of method study, none can be excluded. Strict adherence to their sequence, as well as to their content, is essential for the success of an investigation. After identifying main problem, their performance is calculated in measure phase with the help of data collection. Examine this data by using the techniques. Solutions to solve problem and implementing them are in improve phase. Improvement is maintained in control phase.

Basic procedure-

The basic procedure is a complete fundamental to the whole work study. The examination of the process follows the following sequence of phase in that order [1]**-**[2].

1) **Select** the work to be study.

2) **Record** all the facts relevant to the problem.
3) **Examine** the facts critically but impartially.
4) **Develop** the most practical, economic and effective method.
5) **Define** the new method so that it can be always being identified.
6) **Install** that new method as standard practice.
7) **Maintain** that standard practice by regular routine checks.

III. Selection Of Job

A. Present processes

There are two component uses in this industry for making the modular furniture. Those are the CRCA and Aluminium material. The raw material first through the component processing shop for making the required shaped and size as per costumer's demands then the handling equipments carries the material into the pretreatment shop. In general, for all applications the preparation treatment for Aluminium and CRCA is as follows;

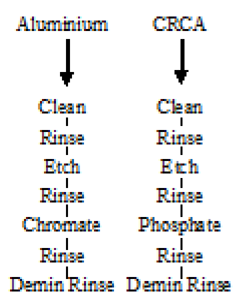

Fig. 1 Flow chart for pretreatment.

Oils and greases are removed in weak alkali or neutral detergent solutions and the surface is etched to remove heavy oxides. After rinsing, the aluminium is dipped into a chromate or phosphate solution to form a conversion coating on the aluminium. This film is chemically attached to the aluminium. After rinsing the aluminium is finally rinsed in demineralised water. Some non-chrome, dried in place pretreatment is beginning to come onto the market; currently, these are not recommended for exterior applications.

The conversion coating has two functions:

- It presents a surface to the powder which favours adhesion more than the oxides that form very readily on aluminium surfaces, and
- It reduces the incidence of under film corrosion, which may occur at holidays in the coating.

The use of demineralised water reduces the presence of chemical salts on the aluminium surface. These salts have been found to cause filiform corrosion in humid conditions. Then, the 'pretreated' articles are jigged and loaded onto the continuously moving overhead conveyor. As the conveyor moves the articles through the coating booth, they are coated on all sides by manual spray guns. The conveyor then carries the articles into the tunnel oven. In the oven, at a skin temperature of 210-213°C, in 15-25 minutes, the powder melts, polymerizes, fuses and cures into the tough uniform and consistent powder coat that has high aesthetic value. At the end of the curing schedule, the article moves out of the oven and allowed to cool down through a cool-off zone. The articles are then removed off the conveyor and taken out of the paint-shop. The part manufacturing will be depending on the job production method. It involves producing one or very few parts of a kind. It thus means that same type and size of product may never get repeated over indefinite period of time. It depends on customer's requirements and specification and sometime also depending on batch production.

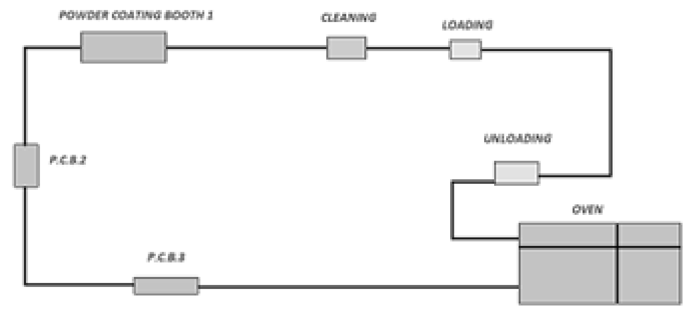

Fig. 2 Plant layout of powder coating shop

B. Problem identification

In the modular furniture industry, the powder coating operation is the bottleneck point. The production rate is totally depending on the powder coating operation. The main problems in the powder coating operation is overspray on the article, unequal paint thickness of the article, undefined powder coating method and insufficient design of the spray booth for restricting the powder particles to spread into atmosphere. Some of the powder particles adhere to the object and some do not, the suction is insufficient to collect this powder. The scope of our project is minimized the powder wastage. Because powder is failing expansive it is desirable to recover the non adherent powder for re-use in the powder coating system. Redesign the spray booth for increasing the efficiency of the suction and minimized the distanced between the article and suction. The present invention relates generally to an improved method and spray booth for spray coating objects with powder which is suited particularly for automatic spray coating operation but also can be used for coating with the aid of hand held powder spray guns.

