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A Case Study of Impact of Changes in the Manufacturing Cycle in Supply Chain Management in Bhel-Hpv Plant, Visakhapatnam

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Abstract: The manufacturing process cycle is a critical sub-stage in integrated Supply Chain Management. The savings from manufacturing supply chain of Supply Chain Management will improve the revenue and returns. BHPV in Visakhapatnam, a public sector engineering unit is made a subsidiary in 2008 and merged into BHEL in 2010. The study is formulated to examine the savings in manufacturing hours and cost in four manufacturing cycle changes in the Supply Chain Management process in each year from 2008-09 to 2012-13. Therefore, a total of 20 manufacturing cycles in the supply chain management are collected at two intervals, one before and another after the change is implemented. The evaluation is done in terms of manufacturing cost and hours saved and its impact on financial performance parameters Return on Investment, Return on Assets, return on sales and Value Added. The analysis shows hypothesis H1 and H2 are true as significant relationship exists for the years under consideration with savings in cost and hours. The Impact of manufacturing process cycle changes on the financial performance in each year is positive except for the year 2009-10. However, the value added is positive and increasing for all the years under consideration. The changes in the manufacutring cycles of supply chain management have contributed to the revenue and time improvement in BHEL-HPV Plant at Visakhapatnam.

Keywords: Manufacturing Cycle Chain; Supply Chain Management; Cost Savings; Time Savings; Financial Performance

JEL Classification: N50

1. Introduction

The manufacturing process cycle is a critical stage in operating cycle of the maufacturing Organisation. The conversion cycle is invariably linked to financial health of the Organization (Davis, 1993). The extended manufacturing time span consequentially increases the cost in inventories and human resource. The shortest manufacturing process cycle is feasible with integrated Supply Chain Management (Cavinato, Joseph, 2002; Marien, Edward, 2000).

The innovation in technology and processes in supply chain management is expected to decrease the time cycle and cost of the product. The rate of change in improvement in time and cost is expected to be 2 to 3 times by replacing with new technology (Kearney, 2017).

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Concept of Supply Chain Management (SCM):

The integration of key business processes from the end user through original suppliers that provide products, services and information that add value for customers (Lambert, Emmelhainz and Gardner, 1996). The successive transform of raw materials into intermediate goods, then to final goods and deliver them to customers (American Production and Inventory Control Society). These views present supply chain management as the processes to add value to raw material to satisfy the end user.

The Supply Chain Management is concerned with the philosophy of nurturing the supplier and operates in a win-win situation by providing goods and services to the customer in a timely and cost-effective manner (Sunil Chopra and Peter Meindal, 2007). The management of supply chain is crucial and has impact on delivery chain, customer satisfaction and returns to business investment. The Supply uncertainty due to unreliability of vendors, process uncertainty due to internal processes and demand uncertainty are some of the major hurdles to effective SCM (Lambert & Cooper, 2000).

The Supply uncertainty can be addressed through a number of initiatives such as vendor development, certification, sharing of production planning information and transport arrangements. The Process uncertainty is due to process time, differential methods, machine breakdowns, uncertain yields and absenteeism, which can be eliminated by good maintenance practices and application of better technology. The Demand uncertainty can be reduced by forecasting techniques and developing a better communication with customers (Agrawal, 2001).

Effectiveness of Supply Chain:

The supply chain process is integrated as a system in the Organization with both internal and external sub-systems like vendors, customers and logistics. The movement of products from vendors to customers through manufacturing facilities, warehouses and third-parties are included under its domain (Silivia Rossi, Claudia Colicchi et al, 2013). Hence, supply chain must work effectively, for which there are five key issues (USAID | Deliver Project, 2011).

(i) Movement of Products in the manufacturing cycle;

(ii) Movement of Information;

(iii) Timing of Service;

(iv) Total Logistics Costs; and

(v) External and Internal Integration of Activities.

Strategies to Improve Effectiveness:

The Supply chain optimization ensures competative advantage (Porter, M. E. 1985). The main objective being the right product is available when it is needed, where it is needed and in the right quantity without excess inventory or extraordinary efforts such as expediting in the supply chain (Beamon, B. M. 1999).

The Strategies have enabled organizations to optimize the design and performance of suppliers, the processes that connect them, and the internal and external logistics processes through which they deliver (Fine, Charles. H. 1999).

Financial Performance and Supply Chain Management:

The financial performance refers to the degree to which financial objectives i. e. measuring the results of a firm's policies and operations in monetary terms has been accomplished (Bowersox and Closs, 1996). The savings from manufacturing supply chain of Supply Chain Management will improve the revenue and returns. The impact on the bottomline increases profits and financial performance.

BHPV was established in the year 1965 as a major public sector engineering unit in Visakhapatnam. BHEL has taken over BHPV as its subsidiary unit in the year 2008 and was merged into BHEL in 2010. The BHEL-HPVP is the 17th unit under the public sector Bharat Heavy Electrical Limited (BHEL). In the integration process several changes in the competitive strategies, policies, procedures, work practices and operational activities are implemented. As a part of above changes, renovations of old machinery and equipment have been taken up by BHEL management. Further, 75 percent of obsolete machinery and equipment were renovated and replaced with computerized numerical system of technology. The managemen has initiated modernisation strategy to purchase and install 120 numbers of CNC machines. Out of these 120 CNC machines, 12 machines were installed and operations are in progress. Since BHEL-HPVP unit is transforming its manufacturing process cycle by implementing latest technology and procedures. Hence, this unit was selected to examine the impact of manufacturing cycle changes on the overall performance of HPVP.

