

# Implementation of BorgWarner Production System - Case Study at DivgiWarner Private Limited

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## ABSTRACT

In the pursuit of manufacturing excellence BorgWarner, Inc., USA has utilized some key aspects of Toyota Production System and General Motors Quality System Basics tools to create a systematic framework called as Borg Warner Production System (BWPS). The goal of BWPS is to have robust manufacturing systems to deliver flawless quality products at lowest possible cost and give hassle free customer experience.

This case study covers the BorgWarner Production System implementation experience of DivgiWarner Pvt. Ltd. India, one of the BorgWarner's plant based in Pune and Sirsi, India.

The BWPS consists of 7 foundational elements and 23 tactical strategies. These seven foundational elements are

- Safety and Environment,
- Quality Systems,
- Employee Development,
- Continuous Improvement,
- Lean Manufacturing,
- Pre-Production Planning,
- Metrics and Audits

This framework delivered following benefits to the company:

- "Zero" safety incidences
- Customer PPM reduced from 675 to 122
- 100% On Time Delivery to customers
- Continual improvement - more than 300 kaizen projects implemented every year
- Overall Equipment Effectiveness increased from 41% to 82.9%
- Inventory Turn Over Ratio (ITOR) increased from 4.8 to 10.1
- Material movement in the plant reduced by 68%

This paper uses BWPS as an example to illustrate how to implement similar production systems, in order to improve manufacturing effectiveness. We also show how to set performance base lines, track continuous improvements, and communicate progress to pursue perfection.

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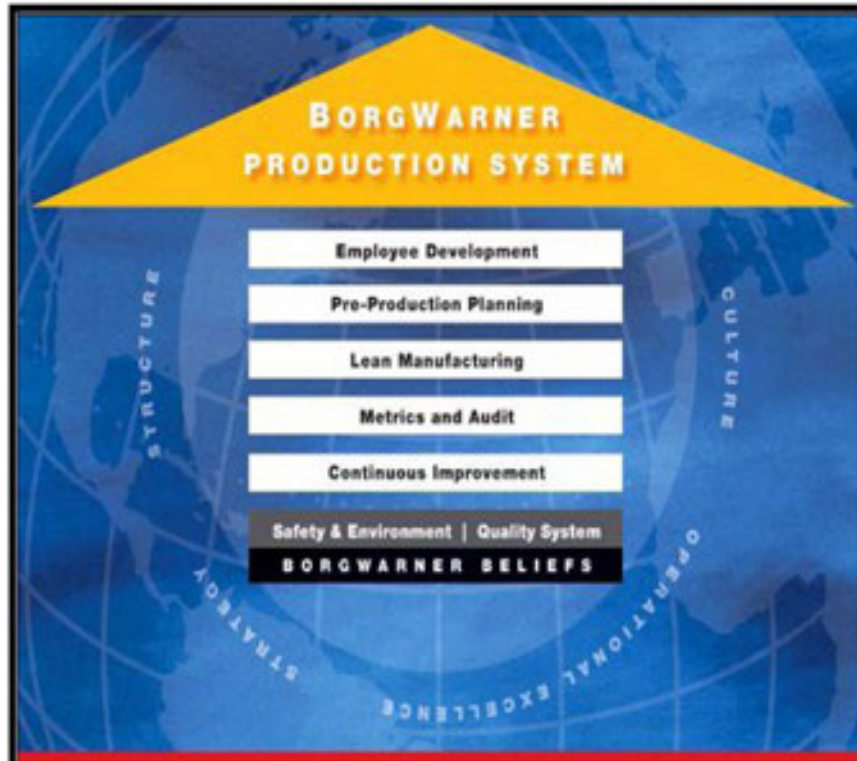


Figure 1. Seven foundational elements of the BWPS

## INTRODUCTION

The Borg Warner Production System (BWPS) was developed by the BorgWarner Inc., USA (hence referred to as 'the company) on the lines of the Toyota Production System. The team of managers at BorgWarner studied individual lean techniques, different business tools and the requirements of other quality systems extensively, designed the entire production system from its inception till its implementation, continuously revised their strategies in every field of operation and finally succeeded in putting their work together in to a business system, which came to be known as BWPS. Continuous response to the problems faced during implementation of the BWPS further refined the system. Operations have now become more adaptable and flexible. Values are defined from the perspective of the customer. Frontline workers are encouraged to improve their own processes. Therefore, lean thinking is applied in a very comprehensive way and the BWPS continues to march towards the perfection in it's every single constituent.

This document in hand discusses the implementation of BWPS at DivgiWarner Pvt. Ltd., India (hence referred as the organization) one of the BorgWarner plants based in Pune and Sirsi, India.

The BWPS aims at achieving manufacturing excellence throughout its enterprise of 64 plants worldwide, thus maintaining common goals, targets and system throughout

these firms. This system helps to minimize the consumption of resources and time, and results in maximization of return on investment and production of superior quality goods. In addition to this, the system facilitates fast, flawless launches and therefore, achieves desired results in a very systematic and scheduled way, thus satisfying the customer needs. The BWPS embraces five beliefs that unite all the production units of the company together. These beliefs are as follows:

1. Respect for each other
2. Power of collaboration
3. Passion for excellence
4. Personal integrity
5. Responsibility to our communities

The BWPS rests on seven foundational elements, supporting twenty-three tactical strategies as mentioned below. These are discussed in detail under the section 'BWPS ASSESSMENT TOOLS'.

### 1. Employee Development

- 1). Employee Empowerment
- 2). Employee Reviews
- 3). Communication

## 2. Continuous Improvement

- 4). Problem Solving
- 5). Cost Reduction Process
- 6). Develop / Protect Proprietary Process Technology
- 7). Kaizen Activities
- 8). Benchmarking

## 3. Pre-Production Planning

- 9). BW Program Management

## 4. Quality System

- 10). Warranty Analysis
- 11). Change Management
- 12). Quality Management Standards
- 13). Supplier Quality
- 14). Traceability
- 15). Quality System Basic (QSB)

## 5. Lean Manufacturing

- 16). One Piece Flow Production
- 17). Inventory Management
- 18). Pull Systems
- 19). Standardized Work
- 20). Total Preventive Maintenance
- 21). 5S / Visual Factory

## 6. Safety and Environment

- 22). Safety

## 7. Metrics and Audit

- 23). Manufacturing Metrics

## HISTORY

A corporate team of the company decoded the DNA of Toyota Production System and developed this framework in the year 2003. Earlier this framework had 44 tactical strategies to implement.

After implementation process, all the plants were audited for these 44 tactical strategies and weaknesses were identified in the framework itself. The following problems were observed by the company:

1. With more than 40 elements of the BWPS, it was observed to be as “too bulky”

2. Most of the strategies were repetitively addressed

3. Common processes and training material were not available

4. Strategic core competencies through information sharing and collaboration were not capitalized

5. Multiple page assessment criteria were defined to evaluate the implementation progress

6. Reports were not user friendly

After thorough review of the auditing results, the weaknesses were eliminated and the company re-launched the framework in 2006. Following changes were made to the previous framework:

1. Number of tactical strategies reduced from 44 to 23.

2. Multiple page assessment criteria defined to evaluate the implementation progress

3. Integrated level reports separated into the executive level and the detail level as shown in [figure 2](#) and [3](#).