IV. Analysis Of The Process

The recording is the next step in the basic procedure, after selecting the work to be studied, is to record all the facts relating to the existing method. The success of the whole procedure depends on the accuracy with which the facts are recorded, because they will provide the basis of both the critical examination and the development of the improved method.

For recording we are selected the seven different materials which is based on the;

- Large in shape and size.
- Critical in shape.
- For coating, article takes more time than standards.
- For coating, stop the conveyor for performing the operation.

- First article of the shifts.

The most commonly used of these recording techniques are charts and diagrams. There are several different types of standard charts available. For recording, the flow process chart is selected. It is a process chart setting out the sequence of the flow of a product or a procedure by recording all events under review using the appropriate process chart symbols. The three types flow process charts, one of those man type flow process chart which records what the worker does. It is used for recording the process. The several man type flow process chart constructed to study what will be happened when article was coated.

By using flow chart it will be find that the operator utilization, working time and production rate [3]-[4].

Operator utilization: - At Conveyor speed=1.5 m/min.

$$\% \text{ utilization} = \frac{WORKING\ TIME}{TOTAL\ CYCLE\ TIME} \times 100$$

TABLE I
OPERATOR UTILIZATION FOR FIRST OPERATOR

Article	1	2	3	4	5	6	7
Idle Time (S)	63	36.94	36.43	75.94	50.27	44.37	29.63
Working Time (S)	55.74	45.17	43.46	43.23	39.11	30.7	69.22
Total Cycle Time (S)	118.8	82.11	79.89	119.17	89.38	75.07	98.85
% Utilization	46.94	55.01	54.39	36.27	43.75	40.89	70.00

TABLE II
OPERATOR UTILIZATION FOR SECOND OPERATOR

Article	1	2	3	4	5	6	7
Idle Time (S)	70.61	39.87	37.15	70.2	53.51	44.20	35.67
Working Time (S)	58.71	41.67	42.47	50.01	33.5	30.81	62.5
Total Cycle Time (S)	129.3	81.54	79.62	120.21	87.01	75.01	98.17
% Utilization	45.33	67.10	56.91	41.60	38.50	41.07	64.36

Production rate per shifts and other important details is given in the Table III; it should be calculated by using the chart details. The total direct cost and indirect cost for one shifts is find out by using chart data and overall industries data.

Total Direct Cost = Powder Cost + Fuel Cost + Power Cost + Labor Cost +Maintenance Cost + other cost

Then, Considered 10% as an indirect cost.

The total production cost of the one shifts are calculate by using total direct cost and indirect cost.

Total Production Cost = Total Direct Cost+ Total Indirect Cost

It is sufficient data to calculate the cost per product, time per piece; piece produced per min and productivity of the machine is shown in Table IV. [4].

Cost of one Product = Total Production Cost / Total production unit

Time per piece in min = shift per hr× 60 / production per shift

Piece produce per min =1/Time per piece

$$\text{Productivity of the machine} = \frac{Productivity\ \ unit}{Machine\ time}$$