2. Methodology

Methodology is the approach adopted in the course of conducting the research. BHEL has implemented many changes in the manaufacturing cycle on post acquisition of erstwhile BHPV. The case study is conducted with the objective to assess the impact of manufacturing process cycle on supply chain management and the financial performance of the BHEL-HPVP Division. The study is formulated with the following hypothesis.

H1-Changes in manufacturing cycle of SCM with respect to manufacturing cost have an impact on the financial performance parameters.

H2-Changes in manufacturing cycle of SCM with respect to manufacturing hours have an impact on the financial performance parameters.

The study is conducted with secondary data collected from the manuals of BHEL-HPVP unit.

In the first phase, the four manufacturing cycle changes in the Supply Chain Management process in each year are considered for 5 years from 2008-09 to 2012-13. Therefore, a total of 20 manufacturing cycles in the supply chain management are collected at two intervals, one before the change is implemented and other after the change is implemented. The evaluation is done in terms of manufacturing cost and hours saved and its impact on financial performance. The financial performance

is evaluated with the following financial parameters (i) Return on Investment (ROI) (ii) Return on Assets (ROA) (iii) Return on sales (ROS) and (iv) Value Added

(i) Return on Investment = Profit / Investment
(ii) Return on Assets = Annual Net Income / Average Total Assets
(iii) Return on Sales = Net Income / Sales
(iv) Value Added = Price that the product or service sold at – Cost of Producing Product

The data on manufacturiing cycle in the particular process is collected from the industrial engineering and costing department and analysed from Time and Cost perspective.

3. Results and Discussion

The standard time recordings are collected from the manuals of the Industrial Engineering Department as per the standard practices of the Organisation. The cost saved in terms of rupees is from the audited records of the respective depatments.

Mafucturing Cycle Changes:

1. Group Stress Relieving Activity: Stress relieving (SR) activity is carried out for the heavy fabrication equipment that is fabricated in the workshops. It is the penultimate operation of the fabrication activities. After completion of all quality checks, this operation is carried out. This process consists of keeping the equipment on the bogie of the furnace, keeping the bogie inside the furnace, closing the doors, lightening the burners and maintaining temperatures according to the quality system to meet the metallurgical requirements. Instead of independent job loading in existing method, similar cycle jobs are identified and regrouping is done. There by increasing productivity and effective SCM structure.

Before Change
Size of annealing furnace: 36metres5metres5metres-120Tons,1100 DegreesC,96Burners.
Furnace cycles per year: 80cycles
Total hours required: 80cycles10hours=800hours
Hourly rate of furnace: Rs. 10,000 per hour
One cycle cost:10 hours10,000per hour=Rs. 1,00,000
Cycles has to be carried out per year:80 cycles
Total cost in the year: Rs1,00,00080=Rs80,00,000

After Change
Total cycles in the year: 80cycles By regrouping it has been brought down to: 65 cycles
Saving in cycles: 80 – 65 = 15 cycles Cycle cost: Rs. 1,00,000
15cyclescost:151,00,000=Rs 15,00,000 Saving in cost: Rs15,00,000
Time saved per annum 10 hours per cycle: 15 cycle10 hours = 150 hours

2. Shop Working Area Optimization: The shop working area is a vital aspect. Space utilization in production area assured affective SCM process identifying undemanded product coverage area and obsolete machinery coverage area in production shops and clears them for space and better utilization.

Before Change
Area available for assembly: 3 bays
Each bay area: 20030=6000sq. metres
For 3 bays: 6000 3=18000sq. metres

After Change
By relocating 3000 sq. metres area is identified and converted for production utilization.
Production area Improvement:3000/18000100= 16%
Value added for total working Area in the year: Rs. 11Crores
Value added for 60% of Assembly area: Rs. 1160/100=Rs. 6. 6Crores

Value added for 16% of production area improvement: Rs. 6. 616/100=Rs. 1. 05Crores or 105 Lakhs

3. Machining Drilling holes: The drilling of tube sheet is a long cycle item and critical operation in Heat exchanger fabrication which occupies time in heat exchanger fabrication cycle. Hence, with implementation of CNC technology, drilling time of tube sheet has reduced with high accuracy in tube holes and quality.

Before Change
The tube sheet and thickness of 100mm, 20dia holes, 500 nos.
Drilling time per hole: 10minutes
Time taken for 500 holes:50010minutes =5000minutes.
Annual Load of 60tube sheets: 5000/6060 =5000 hours
Hourly rate of machine operator: Rs. 280 Total cost per annum: 500hoursRs280=
Rs. 14 lakhs

After Change
Drilling time per hole: 6minutes Time taken for 500holes:5006minutes=3000minutes
Total hours per annum:3000/6060=3000hours Time saved per annum:5000–3000=2000hours Hourly rate of machine Operator: Rs. 280
Total cost saved per annum: 3000hoursRs280=Rs8. 4lakhs
Saving=Rs14lakhs–Rs8. 4lakhs =Rs 5. 6 lakhs

4. Sub-Assembly of Horton Sphere of Petals: Horton sphere of different number of petals and cover under the category of storage vessel of spherical shape. Spheres construction is made out of petals, the number of petals vary depending upon the size of the sphere. Regular practice involves all the petal courses sent for rectification to make as per layout to fit into exact slot in the sphere. It carries more time at sight due to lack of proper infrastructure and facilities.