4. Development of training materials for the top management as well as for the shop floor workers

## WHY ‘BWPS’

The company observed that few manufacturers had difficulties in implementing the Toyota Production System (TPS) successfully. Many of them had confusion about the tools and practices used by TPS within the system itself. They also found the rigid activities, connections and irregular production flows during the implementation of the process. Based on these findings, company customized the TPS and General Motors QSB tools to suit their manufacturing practices and operations in the form of BWPS. It covers all the key aspects of business. It has implementation guidelines and evaluation criteria rated on a scale of 0 to 5. This facilitated identification of action items to go to the next level. We can use evaluation criteria to set performance base lines, track continuous improvements, and communicate progress to pursue perfection.

## IMPLEMENTATION OF ‘BWPS’

The fundamental approach adopted for the implementation of the BWPS was by increasing employee's awareness through training session. Below mentioned three levels of training were held in the organization:

1. **Executive Training:** This training session was organized for top level managers consisting of the president, the vice president, the directors and the plant managers. The main purpose of this training was to develop basic knowledge, to broaden the support for transformation activities, to consult on vision, policy, and structure and to increase the commitment level of top management in supporting activities.

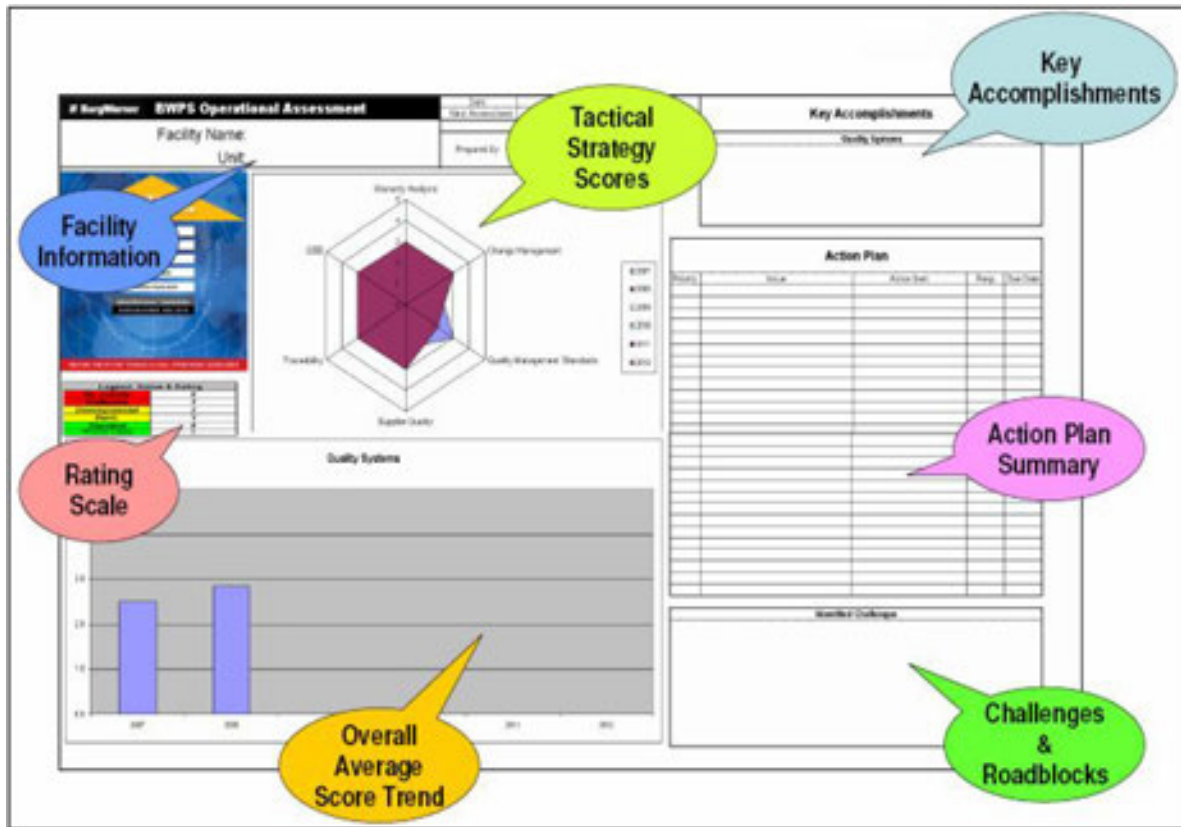


Figure 2. Integrated Reporting - Detail Level

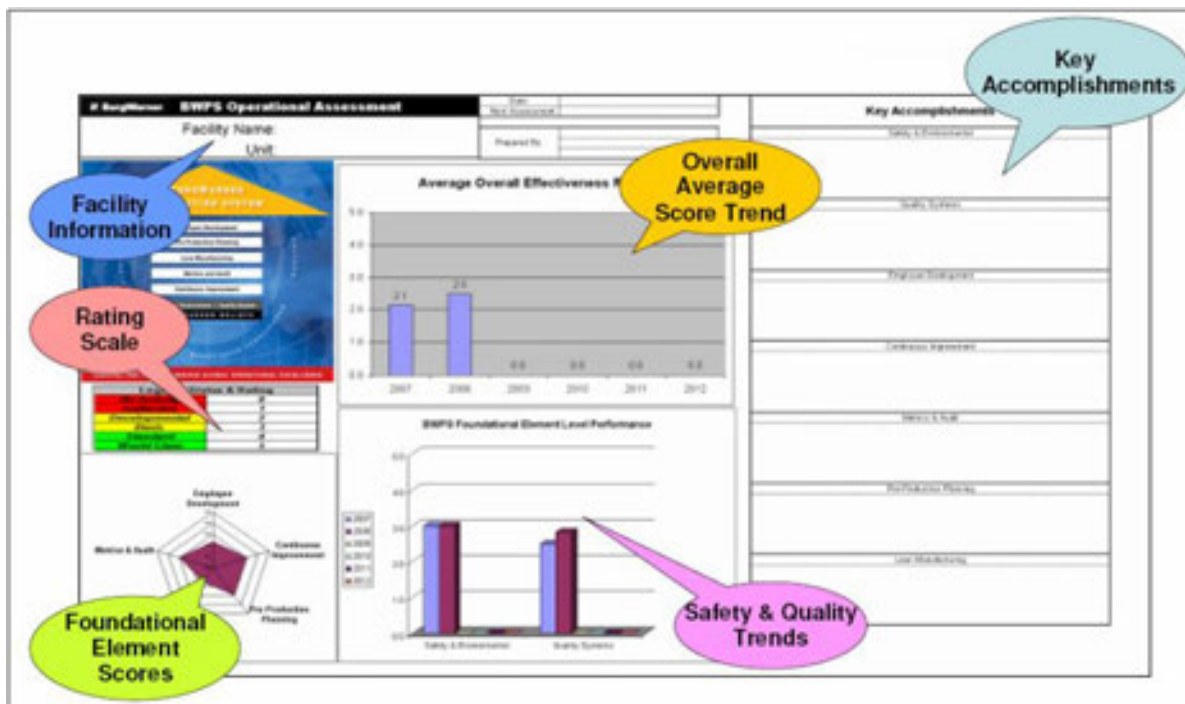


Figure 3. Integrated Reporting - Executive Level

**2. Champion Training:** This training session was organized for middle level managers consisting of the lean champions, the supervisors of different cells and the

managers of various departments. The main propose of this training was to develop internal expertise to plan, lead, manage activities, perform continuous reviews and



**Table 1. Assessment criteria for BWPS elements and strategies**

SCORE	INTERPRETATION OF THE SCORE
0	<b>No activity:</b> means the organization is not at aware of the element or there is not even a slight hint of use of the element in the firm
1	<b>Ineffective:</b> Means that the firm is aware of the element but has failed to implement it to an extent that it serves its purpose
2	<b>Developmental:</b> means the element is under implementation in the firm and is currently the concern of the top management and higher office-holders of the firm
3	<b>Basic:</b> means that the element's implementation is complete and its basics are understood by all; but the use is selective and needs further implementation in other sections of the firm to yield desirable results
4	<b>Standard:</b> means the element has started showing positive results; it is now being fully implemented, implementation is maintained and audits are tracked as an indicator
5	<b>World Class:</b> means that the element is highly recognized; goals set under it are met; consistency has set in; all the employees are well aware and have sense of responsibility in the proper implementation of the element

assessments of processes and to set new targets for continuous improvement.