V. EVALUATION OF THE ALTERNATIVES AND SELECTION OF THE BEST ONE

Now, we have arrived at several partial solutions to the problem under the consideration. Some of these can be eliminated rather quickly and the remaining solutions can be considered more carefully. A critical examination can be made to determine to what extent solution meets the criteria and conforms to the original specifications. The questioning technique is the means by which the critical examination is conducted, each activity being subjected in turn to a systematic and progressive series of questions. There are two techniques; primary and secondary questioning technique. By using both the techniques, we are finding some alternatives. The evaluation of the preferred solution requires careful consideration of future difficulties that might be encountered, such as time and cost to maintain and repair or redesign equipment, the adjustment to widely varying size or product mix and down time of equipment. In such an analysis we would want to know the initial cost, annual operating cost and scrap value. In certain types of problems, we may be concerned mainly with finding the method having the lowest labor cost. In such case a comparative analysis could be made, using predetermine times to determine the total cycle time of each of the several methods. If there is a question as to whether a particular method actually can be performed, it may be necessary to construct a mock- up of the jig or work place in the shop and try out the method.

VI. DEVELOP THE IMPROVED METHOD

After performing the critical examination, it will be find the best suitable alternatives to make a record for a proposed method on a flow process chart. So that it will be compared with the original method and checked to make sure that has no point has been overlooked. The total number of activities taking place under both methods, the saving in distanced, time and saving many all this recorded on summary chart. It will be seen from the summary that there have been considerable reduction in the number of non productive activities. The number of operation has been reduced from existing method but result will be depends on the article. The improved production rate and operator utilization is finding out by analysis of proposed flow chart and summary chart.

Operator utilization: - At Conveyor speed=1.7 m/min.

TABLE V
OPERATOR UTILIZATION FOR FIRST OPERATOR

Article	1	2	3	4	5	6	7
Idle Time (S)	17.55	22.43	35.14	66.37	29.85	24.9	44.11
Working Time (S)	49.05	40.17	31.46	43.23	33.75	30.7	44.49
Total Cycle Time (S)	66.6	62.6	66.6	109.6	63.6	55.6	88.6
% Utilization	73.59	64.16	47.23	39.44	53.06	55.21	61.50

TABLE VI
OPERATOR UTILIZATION FOR SECOND OPERATOR

Article	1	2	3	4	5	6	7
Idle Time (S)	20.89	23.94	35.13	65.93	33.49	28.12	42.82
Working Time (S)	45.71	38.67	31.47	43.67	30.11	27.48	45.78
Total Cycle Time (S)	66.6	62.6	66.6	109.6	63.6	55.6	88.6
% Utilization	68.63	61.77	47.25	39.84	47.34	49.42	51.67

The improved production rate is given in Table VII and the cost per piece, time per piece and productivity of the machine will be shown in Table VIII;

VII. Results And Discussion

Strategy to Increase Overall Production Rate

A. *Improvement In Conveyor Speed*

Conveyor is useful for moving material between two fixed workstation, either continuously or intermittently. They are mainly used for continuous or mass production operation, they are suitable for most operation where the flow is more or less steady. The length of the conveyor is 119 m and higher loads carrying capacity ranging from 180 kg to 700 kg. The conveyor having 238 hooks with 500 mm pitch. The present speed of the conveyor is 1.5 m/min and drive is 1.7 m/min. in proposed method, speed of the conveyor increase from 1.5 m/min to 1.7 m/min because of this idle time of the operator is minimized and efficiency of the equipments is increase upto 10% to 50% without increasing input cost.

B. *Developing Racking and Production Strategies for Powder Coating*

There are two operational strategies [5];

The synchronous strategy: The product components are fabricated, operator are immediately placed on a rack and conveyed all the way to and through the coating operation and then on to the assembly function. The key element here is a continuous closed-loop conveyor system.

Synchronizing the fabrication, coating and assembly operations can be accomplished today with automated systems. The parts can be programmed to arrive at a central conveyor line at the correct rate to ensure that the right numbers of parts are available for loading as “assembly kits” on the conveyor. The parts are loaded and unloaded one time, thereby minimizing handling labor. This approach will virtually eliminate the floor movement of work-in-process inventory. The conveyor acts as the transport device as well as the staging area for the work-in-process.