Before Change
Individual petals are sent to site. Each petal is temporarily set in the course and trial assembled. Then rectification is carried out to suit as per layout. As per the layout, each petal carries 20 hours for rectification to suit exact slot in sphere.
Time required for each petal: 20hours Each sphere contains: 70petals
Expected spheres per annum: 5nos.
Total time required per annum: 70petals5nos. 20hours = 7000 hours
Hourly rate of fitter: Rs. 200
Total cost per annum: 7000hoursRs. 200=Rs14 lakhs

After Change
Trail assembly of each petal course is carried out. By trial assembly, 8 hours of time is taken for each petal to set in to the layout. Then the courses are dismantled and sent for site. Sub-assembly of petals includes the following elements and carried 8 hours for completion of each petal and rectification of elements of sub-assembly (prebending, marking, gas cutting, assembly, grinding and tack welding). Time required for each petal: 8hours
Total time required per annum: 70petals5nos8hours=2800hours
Time saved per annum: 7000–2800=4200 hours
Hourly rate of fitter: Rs 300 Total cost per annum: 2800hoursRs300 = Rs 8. 4 lakhs Total cost saved: Rs14–8. 4=Rs 5. 6 lakhs

5. Pre-bending and rolling of shell plates: Each shell course in pressure vessels, storage vessels and other products. Plate materials are to be prepared suitably and then rolled into shell form on rolling machine. Plate material is to be pre-bent before rolling. These pre-bent operations are carried out in press shop. After pre-bending this has to be moved to shell section for rolling operation. At later stage,

both pre-bending and rolling are done on the same machine. This saves inspection time, transportation time and shop movement, thereby increases productivity and effective SCM. It describes that rolling operation of plates; the plate material is to be pre-bent to the radius required. This operation is carried out in presses division and then they are moved to rolling section for rolling operation in cases of the above thickness of 50mm. In the proposed method a new rolling machine has been envisage which can perform both pre-bending and rolling on the same machine up to thickness of 90mm. This saves operational time, transportation time and inter shop movement delay.

Before Change
The diameter of shell 2000mm, thickness of 70mm, L/S: 1200mm.
Time for pre-bending:150 minutes
For inspection and delivery: 240minutes Rolling and inspection: 140minutes
Total time for completion: 150+140+240=530minutes
Cost of operation per shell: Rs. 5070
Work load per annum: 240 nos.
Total time per annum: 240nos. 530minutes=127200/60 =2120hours Total cost per annum: Rs5070240nos=Rs12. 16laks

After Change
Cycle time for pre-bending and Rolling in proposed method: 210minutes
Work load expected per annum: 240nos
Total time per annum: 240 nos50400/60=840 hours
Operation cost for shell: 210/60Rs 1000 = Rs 3500
Saving per shell: 5070–3500= Rs 1570
Total cost for yearly load: 240 nosRs 3500=Rs 8. 4 lakhs
Total time saving per annum: 2120–840 =1280 hours
Total cost saved per annum: 12. 16–8. 4=Rs3. 76 lakhs

6. Profile gas cutting operation: Profile gas cutting machine, paper template is essential for RF pads, Trunions, lifting lugs, support plates among others. Changes of each size and shape of a component a new paper template is to be prepared. In CNC cutting machine, there is no need of paper template and direct cutting is possible. There by, improving supply chain process and production.

Before Change
With paper template gas cutting for RF pads, lifting lugs, trunions, support plates etc. change of each component in size and design, a new paper template is to be made. Time required for paper template Preparation: 1 hour Quantity required per annum: 790 nos
Time required per annum: 7901hour=790 hours
Hourly rate of Jr. Draughts man: Rs 300
Cost required per annum: Rs 300790 hours=Rs2. 37 lakhs

After Change
Computerized Numerically Controlled cutting Machine is proposed in place of existing profile cutting machine (suprarex). There is no need of paper template for this CNC machine; direct cutting is possible by programming and thereby improving supply chain design. Time taken for paper template: '0' hours (No need of paper template)
Time required per annum: 790'0' ='0' hours
Time saved per annum: 790–0= 790 hours Hourly rate of Jr draughtsman: Rs 0
Cost saved per annum: 2. 37–0=Rs2. 37 lakhs (Note: change before and after SCM, profile gas cutting time is same, therefore gas cutting operation time not considered.)

7. Banana Bends Rectification: The boiler products, most of the components concern with pipe materials. A small bought out items and other various sizes of pipes assembled and welded within small gaps on a straight pipe. The ultimate result, a bend formed on straight pipe due to manual welding. These bends are removed manually on straight pipe with hydraulic presses of 250 tons or 400 tons. Over a time, these practices upgraded with CNC technology, resulted an improvement in SCM process and productivity.