**3. Workforce Training:** This training session was organized for front-line managers and employees consisting of the production operators, the quality inspectors, the material handlers and other shop floor workers. The main propose of this training was to develop end user understanding, participation, acceptance, to enhance the workers' knowledge and understanding about the new concepts and to increase awareness of BWPS among the employees.

After the completion of training sessions for all level workers, an implementation strategy was developed to plan various activities and to set the annual targets. Further, cross functional teams (CFTs) were formed to achieve the set targets as per the schedule. Weekly meetings were planned to check the progress regularly and audits were conducted monthly to evaluate the existing status. Thus, all processes were continuously reviewed and changes made on regular basis. The organization tried to close the audit findings as soon as possible so as to choose new focus areas for improvement. Sustainable program was also developed to maintain the world class status of already improved areas.

With the initial audit, present status was assessed for each element. Review meeting was called to review status and action items in each element. Since it was impractical to work on all elements simultaneously, priority elements were decided to move to upper score.

## BWPS ASSESSMENT TOOLS

Under the BorgWarner Production Systems (BWPS), there are seven foundational elements and under these elements come twenty three tactical strategies. To evaluate the level of implementation of these elements in the

organization, BorgWarner has an assessment criteria and methodology in place. This evaluation, performed once in a year, is referred to as the 'BWPS Operational Effectiveness Assessment'. The Assessment is done by a team of auditors and each tactical strategy is rated on a scale of 0 to 5, each score implying the level of strategy as shown in the table below:

Below is provided an overview of the 7 foundational elements of BWPS and the 23 tactical strategies that fall under these elements. Refer [figure 5](#) for the score sheet used for evaluation of the foundational elements and tactical strategies of BWPS.

### **Element 1: Employee development**

As the name implies, this foundational element focuses on the human resources management activities of the organization. This element ensures that the leaders embrace and promote the corporate philosophy. Three tactical strategies that fall under this element are:

**1. Employee Empowerment** This strategy focus on the level of involvement of the employees in process development, and improvement, new equipment design and approval, kaizen events and safety programs, quality improvement plans and other such activities. To ensure healthy participation of employees working at various levels of hierarchy, in these activities, the organization introduced a monthly suggestion program and scheduled weekly team meetings. Success and valuable contribution in various operations at the shop floor is recognized and awarded. Measures are taken to reduce the gap between the management and the shop floor employees. Most employees are trained in lean manufacturing and basic problem solving concepts. Different work areas are headed by various teams such as the kaizen, 5-S, safety, FMEA, preparation of standardized operator sheets. These teams consist of a team

The image shows a detailed assessment score sheet for BWPS (Business World Process Score). The table is organized into several main sections: Foundational Pillar, Scoring, Tactical Elements, and Rating Scale. The Foundational Pillar section includes categories like Business Strategy, Business Development, Continuous Improvement, and Pre-Production Planning. The Scoring section contains numerical values for each category. The Tactical Elements section lists various process elements such as Business Strategy, Business Development, Continuous Improvement, and Pre-Production Planning. The Rating Scale section provides a color-coded scale from 1 (red) to 5 (green). The Criteria section lists specific performance indicators for each tactical element. A large 'Page 1' watermark is overlaid on the center of the table.

Figure 4. BWPS Assessment tools - score sheet

head and other shop floor employees. Team leaders have authority to halt production for quality issues.

**2. Employee Review** This strategy focuses on the performance of employees. Organizational goals are set and formal training plans are scheduled for employees. Procedures are in place for annual performance reviews of employees. Under these reviews, safety and SMART (specific, measurable, achievable, realistic and timely) objectives are evaluated. To improve employee's performance and to equip him/ her with latest working practices, employee training is planned. A minimum of 80 hours of annual training per employee implies 'World Class' (score = 5) employee review.

**3. Communications** This strategy is to check that the management should not draw conclusions by just reviewing the monthly financial reports. There is proper exchange of information between the shop floor employees, middle management and the top management. Regular visits and interaction of top level managers with the root level employees helps in bridging the gap between them and aligning whole organization to the common goal. Departmental meetings are held weekly and quarterly business reviews are done with 100% participation. Employees are knowledgeable of plant developments and are not afraid to voice their ideas. Short meetings are held at the start of the shift. Communication boards are updated weekly with action items being addressed.

### Element 2: Continuous improvement

Continuous improvement is very important to bring out quality in work and to achieve growth. This element ensures that the organization optimizes its resources whether human or material and focuses on year on year improvement in key

result areas, systems and processes. Five tactical strategies fall under this element. These are as discussed below:

**4. Problem Solving** Problems provide an opportunity to avoid the recurrence of similar events. There are two types of problem solving methods: one is proactive, where problems are anticipated in advance and solved before they arise; the other is reactive, where problems are solved once they come into existence. The organization utilizes proactive and reactive approaches across multiple functions to solve the problems. For this purpose, different tools are used such as why-why, DOE, fishbone diagram, FMEA, & 7 Quality Control (QC) tools. Six Sigma DMAIC approach is used proactively and reactively for breakthrough projects and 8D problem solving approach is used for systematic documentation and communication. This strategy aims at building the culture of proactive problem solving using Six Sigma DMAIC approach. Engineers and technicians are trained on Six Sigma Green belts and Black belts so that they can effectively utilize DMAIC approach. Results of projects and solutions to problems are shared with rest of the company.

**5. Cost Reduction Process** It is very important to provide quality products to the end users at such a cost that no other production stands in competition. Minor changes/ activities can bring down the expenses considerably. Thus, cost reduction process becomes very important for an organization. Cost reduction goals are set followed by weekly cross functional; activities are coordinated to a cohesive plan. Organizational goals cascade to create targets for departmental continuous improvement activities. Savings contributions are made from all functions internally. Plant consistently meets annual cost reduction goals.

**6. Develop/ Protect Proprietary Process Technology** It involves great deal of resources to develop new processes and

products. Their protection thus becomes very important, at least till the point, invention disclosures are submitted and 'trade secrets' or 'patents' awarded for development work. Organization has effective systems to protect proprietary processes. Invention disclosures are submitted only when processes are developed and improved. Engineers are trained on developing and protecting proprietary processes. Non Disclosure Agreement is made with the customer and the supplier made for the same.

**7. Kaizen Activities** Kaizen activity is continual through events and team activities. Specific improvement goals are established keeping customer in focus. This strategy ensures that the waste elimination and lean manufacturing training is given to all employees. Value stream mapping is one of the useful lean tool which helps to identify Kaizen opportunities. Kaizen strategy expects more than 4 Kaizen workshops per year i.e. at least 4 large breakthrough project per year. Tasks are performed consistently to achieve improvement in throughput, lead time, and value added content. Methodology is embraced and understood by majority. Departmental area teams identify opportunities and also conduct workshops. Activities are less than 15% management directed.

**8. Benchmarking** Benchmarking is important in that it helps the organization to gauge their increment or decrement of certain parameters. The organization has a Benchmarking procedure documented. The management identifies improvement areas and actively seeks out benchmarks as a part of project plans. The unit actively identifies Best Practices and Lessons Learned with other facilities to improve their operational efficiency. Multiple examples of organization influence benchmarks to improve operations.