The batch strategy: The components are fabricated they are transported to the coating operation in production lots or batches. The components are placed on racks in batches of like parts and conveyed through the coating operation. After being coated, operators are then transported to the assembly operations or the next phase of the process as appropriate. The company's standard practice had been to send the fabricated components to a job shop to be coated and then on to assembly operations upon their return. The batch strategy was appropriate for this procedure, and the team was familiar with it. The team looked at the concept as though the powder coating system would just replace the coating job shop within their new facility.

C. *Strategies to Improve Transfer Efficiency*

Following are methods that facilities can use to increase their transfer efficiencies:

Stand closer to the workpiece: - A typical gun-target distance is 8 to 12 inches. In general, as the distance increases, transfer efficiency diminishes. As the distance decreases, however, the operator needs to reduce the fluid and/or air pressure to avoid applying too much coating to the part.

Optimize fan size: -The operator must appropriately size the fan for the workpiece on a regular basis. A spray painter uses a fan size of 6 to 8 inches when painting small- or narrow-shaped parts such as metal tubing or angle brackets. Adjusting fan size is not a major problem for operators who work on production lines that coat one type of part or work in long production runs. For those facilities whose parts continuously change size, the most practical strategy is to purchase a cap that the operator can change quickly and easily. Because not all spray guns can be fitted with adjustable caps, facilities may need to contact a variety of vendors to locate this equipment.

Reduce atomizing air pressure (where applicable): - In HVLP, conventional air atomizing, and electrostatic guns reduce air pressure to the lowest possible levels, which results in marked improvements in transfer efficiency rates. For airless, and in some cases, air-assisted airless guns, using a smaller orifice can achieve the same atomizing results.

Reduce fluid pressure: - If the fluid pressure and corresponding fluid flow rate are high, the stream of paint emerging from the spray gun travels a relatively long distance before bending and falling to the ground. Such a flow rate has a very short residence time within the spray gun and requires a large amount of energy for atomization. As fluid pressure decreases, the stream emerging from the spray gun shortens and less energy is needed for atomization. Longer residence times lead to more efficient atomization, which in turn leads to higher transfer efficiencies. Many spray painters argue that lowering fluid delivery rates slows down production speed and raises the cost of painting. This argument is true only for a very small percentage of facilities that have already optimized their fluid delivery rates. At most facilities, fluid delivery rates are considerably higher than the job requires.

Reduce air turbulence in spray booth: - Paint facilities that use several spray booths that all pull from one air make-up system may experience violently turbulent air velocities that change direction from one second to the next. Correcting this problem can be difficult and often requires air conditioning and air ventilation consultants. While this remedy can be costly, having a uniform, laminar air flow through a spray booth improves transfer efficiency and significantly reduces overspray and booth maintenance.

Reduce the air velocity in the spray booth (not below recommended OSHA limits): - OSHA requires a minimum air velocity of 100 to 120 feet per minute through spray booths in which operators use manual spray guns (the automated electrostatic gun's minimum air velocity is 60 feet per minute). Many paint facilities inadvertently run their booths at velocities well above the limit because they are unaware of the effect this can have on transfer efficiency. Lower air velocities are especially important in electrostatic operations because too high a velocity can prevent the coating from wrapping the parts.

Reduce leading and trailing edges: - In cases where a high-quality finish is required, trailing edges are needed to ensure that there are no fat edges. In many cases, however, operators set the spray guns so that they trigger sooner than is necessary, and/or cease too long after the part has passed. When painting small- or medium-sized parts, even a small decrease in leading and trailing edges results in significant improvements in transfer efficiency.

D. *Adopt Proper Manual Spray Techniques*

Untrained and hurried workers using poorly maintained equipment can contribute to the need to rework products and to clean up and dispose of wasted coatings, thereby increasing costs. A well-trained operator is far more important than the type of gun used. By training operators on proper equipment setup, application techniques and maintenance, companies can reduce the use of materials by 20 to 40%. These savings will depend on the parts coated, material sprayed, and operator doors in booth having length is 80 cm and height is 2 m. The operator door will be closed at the bottom by using small door. In door design contain two part one part is 12 cm and other is 13 cm. First part is fixed and other part is moved in up and technique and experience level. The fundamentals of effective spray technique that operators can follow are:

Proper gun setup: - Use the paint gun manufacturer's suggested air cap and fluid tip combination for the viscosity of the product being sprayed. Check the spray gun to see that it produces a proper spray pattern, and keep the air and fluid pressures at the lowest possible settings.