Before Change
After welding nipples and other pipes, a distortion occurs on a straight pipe and formed banana shape. By using medium (capacity Hydraulic presses 250T/400T) presses in progressive fashion each time checking on layout. Jib cranes are used to handle the components. This is a trial and error process with lot of manual intervention. In a year on an average 400 bends are rectified
Time taken for each bend is to a tune of: 240 minutes
Total time required per annum: 400nos240minutes =96000/60minutes=1600 hours
Hourly rate of press operator: Rs190
Total cost required per annum: Rs1901600hours=Rs3. 04 lakh

After Change
Goose neck CNC (600 T) capacity is suggested as a proposed alternative for carrying out this operation. The rate of output of this machine for the above capacity job is at 60 minutes per bend. Time taken for each bend: 60minutes Bends rectified per year: 400nos. 60minutes=24000/60minutes
Total time required per annum: 400 hours Total time saved per annum: 1600–400=1200hours
Hourly rate of press operator: Rs. 275
Total Cost per annum: 400hoursRs275=Rs1. 1 lakhs
Total cost saved per annum: Rs3. 04–Rs1. 1=Rs1. 94 lakhs

8. Cycle Time Reduction on Layout Checking of Bends: After bending of each pipe, keeping bend on layout, and check any deviations, such deviations are marked and rectified. For various sizes of bends and multiple bends are required, separate layouts and the checking process repeated to keep design parameters and to maintain quality and suitability. Instead of 180 degree checking each bend, random checking with templates consumes less time. The ultimate result is cycle time reduction.

Before Change
After bending of each pipe, keeping bend pipe on layout and check if any deviation with layout, such deviations are to be marked and rectified. Depending on type of bend size, different number of layouts is used for checking of dimensions.
Layout marking and checking: 30+10+5+15 = 60 minutes
Bends per Annum: 900nos.
Total time required in existing system:900nos. 60minutes=54000/60minutes=900hours Hourly rate of marker: Rs 215
Total cost per annum: Rs 215900nos=1. 93 lakhs

After Change
Random checking of one bend in batch of 10 pipe bends: 30+10+5+15=60minutes
For checking 900 bends: 900/10=90 pipe bends
Total time at random checking: 60minutes90bends =5400/60=90hours Templates preparation for four nos.: 60minutes4nos. =240/60=4hours
Total time required: 90+4hours=94hours Saving time per annum: 900–94hours= 806 hours
Hourly rate of marker: Rs 325
Cost saved per annum: 94hoursRs325=0. 3 lakhs=1. 93–0. 3 =Rs1. 63 lakhs

9. Multiple Pipe Cold Bending: In the present practice multiple pipe bend of 180 degrees on a single plane machine involves layout marking, push and bend and keeping bend on layout for checking required parameters. This sequence will be repeated twice or thrice for this type of multiple bends on single plane machine. In order to upgrade this process, a multiple pipe of cold bending on a CNC multiple 185 plane machines were envisaged. Hence an improvement is noticed in harmonious supply chain relationship.

Before Change
Multiple Pipe Bends on single plane machine. Layout marking, push and bend, keeping bend on layout and Checking for required parameters: 120+40+12+8=180minutes
Total number of bends per annum: 400nos. Total time required per annum: 400nos. 180 minutes=72000/60= 1200hours

After Change
Multiple pipe bends on CNC Multiple plane Cold bending machine Preparation of programme on CNC, loading and bending and Checking to required parameters: 30+8+12=50 minutes
Total number of bends per annum: 400nos Total time in change after SCM: 400nos50 minutes =20000/60=334 hours

Hourly rate of bending operation: Rs 205 Total cost required per annum: Rs205120hours=Rs 2. 46 lakhs

Time saved over change before SCM: 1200-334 = 866 hours
Hourly rate of bending operator: Rs 265
Total cost saved per annum: 334hoursRs 265= Rs 88510=Rs0. 88 lakhs=Rs2. 46-Rs0. 88=Rs1. 58 lakhs

10. Pipe Welding: Pipe to pipe assembly, welding and grinding operations carried manually by using tackles and tools. In upgrading this activity, the above operations carrying on rotary welding machine can automatically align, assembled, welded and grinded thereby resulted in time and cost saving.

Before Change
Piping Assembly, Welding, grinding of pipe size 60 diameter, thickness of 8mm, length 3metres. The above operations carried manually by using tools and tackles. Time required for piping assembly, grinding, welding, and dressing: 20 + 16 + 45 +15= 96 minutes
Total number of pipes per annum: 2500nos. Total time required per annum: 2500nos. 96minutes=240000/60minutes =4000 hours Hourly rate of fitter: Rs. 215 Total cost required per annum: Rs. 2154000hours=Rs8. 6 lakhs

After Change
In the new method all the above operations carrying on Rotary Welding Machine can automatically align, assembled, welded and grinded are carried on.
Time required for operations: 20minutes
No. of pipes per annum: 2500nos.
Time required per annum: 250020minutes=50000/60minutes=834hours Time saved per annum: 4000 – 834 = 3166 hours
Hourly rate of machine operator: Rs 300
Total cost per annum: 834 hoursRs 300= 2. 5 lakhs
Total cost saved: Rs 8. 6 – 2. 5 = Rs 6. 1 lakhs

11. Facing and Beveling of pipes: The existing work practice, marking on pipe, loading, facing and beveling on portable pipe chamfering machine. All the above operations except marking and loading are carried on 80 CEP Automatic Tube cutting and Edge planning machine. Comparatively, the above work tasks are completed more early than manual operations. This resulted in an improvement over the previous practices.