### ***Element 3: Pre production planning***

Planning is the first activity that is discussed, documented and then implemented once a new idea is conceived and to be put into action. The organization believes that 'it is better to spend a little extra time during the upstream process so that the downstream processes are free from errors'. Pre production planning is one of the foremost steps towards new product development.

**9. BW Program Management** New product development is initiated in a very systematic way. Weekly cross-functional team meetings are held and action items are assigned. In addition to this, monthly financial reviews are held to review contract and obstacles. EOT (Executive Over site Team) reviews are conducted quarterly depending on program size/scope. Advanced Product Quality Planning (APQP) meetings are held weekly while Product Failure Mode and Effect Analysis (PFMEA) are scheduled regularly. Ongoing changes and issues are discussed and resolved. Launch readiness and performance issues are reviewed and addressed to ensure no interruption for customer at launch.

### ***Element 4: Quality systems***

The intent of Quality Systems is to develop systems and processes to deliver quality products and provide hassle free

experience to the customer. There are six tactical strategies that help the organization to achieve world class quality practices. We discuss these strategies briefly below:

**10. Warranty Analysis** Warranty Analysis system helps to monitor and improve warranty performance. The system demonstrates effectiveness through the measurement of warranty return level performance. The organization uses advanced statistical tools for improvements to new and existing product by measuring warranty performance to identify product and process needs. Related activities are implemented in Design, Supply Chain and Manufacturing areas.

**11. Change Management** Managing engineering changes in design and drawing is very important for an organization. In this regard, all engineers in the plant are trained on Change Management procedures. Weekly meetings are held with participation of people from various departments of the organization like Engineering, Manufacturing Engineering, Supply Chain Management, Quality, Manufacturing etc. The change management process puts a check that no customer incidence occurs due to failure to follow change management procedure.

**12. Quality Management Standards** The organization has a thoroughly documented quality system to maintain its standards. The Quality System is well understood and followed throughout the plant. Layered Process Audit is scheduled and performed on monthly basis. Customer metrics and balanced scorecard (BSC) demonstrate that the quality expectations are clearly surpassed. The organization has recorded 'Zero non conformances' in last 3 surveillance audits of TS- 16959.

**13. Supplier Quality** Committed supplier chain is an integral part of the whole process. The intent of supply chain management is to utilize systems and processes to develop, monitor and control supplier's quality and delivery standards. The organization has a Supplier Manual so that the quality expectations are met by all suppliers. Suppliers and organization have developed close relationship to ensure 100% APQP compliance, on-time Production Part Approval Process (PPAP), zero launch issues and minimal on-going quality and delivery issues.

**14. Traceability** To meet customer requirement, it is important to have formalized traceability systems in place. The organization has the ability to trace component, assembly data, supplier and raw material with no gaps in system. Parts shipped to customer can be traced to unique serial number, manufacturing date and operator, electronically. Effectiveness is demonstrated in all such processes.

**15. Quality Systems Basics (QSB)** Quality System Basics, (QSB) is a set of initiatives meant to reinforce the current quality management system. QSB consists of 10 fundamental but very powerful elements which help to deliver world-class quality products. QSB was, first of all,



developed by the General Motors and it is mandatory to implement these tools by GM's entire supplier base. BorgWarner has customized these elements and incorporated in BWPS. The organization conducts workshops share QSB practices with its supply base. QSB elements are discussed in detail under the section 'IMPLEMENTATION OF BWPS - CASE STUDIES' of this document.

### **Element 5: Lean manufacturing**

The primary objective of lean manufacturing is to improve company's operations and become more competitive by implementing different lean manufacturing tools and techniques. Lean manufacturing means "A systematic approach of identifying and eliminating waste through continuous improvement". There are six tactical strategies in BWPS that focus on the implementation of Lean Manufacturing.

**16. One-piece flow production** Single piece flow production controls work in process inventories and helps in reducing working capital. Normal tendency in the industry is to produce big production lots to avoid frequent setups. One piece flow production technique uses Single minute exchange of dies i.e. SMED tool to reduce setup times, thus helps produce smaller batches in short intervals. Smooth flow of material always results in better efficiency and output. To ensure this, the organization uses First-In-First-Out (FIFO) system with visual color codes followed in stores and machine shops. Change over (setup) time has been reduced to less than 20% of available time. Line balance is matched to multiple takt times. Value Stream Mapping (VSM) of critical parts is done with utmost care. Significant reduction of more than 50% in process lead time has been achieved.

**17. Inventory Management** One of the important resources with the organization is its inventory. Its management is important for that either its excess or deficit can be a source of loss to the organization. Therefore, the organization has buffer and safety stock areas controlled to match standard levels. Limited stock is available at the cells. Stock is controlled to clear standard levels. Visual Kanban system is used to reduce inventory levels Buffer and safety stocks are managed to an extent that can absorb minor changes in customer volume easily.

**18. Pull Systems** Pull systems are used to manage inventory and operations. It stocks smaller amounts relatively and is frequently replenished with the help of visual Kanban system. It is to be noted that the Kanban card is used for signaling between the customer and the supplier. The organization performs standardized work in material handling. Only parts and finished good being worked on are present at a particular cell. One for one flow is practiced. One scheduling point is driven by pacemaker process, pull flow, and sequence changes typical during production.

**19. Standardized Work** Standardize Work is a systematic approach to maintain workplace activities in an organized

manner and to employ best methods to perform an existing operation by forming multi-disciplinary teams. Work standardization saves time, helps operators and also ensures uniformity in all the processes. Towards this end, the organization has well-documented Standard Operations Sheet (SOS), Job Element Sheet and other related sheets of information is place for various processes. To ensure that these work instructions are updated and followed, a layered process audit exists which includes all management levels. Operator licensing process ensures that the operator is fully aware for the process before he is actually going to perform his work. Adherence to standard work is, thus monitored and actions taken to make corrections and improvements.

**20. Total Productive Maintenance (TPM)** Maintenance of equipment is crucial so that as and when it is required; the equipment should be in its best working condition. The organization has the Maintenance Department to look after these issues but it is the collective responsibility of all the employees to ensuring proper functioning of the equipment used by them. The organization makes use of Total Productive Maintenance (TPM) and Overall Equipment Effectiveness (OEE) to improve equipment design and to avoid unplanned maintenance. Formal operator certification is done in this regard. On-going evaluation of maintenance is done and procedures and resource effectiveness is in place. Root cause is determined for major problems. Predictive Maintenance is also implemented.

**21. 5S/ Visual Factory** The organization follows the principle of 5S. Work stations are organized and standardized for WIP, in-out arrangement, defined place for tooling, gauges, inspection, visual work instructions and rework-reject parts. Monthly 5S audits are conducted in all areas and non conformances are tracked till closure. The organization has achieved Level 5 in visual management. Color codes, shadow board and visual displays are commonly used. House keeping and visual controls are in place. Strong ownership is given to employees to maintain the discipline of 5S and responsibility for each area is defined.

### **Element 6: Safety and environmental**

Realizing that natural resources are limited, it is important to consider environmental protection to be consistent with the organization's overall goals and values. Safety and environment issues form one of the foundational elements on which the organization rests. Therefore the programs and processes are designed to make optimum consumption of resources; making best efforts to save energy, minimize environmental pollution and prevent accidents. The organization has a well documented Environment, Health and Safety Policy (EHS) in place which is communicated to all the employees and is inculcated in to the culture of the organization.