Spray distance and angle: - Keep the distance between the gun and the part being sprayed as close as possible to the manufacturer's recommendations at all times (e.g., 6 to 8 inches for conventional spraying, 12 to 15 inches for airless spraying, and 10 to 12 inches for electrostatic spraying). Move the spray gun parallel to the work, keeping the gun at a right angle.

Triggering and overlap: - Overlap each successive stroke (e.g., 50% for conventional spraying or 25% for airless spraying), using a crosshatch overlap when required. Trigger the spray gun at the beginning and end of each stroke, making sure that the gun is in motion before triggering. In so doing, operators can minimize the lead (i.e., the distance between where the gun is triggered and the point where the gun pattern hits the part) and the lag (i.e., the distance between the point where the pattern leaves the part and the point where the gun is untriggered), thereby reducing overspray.

Whenever helping companies adjust the spray technique of operators, technical assistance providers should keep in mind that, over a period of time, the firm may have selected a coating and application equipment to conform to an incorrect technique. Equipment settings and materials might need to be changed to conform to an improved technique.

E. *Design Modification in Existing Booth*

The powder coating system that operate to apply a coating of electrostatically charge particles or powder to an object are known. A typical powder coating system include a booth (Double Door Booth in company) through which object to be coated with powder are conveyed and one or more powder applicators that spray electrostatically charged powder toward the objects to be coated. Some of the powder adheres to the object and some do not. Because powder is fairly expensive, it is desirable to recover the non adherent powder for reuse in the powder coating system. The powder not adhering to the object can be drawn from the booth floor and separated from the exhaust airflow by means of powder separation, cyclone and filter element, subsequently screened and thereafter device and spray again. But some amount of particle spread into atmosphere from the operator door and material opening. For avoiding this problem, powder booth must be compact. We have slightly modified in the existing booth.

Modification in operator door: -There are two operator down direction, these design is convenient to the operator when large part in booth and easy to opening and closing operation.

Modification in material opening: -There are two opening in booth, this opening also closed by using moveable door. The door will be installed by using two rollers in upper and downward casing; it's like a channel gate. These doors minimized the width of the opening when small width of the material comes into booth for powder coating operation. These design restricted the particle to sprayed into the environment and reclamation wasted powder reduced the manufacturing cost. By using these design ventilation are reduced below the present. Therefore, less energy is needed to control the environment.

Plastic coating on inner surface of the booth: -The powder coating booth is made-up of metal sheet, it is more difficult to cleaning and time consuming when more powder is allowed to deposit in the booth and on the other parts. Therefore, metal sheet is coated by plastic sheet is 1mm thick, since the powder particles adhere less strongly and in smaller amounts to the latter than they do to metal booths. The powder particles consist mostly of plastic, but may consist also of ceramics. By using these design, surface adhere powder easily remove without containing the foreign particle while reclamation of surface powder reduces the manufacturing cost.

By applying this strategy, we are getting the some profit ratio, the percentage of saving in time and increasing in output in percentage in the Table IX; and the fig 3 shows that the cost of the product per piece (a) is less and production rate (b) is increase in improved method than existing method for different cycle time.

VIII. CONCLUSION

The research study was completed with the sequencing problem. A real industrial data was used to demonstrate the sequencing problem and with the objective of minimizing cost and keeping constant consumption of each part. Our proposed cost model demonstrates in favour of saving cost. Followings are the main contribution of the current research;

i. It is also observed that the best sequence pattern and its job order, depends on production and demand quantity.
ii. The best sequence yields continue consumption of parts and minimize the overall cost.
iii. Maximum cycle time is also a factor for higher cost.