Before Change
Before change in SCM, pipes with restricted length and of 76. 1 diameter marking, loading, facing and beveling carried on by both manual and portable pipe chamfering machine. Time required for marking, loading, Facing and beveling: 6 + 9 + 17 = 40 minutes
Total number of pipes per annum: 2000nos. Total time required per annum: 2000nos. 40 minutes= 80000/60minutes =1334 hours Hourly rate of operator: Rs 208
Total cost per annum: Rs2081334hours=Rs 2. 7 lakhs

After Change
After change in SCM, all the above operations except marking and loading are carried on 80 CEP automatic tube cutting and EP machine Time required for marking, loading, facing and beveling:8 +5 + 4 = 17 minutes
Total number of pipes per annum: 2000nos. Total time required per annum: 2000nos. 17minutes =34000/60 minutes =567 hours
Time saved per annum: 1334 –567hours= 767 hours
Hourly rate of machine operator: Rs 330 Total cost per annum: 567hoursRs330 =Rs1. 87 lakhs
Cost saved perannum: Rs2. 7–1. 87lakhs=Rs0. 83 lakhs

12. Drilling holes on Header pipes: Boiler headers drilling carried on radial drilling machine. Drilling includes both center drilling and pre-drilling. As an improvement in operations, CNC Gantry drilling machine installed in this machine both center drilling 191 and pre-drilling carried with same set up time, thereby resulted in reduced cycle time and in value chain of SCM.

Before Change
Before change in SCM boiler headers drilling carried on radial drilling machine. Size of hole 60diametre and header thickness of 90mm with following sequence for each hole of drilling. Total time required per hole include centre drilling, Time required for hole: 10minutes 100 holes in a row and 400 headers per annum:10minutes100holes400nos=400000/60minutes = 6667 hours
Total time required per annum: 6667hours Hourly rate of machine operator: Rs 215
Total cost required per annum: Rs 2156667 hours=14. 3 lakhs

After Change
After change in SCM boiler header drilling carrying on CNC gantry drilling in two stages. Time required for hole: 2. 5minutes 100 holes in a row and 400 headers per annum:2. 5minutes100holes400nos=100000/60 minutes =1667 hours
Total time required per annum: 1667 hours Time saved per annum: 6667 – 1667 hours= 5000 hours
Hourly rate of machine operator: Rs 300
Total cost saved per annum: Rs3001667hours =Rs 5 lakhs
Total cost saved: Rs 14. 3 –5 lakhs= Rs 9. 3 lakhs

13. Pipe Cutting and Deburring: Activity on nozzle pipes and manhole pipes cutting and deburring operation performed on Muller flame cutting machine. In re-engineering process and an advent of sophisticated technology, a pipe sawing band saw (600mm) 193 machines was installed and carried the above operations on this machine which results in a specified positive outcome in the above operation.

Before Change
Before change in SCM operations involve nozzle pipes and manhole pipes cutting and deburring operation carried on muller flame cutting machine for cutting and deburring of diameter 500mm and thickness of 40mm.
Total time required per pipe including cutting and deburring: 30+ 4 = 34 minutes
Pipes required per annum: 1100nos
Total hours required per annum: 34minutes1100nos=37400/60minutes=623hours Hourly rate of machinist: Rs 180
Total cost per annum: Rs 180623 hours=Rs1. 1 lakhs

After Change
After change in SCM cutting and deburring of pipes was carried out on pipe sawing band saw machine (600 mm). Time required per pipe: 7minutes
pipes required per annum: 1100 nos
Total time required per annum: 1100nos 7 minutes =77000/60minutes=128hours
Time saved per annum: 623 – 128 hours= 495 hours
Hourly rate of machine operator: Rs 250 Total cost saved per annum: Rs250128hours=Rs0. 32 lakhs
Savings = Rs1. 1 – 0. 32= 0. 78 lakhs

14. C/Seam and L/Seam Grinding: Boiler Drum C/Seam and L/Seam joints after completion of welding and grinding operation manually performing by using abrasive grinding wheels. In place of these grinding wheels, abrasive belts of LS and CS grinding machine introduced. With the introduction of this abrasive belt system, an expected output and integrated SCM was obtained.

Before Change
Boiler Drum, C/Seam and L/Seam joints, Header pipe Joints after completion of welding, grinding operation carried manually with pneumatic abrasive wheels. (Drum size of diameter 1000 mm x thickness of 50mm)
Time required for above drum size: 360 minutes
800 headers & Boiler drums per annum:800360=288000/60minutes=4800 hours Hourly rate of grinder: Rs 165
Total cost per annum: Rs1654800hours=Rs7. 9 lakhs

After Change
After change in SCM grinding of C/Seam and L/Seam joints carrying by using abrasive belts of LS and CS grinding machine.
Grinding time required per item: 45/60 minutes= 0. 75 hours
800 drums and headers per annum: 800nos 0. 75hours= 600 hours
Time saved per annum: 4800 – 600 hours= 4200 hours
Hourly rate of grinder: Rs 225
Total cost saved per annum: Rs225600hours=Rs1. 35 lakhs
Savings:Rs 7. 9-1. 35 =Rs 6. 55 lakhs

15. Preparation of Bevels on pipes: In existing system, pipes of diameter 600mm and thickness of 40mm gas cutting and beveling operations are carried manually. By installing computerized numerically controlled pipe edge preparation machines, the above manual operations are taken up on this machine and yields more returns.