**22. Safety** The organization implements safe work practices to avoid any accidents. The Global Star Safety Framework (GSSF) is followed and all employees are trained in this



regard. The Global Star Safety Framework audit is carried out to meet the safety standards. This strategy also ensures that the plant has achieved Certification for the latest recognized environmental standard.

### Element 7: Metrics and audit

The organization sets goals and targets annually. These are further broken down into stages and tasks headed by various teams/ team leaders. To gauge the completion of these tasks and goals, metrics is employed. Metrics presents a mosaic of various parameters giving an overview as to what extent the organization's goals are achieved. And to put a check on the processes involved, audits are conducted weekly, monthly and sometimes, regularly depending on the seriousness and time frame of the goal. The internal audits serve as a feedback mechanism by highlighting the changes and additions required and implementing the same. Thus, metrics and audit are understood as one the foundational elements of the BWPS.

**23. Manufacturing Metrics** Organizational Balanced Score Card (BSC) that consists of key result areas of the organization is displayed throughout the facility and reviewed monthly. Red-yellow items are monitored to improve BCS performance. Main BSC is further divided into department level scorecards and used to monitor departmental Key Result Areas (KRAs). BSC provides inputs for KAIZEN events. Monthly BSC performance is shared with all employees.

## IMPLEMENTATION OF BWPS - CASE STUDIES

The organization has implemented BWPS and continuous success has been achieved in the all functional elements. Improvement has been made in all the areas. Below we discuss five case studies on different elements to highlight the importance and fruitful results of the BWPS application.

### Case Study 1: Suggestion Scheme for Employee Empowerment

'Employee Empowerment' comes under the 'Employee Development' element of the BWPS. Suggestion scheme is a very important and popular feature of the organization. To empower the employees and to improve employees' participation, the organization introduced suggestion scheme program in the year 2007. Initially the response of employees was poor because of lack of interest and awareness among them. Efforts were made by the top management of the organization so as to boost their employees' confidence and morale with regard to the scheme. Suggestions are reviewed during daily Fast Response Meetings (FRM) on the shop floor. In these meetings, the receipt of every suggestion is acknowledged. Also, responsibilities are assigned to the concerned personnel for implementation of the suggested changes and review is done in the next FRM meeting. Suggestions are categorized into four main groups.

1. **Accepted:** The suggestion has been recognized as feasible and productive.
2. **In Progress:** The suggestion is being executed
3. **Implemented:** The suggestion has been executed.
4. **On Hold:** The suggestion is not feasible at the moment.

Monthly, a theme is decided and communicated to all to give their suggestions on that theme of the month. Themes covered till now include quality, safety, productivity, employee satisfaction, cost reduction and the like. The organization tracks down the number of suggestion received daily to get the daily employee response. At the end of each month, suggestions are reviewed by a kaizen team and a 'Monthly Suggestion Awards' ceremony is organized. This implementation criterion is based on the suggestion quality effectiveness, cost saving, innovative changes, waste reduction, and safety and 5S implementation.



Figure 5. Monthly Suggestion Awards being distributed

ALL IDEAS MATTER				
DWPL SUGGESTION SCHEME				
LOCATION	PREVIOUS MONTH'S SUGGESTION RECEIVED	NO OF SUGGESTION RECEIVED YESTERDAY	CUMULATIVE FOR THE MONTH	CUMULATIVE FOR THE YEAR
BHOSARI	80	5	66	231
SIRSI	75	3	85	239
TOTAL	155	8	151	463
BEST SUGGESTOR OF THE MONTH			1) Mr. D. P. Patil 2) Mr. Imran Khan 3) Mr. G. R. Ramesh	

Figure 6. Daily Suggestion Tracking Board

Track records of number of suggestions implemented through suggestion scheme are analyzed by the organization. This helps to monitor implementation progress.

**Table 2. Data for the suggestions received and implemented in the year 2011**

<b>KAIZEN THROUGH SUGGESTION – 2011</b>		
<b>Month</b>	<b>Total Suggestions Received</b>	<b>Suggestions Implemented</b>
<b>Jan-11</b>	63	33
<b>Feb-11</b>	24	12
<b>Mar-11</b>	41	22
<b>Apr-11</b>	29	18
<b>May-11</b>	20	12
<b>Jun-11</b>	68	46
<b>Jul-11</b>	93	44
<b>Aug-11</b>	66	19
<b>Sep-11</b>	75	28
<b>Oct-11</b>	25	6
<b>Nov-11</b>	59	17
<b>Dec-11</b>	110	36
<b>Total</b>	<b>673</b>	<b>293</b>

### ***Suggestion implementation process***

1. Employees drop their suggestions in the suggestions box which are kept at various locations at the organization's premises.
2. Everyday these suggestions are collected and reviewed in the Fast Response Meeting
3. All suggestions are reviewed again at the end of the month by the team and the best three suggestions are recognized and awarded.
4. All the accepted suggestions are adopted by the kaizen team for implementation.
5. Status of the implementation is communicated to the team and the person who made the suggestion.
6. The trend of suggestions received and implemented is reviewed in monthly management review meetings.

The organization always tries to implement suggestion to the complete extent. One of the recently implemented suggestions in the organization is the installation of fine lead screw for dress cutting operation on cylindrical grinding machine at Flange Companion (FC) cell. Suggestion to prevent the problem of undersized ground diameter was given by an employee. A cross functional team (CFT) was formed and a list of action items was prepared to implement the suggestion systematically. Brief description on step by step approach is given in the figure below. Also, refer [appendix 2](#) in this regard.

Similarly, more than 300 kaizen projects were implemented every year and the organization gets benefited through this suggestion scheme in various areas such as productivity, quality and cost.

### **Case Study 2: Quality System Basics (QSB)**

‘Quality System Basics’ comes under the ‘Quality System’ foundational element of the BWPS. It comprises a set of initiatives meant to reinforce the current management system. It does not replace the existing system but is intended to strengthen it.

At the organization under discussion, QSB is being implemented since 2007 as a part of BorgWarner Production System. Initially Mr. Bill O'Hara, BorgWarner Quality Consultant trained all the key personnel including operators. This mission was further taken up by members of both the plants of the organization under the guidance of BWPS coordinator. Using systematic planning, all the elements were successfully implemented.

Initially, regular feedback was taken in weekly meetings and after stabilizing, review is taken in monthly management meetings to verify the effectiveness. After nearly five years of successful implementation, QSB has become an important ingredient of the plant culture. The organization has also started to train its suppliers and demonstrates how these tools are used on the shop floor. The benefits achieved through QSB are: reduced customer complaints, fast response to the problem and proactive risk reduction.

<p>Name - P.M.Jarande                  Company Name: Divgi Warner Pvt. Ltd                  Department - Machine Shop                  Location - Pune                  Immediate superior (Name &amp; email) - R.R.Sharma                  rrsharma@divgi-warner.com</p>	<p><b>Kaizen theme/ title - Ground diameter undersize</b>  <b>Problem/ Present status - 2 Incident (Till Aug-10)</b>  <b>Target/ Benchmark - 0 incidences (Sept-'10)</b></p>
<p><b>Analysis -</b>                  a) Ground diameter undersize on cylindrical grinding m/c after dressing.                  b) In present method - Dresser unit is fixed, set diameter size to be disturbed manually by rotating table wheel for wheel dressing.                  c) After dressing, grinding wheel needs to take backward by 0.3 mm (operator dependent ). But if fails to take wheel backward &amp; start the cycle, part gets undersize.</p>	<p><b>Team members -</b>                  1. R.R.Sharma ( Mfg)                  2. P.M.Jarande ( Prod'n)                  3. G.R.Ronimath (QA)                  4. V.H.Phule ( Manit.)</p> <p><b>Start date - 10.08.10</b>  <b>End date - 26.08.10</b></p>
<p><b>Action -</b>                  1) Dresser unit made moveable with fine lead screw &amp; circular scale, also dressing method modified.                  2) Now no need to disturb the table wheel during dressing                  3) After dressing, first part comes with in specification.</p>	<p><b>Results - No parts reported after 27.08.2010</b>  <b>Effectiveness under monitoring</b></p>

Figure 7. Suggestion analysis and action items

There are ten key elements covered in QSB as mentioned below:

1. Fast Response Meeting
2. Control of Non-Conforming Product
3. Error Proofing Verification
4. Layered Process Audits
5. RPN Risk Reduction
6. Standardized Operations
  - Standardized Work Instructions - SOS
  - Operator Instructions - JES
7. Standardized Operator Training
8. Contamination Control
9. Supply Chain Management
10. Verification Station

Let us discuss these elements one by one.