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TABLE III
PRODUCTION RATE PER SHIFT

Sr. No.	Product Name	Length (Cm)	Time taken to cross the door (S)	Activity		Operator working time (S)		Waiting time (S)		Total working time (S)		Total cycle time (S) (1+2)	Total number of part produced	Production per hour	Production per hr (7 hr)
				1	2	1	2	1	2	1	2				
1	10 CRCA long Plate	60	56	32	33	55.74	58.17	63	70.61	118.8	129.32	248.12	10	145	1015
2	8 Threseal Black Plate	48	51	34	34	45.17	41.67	36.94	39.87	82.11	81.54	163.65	8	175	1225
3	2 AL Plate	60	56	19	13	43.46	42.47	36.43	37.15	79.89	79.62	159.51	2	45	315
4	AL I Block	180	104	18	26	43.23	50.01	75.94	70.2	119.17	120.21	239.38	1	15	105
5	3 AL Triangular Black	50	52	25	24	39.11	33.5	50.27	53.51	89.38	87.01	176.39	3	61	427
6	AL Rectangular Box	25	42	12	12	30.7	30.81	44.37	44.20	75.07	75.01	150.08	1	23	161
7	AL Sieve Plate	120	80	15	16	69.22	62.5	29.63	35.67	98.85	98.17	197.02	1	18	126

TABLE IV
TOTAL DIRECT COST PER SHIFT

Article No.	Product produce in 1 min	Total surface area coated (M^2)	Powder consume (Kg)	Excess amount of powder consume (10%)	Total powder consume (Kg)	Powder cost (RS)	Fuel cost (RS)	Power consumption (Rs)	Labor cost (Rs)	Maintenance cost	Total direct cost (Rs)	Productivity of machine
1	2.4	45.68	4.57	0.45	5.03	678.62	2280.8	15778	3750	685	23172.47	2.1
2	2.9	13.23	1..32	0.13	1.45	196.06	2280.8	15778	3750	685	22689.91	2.5
3	0.75	113.4	11.34	1.13	12.47	1683.9	2280.8	15778	3750	685	24177.84	0.65
4	0.25	113.4	11.34	1.13	12.47	1683.9	2280.8	15778	3750	685	24177.84	0.21
5	1.02	10.68	1.06	0.106	1.17	157.51	2280.8	15778	3750	685	22651.36	0.88
6	0.4	20.13	2.013	0.201	2.214	298.92	2280.8	15778	3750	685	22792.77	0.33
7	0.3	90.72	9.07	0.907	9.98	1346.9	2280.8	15778	3750	685	23840.77	0.26

TABLE VII
PRODUCTION PER SHIFT FOR IMPROVED METHOD

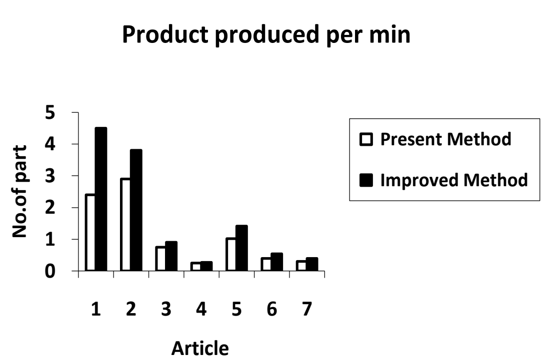
Sr. No.	Product Name	Length (Cm)	Time taken to cross the door (S)	Activity		Operator working time (S)		Waiting time (S)		Total working time (S)		Total cycle time (S) (1+2)	Total number of part produced	Production per hour	Production per hr (7 hr)	Extra production per shift
				1	2	1	2	1	2	1	2					
1	10 CRCA long Plate	60	49	29	29	49.1	45.7	17.6	20.9	66.6	66.6	133.2	10	270	1890	875
2	8 Threseal Black Plate	48	45	33	33	40.2	38.7	22.4	24.0	62.6	62.6	125.2	8	230	1610	385
3	2 AL Plate	60	49	12	12	31.5	31.5	35.1	35.1	66.6	66.6	133.2	2	54	378	63
4	AL I Block	180	92	16	20	43.3	43.7	66.4	65.9	109.6	109.6	219.2	1	16	112	7
5	3 AL Triangular Black	50	46	23	23	33.8	30.1	29.9	33.5	63.6	63.6	127.2	3	85	595	168
6	AL Rectangular Box	25	38	12	12	30.7	27.5	24.9	28.1	55.6	55.6	111.2	1	32	224	63
7	AL Sieve Plate	120	71	14	14	44.5	45.8	44.1	42.8	88.6	88.6	177.2	1	20	140	14