Before Change
Pipes thickness of 40mm, diameter 600mm after gas cutting beveling operations are carried manually.
Time required for gas-cutting and bevel making: 65 + 36minutes= 101 minutes
Total no. of pipes per annum: 1400nos.
Total time required per annum: 1400nos101minutes=141400/60minutes =2357 hours
Hourly rate of operator: Rs 150
Time required per annum: Rs1502357hours=Rs3. 53 lakhs

After Change
After change in SCM pipes thickness of 40mm, diameter 600 mm both cutting and beveling operation are carried on CNC pipe edge preparation machines.
Time required for beveling: 24minutes
Total No. of pipes: 1400nos.
Total time required per annum: 1400nos. 24 minutes = 33600/60 minutes = 560 hours
Time saved per annum: 2357 –560 hours= 1797 hours
Hourly rate of machine operator: Rs. 218
Total cost saved per annum: Rs. 218560hours=Rs1. 22 lakhs
Savings: Rs3. 53–1. 22 = Rs 2. 31 lakhs

16. Panel processing: An obsolete panel processing machine consists of 6 torches and 18metres length and comprising of 4 pipes used for welding. Instead of above machine a modern panel processing (20 torch) CNC panel processing comprising of 10 pipes was erected in a new bay which yields an output of 3 times more than previous one

Before Change
Panel processing using 6 torches consists of 18 metres length and comprising of 4 pipes.
The rated output per panel: 18metres24minutes=432minutes
Welding time of pipes with torch: 18metres4minutes= 72 minutes
Total Time per panel: 432+ 72= 504 minutes Total panels per annum: 60Nos
Total time required per annum: 504minutes60nos=30240/60minutes=504 hours
Hourly rate of welder: Rs 155
Total cost required per annum: Rs155504hours=Rs 0. 78 lakhs

After Change
After change in SCM, 20 torches CNC panel processing is proposed to cater to the need. This machine assuming to length of 18 metres and comprising of 10 pipes.
The rated output per panel: 18metres4minutes=72 minutes
Total panels per annum: 60Nos
Total time per annum: 60nos 72 minutes= 4320/60 minutes= 72 hours
Time saved per annum: 504 – 72 hours= 432 hours
Hourly rate of machine operator: Rs 290
Total cost saved per annum: Rs 29072hours= Rs 0. 2 lakhs= Rs 0. 78–0. 2 = Rs 0. 58 lakhs

17. Drilling on Boiler Drum: Drilling of holes on boiler drum carried on horizontal boring machine of large diameterand higher thickness. With the assistance of method study, an easy and economical method has developed in the place of above operation. This method has both gas-cutting and boring on horizontal boring machine provides a better output and effective SCM.

Before Change
Drilling of hole of diameter 200 mm on drum. Thickness of drum consists of 40mm. Time required for stage wise drilling of one hole: 31 minutes
10 drums per annum and each Drum contains 100 holes: 10nos 100 holes 31 minutes= 31000/60 minutes

After Change
Time required for gas cutting, Horizontal boring for one hole: 15+10 = 25 minutes
Total drums per annum 10 nos and each drum contains100holes:10nos100holes25minutes= 25000/60 minutes

Total time required per annum: 517 hours Hourly rate of machinist: Rs 180
Total cost required per annum: Rs180517hours=Rs0. 93 lakhs

Total time required per annum: 417hours Time saved per annum: 517 – 417 = 100 hours Hourly rate of machine operator: Rs 200
Total cost saved per annum: 200417 hours =Rs 0. 83lakhs = Rs 0. 93-0. 83=Rs0. 1lakh

18. Welding Operation: In present work practices cross-sectional and longitudinal seam welding of shell courses in fabricated equipment carried manually by welders. Instead of above manual operations, submerged arc-welding machines employed and which yields more output in welding.

Before Change
Time required for manual welding for 4 L/Seams of 2 meters length: 224minutes
Time required for manual welding for 3 C/Seams of 3 meters length: 320 minutes Total work orders per annum: 65nos
Total time required per annum: 224 + 320 = 544 minutes=544minutes 65 nos =35360/60= 589 hours
Hourly rate of welder: Rs 275
Total cost required per annum: Rs275589hours=Rs1. 6 lakhs

After Change
Time for submerged arc welding for 4 L/seams of 2 metres length: 146 minutes
Time for submerged arc welding for 3 C/Seams of 3 metres length: 195 minutes Total work orders per annum: 65nos
Total time required per annum: 146+195= 341 minutes= 341 minutes65nos =22165/60=369 hours
Time saved per annum: 589 – 369 = 220 hours Hourly rate of welder: Rs 290
Total cost required per annum: Rs290369hours=Rs1 lakh
Total cost saved per annum: Rs 1. 6 – 1= Rs 0. 6 lakhs

19. Material Handling In Material Preparation Shop: Plate material stacked in the storeyard for picking up with trailer, tractor and mobile crane units from plate material yard. In the present system, handling of plate material by mobile crane and tractor and trailer unit involves a number of handlings and moved through longer distances to feed production shops. Break down to any of this equipment is causing further delay in supplying material to shops. So in order to overcome this problem, Gantry crane facility established, thereby reduced cycle time and enhanced space utilization in the store yard.