**1. Fast Response Meeting:** Every day begins with a Fast response quality meeting, held at 9 a.m. sharp. The purpose of this meeting is to communicate the significant quality issues arising in the past 24 hours and assign ownership for resolution. A typical agenda of this meeting includes -

- Safety and Environmental issues
- Report on containment or corrective actions of Quality issues in last 24 hours

- Delivery Review
- Production Review
- Review of Key Metrics

Cross functional team from various functions like Manufacturing, Quality, Maintenance, Stores, Manufacturing Engineering, Supply chain, Sales and Customer Support attend this meeting. This meeting utilizes a visual method of displaying important information. It assures all issues are resolved and daily quality status is displayed.

**2. Control of Non-Conforming Product:** The intent of this initiative is to isolate non-conforming parts i.e. reject and rework and to reduce the risk of shipping them with conforming parts. Whenever operator finds out-of-specification parts, he identifies the parts with appropriate tag and color like red for rejects, yellow for rework and white for review. After that he keeps the parts in red color bin provided at each workstation. These parts are further reviewed by cross functional team after fast response meeting and appropriate decisions are taken. The respective documents like defect tracking sheet, Failure Mode and Effect Analysis (FMEA), Control Plan, Layered Process Audit (LPA) are updated. Typical benefits earned from the control of non-conforming parts are:

- 1). It assures all suspect and non-conforming products are contained
- 2). Reduces repetitive quality disruptions and increases customer satisfaction.



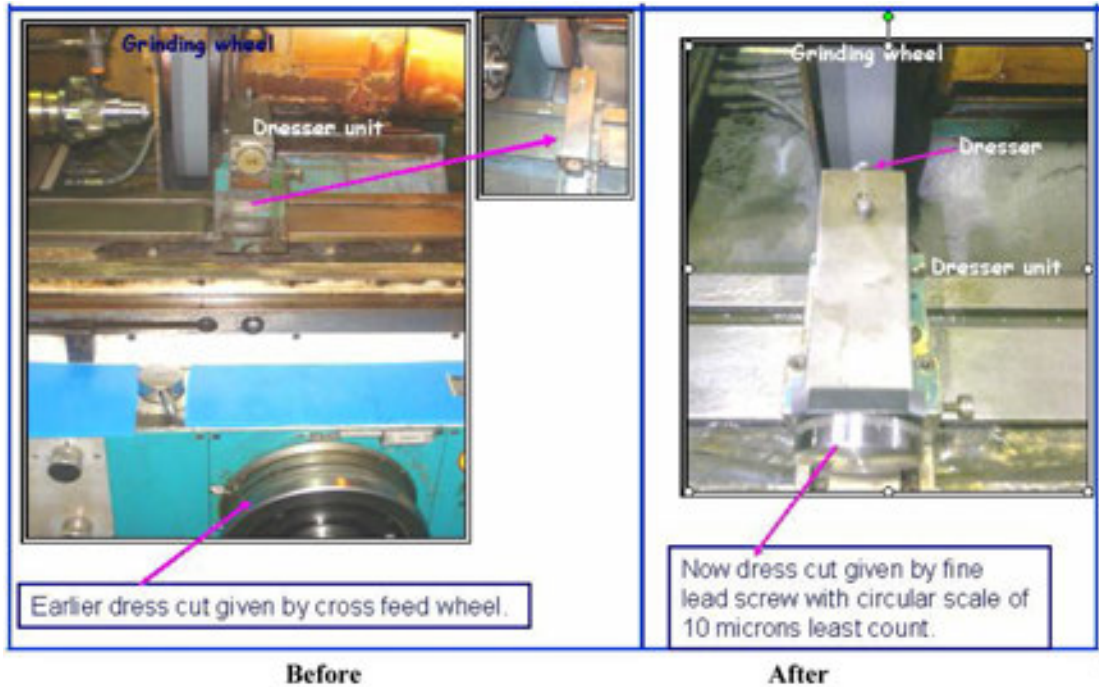


Figure 8. Implemented Suggestion

Fast Response Meeting - Tracking Board

SAFETY & QUALITY REVIEW

PRODUCTION STATUS

CONCERNS

Figure 9. Daily Fast Response Meeting Board

**3. Error Proofing Verification:** The assembly supervisor verifies the Error proofing devices once per shift to ensure that the error proofing devices are functioning correctly. An efficient method to verify error proofing devices working is to use no good masters for verification. No good masters are purposely used on the machine and if a machine detects the no good master then it assures that error proofing detection

devices are working as intended. After completion of error proofing verification, records are updated. It prevents nonconforming product from being made or transferred to customer.

**4. Layered Process Audits:** The most important elements of Quality & safety are verified every shift; by different layers in the organization. This includes:





Figure 10. Control of Non Conforming Product



Figure 11. Non Conforming Product Area

- Verification of job safety elements & corrective actions of past quality issues
- Verify whether the Gauges are calibrated, are working in order and are being used correctly
- Daily preventive maintenance performed
- 5's & workplace organization maintained properly
- Certified operator is operating the machine

◦ Operator is working as per standard work instructions  
Layered process has several benefits, It Adds integrity to the process. It gives confidence to the individual. It serves as an Excellent training aid for Operators, Supervisors, Engineers and Managers

**5. Risk Reduction:** - The goal of this initiative is to proactively reduce the risk of a potential quality failure. The

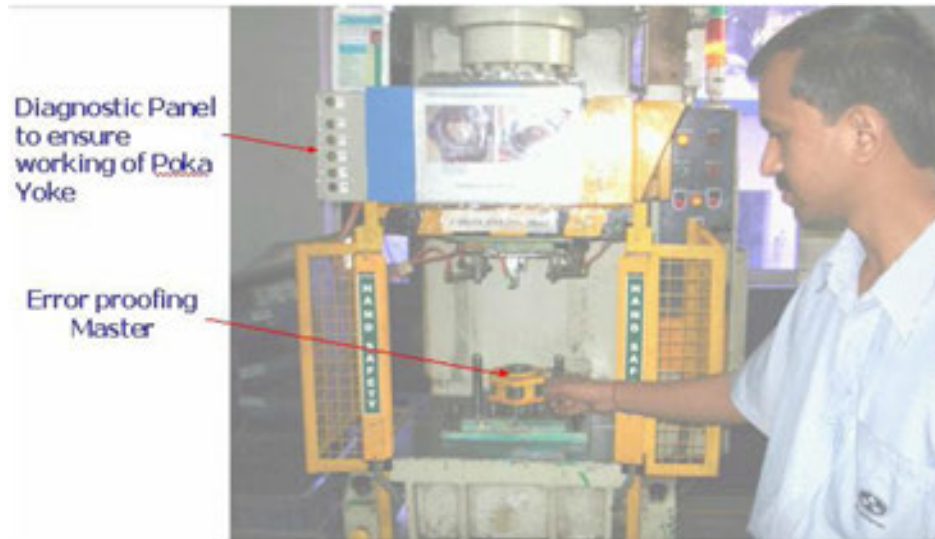


Figure 12. Error Proofing Verification



Figure 13. Layered Process Audit on Shop Floor

organization conducts weekly FMEA meetings where cross functional team reviews Process Failure Mode and Effect Analysis (PFMEAs) and a list of high risk priority numbers and risk reduction opportunities are established. Actions are planned to reduce risk priority numbers and their progress is tracked. It entails several benefits, provides support for continual improvement as expected by TS-16949, allows leadership to allocate appropriate resources to critical areas, and provides an effective basis for error-proofing and problem solving.