TABLE VIII
TOTAL DIRECT COST PER SHIFT FOR IMPROVED METHOD

Article No.	Product produce in 1 min	Total surface area coated (M^2)	Total powder consume (Kg)	Powder cost (RS)	Fuel cost (RS)	Power consumption (Rs)	Labor cost (Rs)	Maintenance cost	Total direct cost (Rs)	Productivity of machine
1	4.5	85.05	8.51	1148.17	2280.85	15778	3750	685	23642.02	3.9
2	3.8	17.38	1.74	234.74	2280.85	15778	3750	685	22728.58	3.3
3	0.9	136.08	13.61	1837.08	2280.85	15778	3750	685	24330.93	0.78
4	0.27	120.96	12.09	1632.96	2280.85	15778	3750	685	24126.81	0.23
5	1.41	14.87	1.48	200.8	2280.85	15778	3750	685	22694.66	1.24
6	0.54	28	2.8	378	2280.85	15778	3750	685	22871.85	0.47
7	0.34	100.8	10.08	1360.8	2280.85	15778	3750	685	23854.65	0.29

TABLE IX
OVEALL PROFIT FOR DIFFERENT CYCLE TIME

Article. No.	Time per product (Min)		% of savi-ng in time	Increa-se in output in %	Particulate Daily Emissions (Pound)		VOC Emissions (Pound)		Cost per part (Rs)		Cost of extra product (Rs)	Extra income per day (Rs)	Indir-ect wages in day (10% - 50%) (Rs)	Profit (Rs)
	Prese-nt	Improv-ed			Prese nt	Improve d	Prese nt	Improve d	Prese nt	Improve d				
1	0.41	0.22	46.4	87.5	2.65	4.5	0.38	0.64	22.83	12.50	19976.3	59928.8	5992.9	53935.9
2	0.34	0.26	23.5	31.03	0.77	0.92	0.11	0.13	18.52	14.11	7131.11	21393.4	2139.3	19254
3	1.33	1.11	16.5	20	6.6	7.2	0.94	1.02	76.75	64.36	4835.56	14506.7	1450.7	13056.0
4	4	3.70	7.5	8	6.6	6.55	0.94	0.93	230.3	215.41	1611.85	4835.56	483.5	4352
5	0.98	0.70	28.6	38.23	0.62	0.78	0.08	0.11	53.05	38.14	8912.01	26736.1	2673.6	24062.4
6	2.6	1.87	26	35	1.22	1.49	0.17	0.21	141.6	102.1	8918.9	26756.7	2675.7	24081.0
7	3.3	3	12.1	13.3	5.35	5.4	0.76	0.77	189.2	170.39	2648.97	7946.69	794.6	7151.99



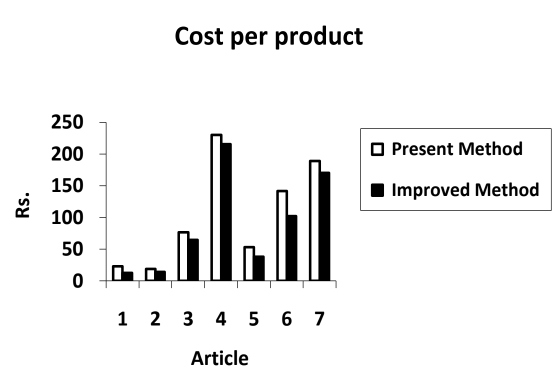


Fig-3 Comparison between the present and improved method a) product produced per min for different article (b) cost per product for different article.