Before Change
The issues are delayed by 20 to 22 days in the existing system.
Days delayed per cycle: 22days
Cycle contains hours: 16hours
Total cycles per annum: 12cycles
Total time required per annum: 22days16 hours12cycles=4224 hours

After Change
Before change in SCM Gantry crane facility is suggested to replace the existing material handling system in plate material store yard. By the proposed system, issues can be made within one or two days only. This results in 20 days of saving in the cycle time of manufacture.
After change in SCM issues made in 2 days assuming 16 working hours per day:2days16hours= 32 hours
Number of cycles per annum: 12cycles
Total time required per annum: 32hours12cycles=384hours
Total time saved per annum: 4224 – 384 =3840 hours

20. Material Handling in PV Assembly Shop: In PV assembly shop provided with handling capacity of 60 tons in a single handling. In case of more weights, two 60 tons EOT cranes are used in Tandem to lift up to 120 tons. For equipment weighing more than 120 tons, lifting with great difficulty and consuming more time. In order to overcome this situation Jacking and Beam arrangement designed and

developed to lift up to 300 metric tons without higher capacity EOT cranes. With this material handling design, considerable time saving and opportunity in SCM for long term competitive advantage.

Before Change
Time taken for a crew of 5 employees: 3hours Total equipment per Annum: 20 nos.
Hourly rate of 5 employees:500+500+300+220+220 =Rs1740
Total time per annum:3hours 20 nos= 60 hours
Total cost per annum: Rs. 174060hours=Rs 1,04,400

After Change
Time taken for a crew of 5 employees: 1hour Total equipment per annum: 20nos.
Hourly rate of 5 employees: Rs 1740
Total time per annum: 20nos. 1 hour= 20 hours
Total cost per annum: Rs 1740 20 hours= Rs 34800
Time saved per annum: 60 – 20 hours= 40 hours
Total cost saved per annum:
Rs. 1,04,400– 34800=Rs 0. 69 lakhs

The consolidated savings in cost and time for the sample 20 changes are presented in table no. 1.

Impact of Manufacturing Cycle Changes on Financial Performance:

The financial parameters of the respectives years are analysed with cost savings to estimate the impact of manufacturing cycle changes (table no. 2). BHEL- HPVP unit for the year 2008-09 has earned profit of Rs 96. 92 crores with an Investment of Rs 48. 96 crores. The return on investment (ROI), the return on sales (ROS), and the return on assets (ROA) are calculated as 197. 9 percent, 114. 8 percent and 35. 6 percent respectively. The value added for the company is 23. 5 percent.

In the year 2009-10, BHEL-HPVP has earned a loss of Rs 7. 5 crores with an investment of Rs 41. 03 crores. The return on investment (ROI) and the return on sales (ROS) are negative with 18. 2 percent and 7. 19percent respectively whereas the value added is 35. 85 percent. In the year 2010-11 the Profit earned by the company is Rs8. 77crores with an increased investment of Rs. 64. 35crores. The return on investment (ROI) is 13. 6 percent and comparitively more than the preceeding year. The return on sales (ROS), return on assets (ROA) and value added are 6. 4 percent, 2. 95 percent and 41. 2 percent respectively. The financial performance presents an improvement over the previous year.

The return on sales (ROS), return on assets (ROA), return on investment (ROI) and value added in the year 2011-12 are 6. 91 percent, 4. 04 percent, 14. 2 percent and 45. 2 percent respectively. And the net profit has improved to Rs. 10. 44 crores with an improvement over the previous years. The table no presents value added was increasing continuously from 2008-09 to 2011-12. The financial year 2012-13 presents net profit as Rs. 35. 04 crores with an improved turnover of Rs. 240. 27 crores. The return on sales (ROS), return on assets (ROA), return on investment