**6. Standardized Operation:** The organization follows a systematic approach to maintain workplace organization and prepare the best method to perform an existing operation using multi-disciplinary teams. The organization has organized every workplace to reduce wastes in processes and improve ergonomics. Typical work centre consists of a neat

and clean machine setup with separate in and out arrangement to avoid mix-up of the parts, separate areas for displaying important documents such as Manufacturing Process Layout (MPL), Standardized Operation Sheet (SOS), Job Element Sheet (JES) and work instructions.

**7. Standardized Operator Training:** Standardized operator training procedure assures that all the operators have adequate and similar training. The training program starts with safety and quality policy of the organization. After this, the operator undergoes through a systematic training which includes classroom and 'on the job' training for 3 days. Classroom training includes a standardized training module especially developed for new operators which includes understanding of documents like standard operation sheet, control plan. Then a written and practical examination is conducted to evaluate that operator and if he qualifies in



Figure 14. Standardized Operation Display Board

written and practical examination a license is issued to him and skill matrix is updated. After issuing the license, the operator is monitored in daily layered process audits.

Divgi Warner Pvt Ltd					
Operator License					
Name : M.M.KUCHEKAR					
Dept : Manufacturing					
Work :CNC Grinding Shop					
Cell : Machine Shop					
DOB : 15.08.2005					
Sl. #	Operation	Learner / Skilled			
		I	L	U	O
1	Vertical Machining Center	✓			
2	Turning Center				
3	CNC Grinding	✓			
4	Micromatic Grinding	✓			
5	Welding				
6	Leak Test				
7	Deburring				
8	General work & Inspection				

Figure 15. Operator License

**8. Contamination Control:** The intent of Contamination control is to have contamination well within the specified limits on the parts. Contamination control avoids product failure due to sediments like dirt, foreign materials and extra parts such as extra fasteners. The organization's contamination control initiatives include:

- Washing parts before assembly
- Using of hand gloves while handling parts
- Storing and moving parts in clean trays

- Monitoring washing fluid change frequency as per quality control plan.
- Monitoring cleanliness of assembly and packaging area.
- Conducting regularly contamination checks on product and its child parts Contamination Test results show the organization is well within the limits.

**9. Supply Chain Management:** - The intent of supply chain management is to utilize systems and processes to develop, monitor and control supplier's quality and delivery standards. For this, monthly quality and delivery rating of suppliers is monitored and a monthly scorecard along with defect tracking sheet is issued to the supplier. The organization also organizes yearly supplier meet and top three suppliers are recognized according to their performance in terms of quality, delivery and value improvement as per the rolling average scores. Organization extends different training programs to improve key personnel at supplier end. There are planned audits at supplier end to ensure quality practices specified are followed. Supplier APQP plays a vital role in development of quality products at supplier end.

**10. Verification Station:** Verification station protects customer from non-conforming product and discrepancies. On Verification station all outgoing parts are verified for quality key parameters, just before the part reaches the next station. Typically such stations are used where there are recurring problems, highest risk priority number and process capability below 1.33. Each product is therefore checked at verification station.

- This incorporates 100% inspection
- Immediate actions are initiated whenever defects reach an alarming limit





**Figure 16. Annual Supplier Conference**



**Figure 17. Verification Station Board on Ford J97 Assembly Line**

- Information board is placed near every verification station. Quality System Basics tools helped organization to bring down customer PPM and customer complaints. Typical benefits of QSB are discussed in “Competitive Advantages of BWPS” section of this paper.

### Case Study 3: Standardized Work

The tactical strategy ‘Standardized Work’ comes under the ‘Lean Manufacturing’ foundational element of the BWPS. ‘Standardized work’ is systematic approach to maintain workplace organization & prepare the best method to perform an existing operation using multi-disciplinary teams. The

principles of lean do not work well if everyone is allowed to choose their own work method or work sequence to do a job, since this reduces throughput and develops unanticipated outcomes. Without standardized work, continuous improvement activities are not manageable because any improvement will be just one more variation that is occasionally used and often ignored. Furthermore, standardized work makes abnormalities visible. Absolute understanding of the steps needed to be taken to complete tasks is necessary to eliminate root causes of variability and permanently resolve issues. Therefore, standardized work provides the baseline required for continuous improvement.



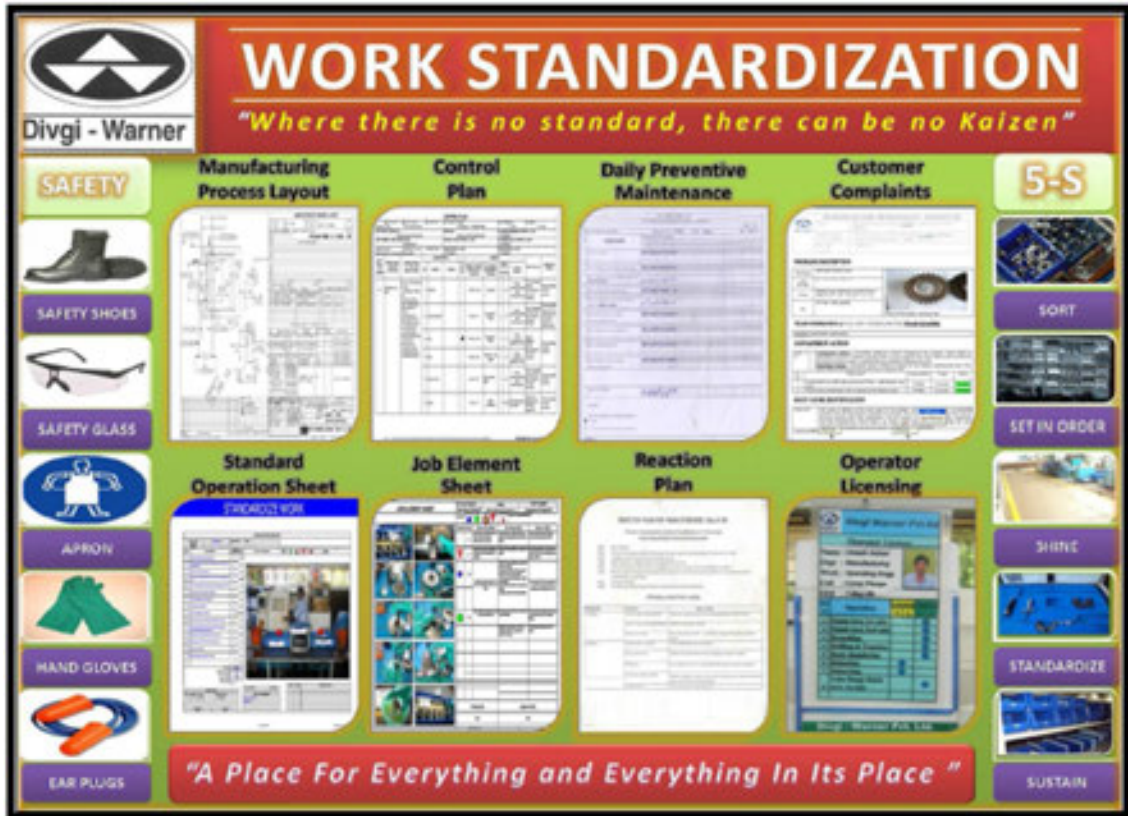


Figure 18. Work Standardization

The organization makes efforts to ensure that work standardization is maintained and methods are employed to standardize an existing operation using CFTs. Steps are taken to organize every workstation, to reduce wastes in processes and to improve ergonomics. Typical workstation consists of a neat and clean machine setup with separate in-and-out arrangement to avoid mix-up of the parts and separate areas for display of important documents.