Table 1. Consolidated Statement of Savings in Time in Hours and Cost in Rupees

Activity	**Before change in SCM**	**After change in SCM**	**Savings per Annum**	
			Time	**Cost (in lakhs)**
Group SR Activity	Independent job loading	Regrouping similar Jobs while job loading	150 (18. 75%)	15 (18. 75%)
Shop optimization	Floor occupied by machinery for undemand product	Identified 3000sq. mtrs. For utilization.	NA	105 (15. 9%)
Drilling operation	Radial drilling	CNC drilling	2000 (40%)	5. 6 (40%)
Sub assembly of petals	Rectification and subassembly of petals at site	Rectification of petals at HPVP a unit of BHEL	4200 (60 %)	5. 6 (40%)
1. 2008-09			**6350**	**131. 2**
Rolling and pre-bending of shell plates	Rolling of shell at shell section pre-bending at press shop	Rolling and prebending on rolling machine at shell section	1280 (60. 3%)	3. 76 (31%)
Profile gas cutting	Suprarex cutting machine with paper template for each component	In CNC cutting machine no need of paper template	790 (100%)	2. 37 (100%)
Banana Bends rectification	Hydraulic presses (250T/400T)	Goose Neck CNC press (600T)	1200 (75%)	1. 94 (63. 8%)
Cycle time reduction on layout checking of bends	Each pipe bend checking on layout	Random checking of pipe bends using templates	806 (89. 5%)	1. 63 (84%)
2. 2009-10			**4076**	**9. 7**
Multiple pipe cold bending	Multiple pipe cold bending on a singleplanemachine	Multiple pipe cold bending on a CNC multipleplane machine	866 (72. 1%)	1. 58 (64. 2%)
Pipe Welding:	Manual pipe welding	Welding on Rotary welding machine	3166 (79. 1%)	6. 1 (71%)
Facing and beveling of pipes	Marking, loading, facing and beveling on portablepipe chamferingmachine	80 CEP automatic tube cutting and EP machine	767 (57. 4%)	0. 83 (30. 7%)
Drilling holes on Header pipes	Radial drilling machine	CNC gantry drilling	5000 (74. 9%)	9. 2 (65. 4%)
3. 2010-11			**9799**	**17. 87**
Pipe Cutting and Deburring:	Cutting of pipes on muller flame cutting machine	Cutting of pipe on pipe sawing band saw 600mm machine	495 (79. 4%)	0. 78 (70. 9%)
C/Seam and L/Seam Grinding:	Manual grinding with pneumatic abrasive wheels	Grinding by abrasive belts of C/Seam & L/Seam Grinding machine	4200 (87. 5%)	6. 55 (82. 9%)
Preparation of Bevels on pipes:	Gas cutting and beveling manually	Direct beveling on CNC pipeedge preparation machine	1797 (76. 2%)	2. 31 (65. 6%)
Panel processing	6 torches, 4 pipes, 18	20 torches 10 pipes	432	0. 58

	meters lg	18 mts lg	(85. 7%)	(74. 3%)
4. 2011-12			**6924**	**10. 22**
Drilling on Boiler Drum	Drum Drilling on radial drilling machine	Partly gas cutting Remaining boring on HB machine	100 (19. 3%)	0. 1 (10. 7%)
Welding Operation	Manual welding	Submergedarcwelding	220 (37%)	0. 6 (38%)
Material Handling In Material Preparation Shop	Plate material picking up with tractor, trailer and mobile crane units	Gantry crane from stores to common area. Extension of MP Bay to common area	3840 (90. 9%)	NA
Material Handling in PV Assembly Shop	Lifting and loading with capacity of 60 tons, 2 EOT cranes, equipmentweighing upto 200 tons	Jacking and beaming Arrangement designed as an addition for 2 EOT cranes for lifting and loading 250 to 300 tons	40 (66. 6%)	0. 69 (69%)
5. 2012-13			**4200**	**1. 39**

(ROI) and value added in the year 2012-13 are 14. 5 percent, 10. 8 percent, 36. 9 percent and 46. 1 percent respectively. The table no. 2 presents except in the year 2009-10 the finacial returns show positive trend but value added in 2009-10 is positive.

Table 2. Finacial Changes due to Manufacturing Cycle Changes in Five Years

Parameter	2008-09	2009-10	2010-11	2011-12	2012-13
Cummulative changes on each year	4 changes	8 changes	12changes	16changes	20changes
Cumulative cost savings due to changes(Rs. In Crores)	1.312	1.31+.97 =1.409	1.31+.97 +1.787=1 .587	1.31+.97+ 1.787+.10 2 =1.588	1.31+.97+1. 787+.102+. 139 =1.590
Net Profit (Rs. In Crores)	96.92	(-) 7.5	8.78	10.44	35.04
Investments (Rs. In Crores)	48.96	41.03	64.35	73.39	95.73
Turnover (Rs. In Crores)	84.39	104.31	136.98	155.8	240.27
Return on Sales	114.8	(-) 7.19	6.4	6.91	14.5
Return on Assets (%)	35.6	(-) 2.46	2.95	4.04	10.8
Return on Investments (%)	197.9	(-) 18.2	13.6	14.2	36.9
Value Added (%)	23.5	35.85	41.2	45.2	46.1

The relationship was estimated between the financial performances for five years, after the manufacturing cycle changes in each year. The analysis shows significant relationship for the years under consideration namely 2008-09, 2009-10, 2010-11, 2011-12, and 2012-13. The mean and standard deviation scores for compounded values are provided in the table no. 3.

Table 3. Mean and Standard Deviations for Compounded Financial Parameters

Particulars	Mean	Standard Deviation
Compounded ROI for 5years	. 4880	. 8513
Compounded ROS for 5years	. 2680	. 4933
Compounded ROA for 5years	. 1040	. 1504
Compounded Value Added for 5years	58. 5520	34. 5670

4. Conclusion

The hypothesis H1 and H2 are true as the savings in time and cost are estimated as positive and the cumulative impact is also positive. The Impact of manufacturing process cycle changes on the financial performance in each year that is 2008-09, 2010-11, 2011-12 and 2012-13 are positive except for the year 2009-10. However, the value added is positive and increasing for all the years under consideration. Therefore the 20 changes in the manufacutring cycles of supply chain management have contributed to the revenue improvement in BHEL-HPV Plant at Visakhapatnam.

The manufacturing cycle time reduction will result in improving the revenue and also reduce the supply chain time. The supply chain effectivess is improved with positive changes to the manufacturing cycle.

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