At each workstation, the organization has displayed a Manufacturing Process Layout (MPL), Standardized Operation Sheet (SOS), Job Element Sheet (JES) and work instructions for every operation; these sheets include:

- Work Sequence (number of steps)
- Takt Time
- Cycle time
- In-Process Stock (Minimum Stock Quantities)
- Job flow and Work Place Organization

Display of these documents delivers following benefits to the organization:

- Summary of the current best method
- Visual control tool
- Basis for problem solving

- Visibility of the waste in a process
- Training tool to instruct new team members

## COMPETITIVE ADVANTAGES ACHIEVED

BWPS delivered following competitive advantages to the organization. We will highlight some of the key achievements under each foundational element.

### 1. Employee Development:

- Employee participation in suggestion scheme reached 43%
- Continual improvement - more than 300 kaizen projects implemented every year
- Shop floor employees are involved in the activities of process development and new equipment design
- Training hours increased from 36 hour to 80 hours per employee per year
- Employees articles regularly published in monthly company bulletin 'Innovation Times'
- Employee participation in problem solving is increased which in turn helped to improve quality

STANDARD OPERATION SHEET					
GROUP / TEAM		PROCESS NAME: Input Shaft TATA OD Grinding			
OPERATION NAME / #		PART NAME: Input Shaft TATA			
JOB ELEMENTS		ELEMENT TIME		WORK FLOW DIAGRAM	
1	Open the door with left hand	2			
2	Remove part with mandrel from machine & put it on table	8			
3	Clean the center of machine	11			
4	Load next part in machine.	75			
5	Close the door & cycle start	4			
6	Machining cycle		85		
7	Loose mandrel by 23mm spanner, remove part from mandrel & put it on table	75			
8	Clean the mandrel by cotton.	4			
9	Take part from "IN" tray	4			
10	Verification for job. Identification groove at face for M&M at the center clean part ID by cotton	7			
11	Put it in mandrel & tight by 23mm spanner	7			
12	Apply grease at both center of mandrel to keep ready for next cycle	7			
13	Apply R.P.O. Oil VCI-415 to grounded part.	8			
14	Put the part in "OUT" tray	4			
SET TIME		Sec of job	50	55	
CYCLE TIME		Sec of job	50		
		HANDWORK + WALK TIME	15		
		WIP-IN-CYCLE TIME	195		
		TOTAL CYCLE TIME			
		PARTS PER CYCLE	1		
INITIAL BLOCK		REV. DATE:	J.E.S. LOCATION: FORK STATION		Freq. Time
Signatures		INCIDENTAL WORK		110	54
Team Leader		SAFETY REQUIREMENTS		105	25
R.N.Mohite		Head gloves		120	Surface finish on OD 41.32 checking (1.1/100K)
Spring Leader		Safety Shoes		120	Surface finish on OD 41.32 checking (0.2/0.1/1mm)
Y.H.Yemala				120	SAFETY OF FORK LIFTING

Figure 19. Standard Operation Sheet

JOB ELEMENT SHEET				Sta# - Rev#	
Element Names		Option: <input type="radio"/> Basic: <input checked="" type="radio"/>		Grinding Machines	
Input Shaft TATA Grinding		Symbol:	Written by: THT		
Symbol	Step #	Major Step (What)	Key Point (How)	Reason (Why)	
	3	Close the machine center	With Right hand	To avoid runout & ovality on OD on produced part.	
	9	Take part from "IN" tray & clean ID	With right hand & clean it by using cotton	To avoid mix up of machined & non machined parts.	
	10	Verification for identification groove	Visually	To avoid mix up for Tuts & MM	
	12	Close the center & apply grease on both side	Center close by cotton & Grease with Right hand	To avoid runout & ovality on OD from produced part & grease on both side to avoid center damage due to heat generation during grinding near center.	
	13	Apply R.P.O. Oil	Dip the job in VCI-415 R.P.O. as shows in figure.	If not done, rust may occur in future.	
	14	Put part from "OUT" tray	Put the job in Right out tray	To avoid mix up of machined & non machined parts.	

Figure 20. Job Element Sheet

◦ Communication helped to reduce the gap between top management and shop floor employees. Effective and timely communication aligned all the employees to the organizational goals.

## 2. Quality Systems:

- Customer PPM reduced from 675 to 122
- In-house PPM reduced from 1201 to 189

- Supplier PPM reduced from 2996 to 1240
- Zero warranty complaints and field returns

### 3. Continuous Improvement :

- More than 4 major six sigma projects are completed every year
- More than 300 kaizen projects done by the operating employees every year
- Minimum 4 benchmarking trips completed annually

### 4. Pre Production Planning:

- Flawless and on time launch of new products
- Zero launch issues to customer (Quality and Delivery)
- APQP process is followed for new product development

### 5. Safety and Environment :

- “Zero” safety incidences since 2007
- Achieved ISO-14001 certification
- Implementation of Global Star Safety Framework
- Water and Electricity saving projects completed successfully

### 6. Lean Manufacturing :

- Inventory Turn Over Ratio (ITOR) increased from 4.8 to 10.1
- Material movement in the plant reduced by 68%
- Overall Equipment Effectiveness increased from 41% to 82.9%
- Overall Setup time reduced by 66%

### 7. Metrics and Audits :

- Organizational Key Performance Indicators (KPI's) are tracked through balanced score card
- Balanced Score Card is reviewed every month and actions are taken to achieve organizational targets.

## CONCLUSION

BWPS is observed to be an ideal system to achieve operational excellence throughout the enterprise. It helps to build culture of continuous improvement. This paper provides industrial insight and experience of BWPS implementation, which can be applied to implement similar production systems.

This framework provides different tools and techniques to improve organizational effectiveness. It is evident from the above mentioned competitive advantages that the

BorgWarner Production System can yield several benefits to the organization when appropriately applied.

Objective benefits achieved from this system can be summarized as

- “Zero” safety incidences
- Customer PPM reduced from 675 to 122
- 100% On Time Delivery to customers
- Continual improvement - more than 300 kaizen projects implemented every year
- Overall Equipment Effectiveness increased from 41% to 82.9%
- Inventory Turn Over Ratio (ITOR) increased from 4.8 to 10.1
- Material movement in the plant reduced by 68%

This paper also shows how to set performance base lines, track continuous improvements, and communicate progress to pursue perfection.

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## ABBREVIATIONS

**BWPS** - BorgWarner Production System  
**TPS** - Toyota Production System  
**ITOR** - Inventory Turn over Ratio  
**QSB** - Quality System Basics

**CFT** - Cross Functional Team

**FMEA** - Failure Mode & Effect Analysis

**APQP** - Advanced Product Quality Planning

**FRM** - Fast Response Meeting

**GSSF** - Global Star Safety Framework

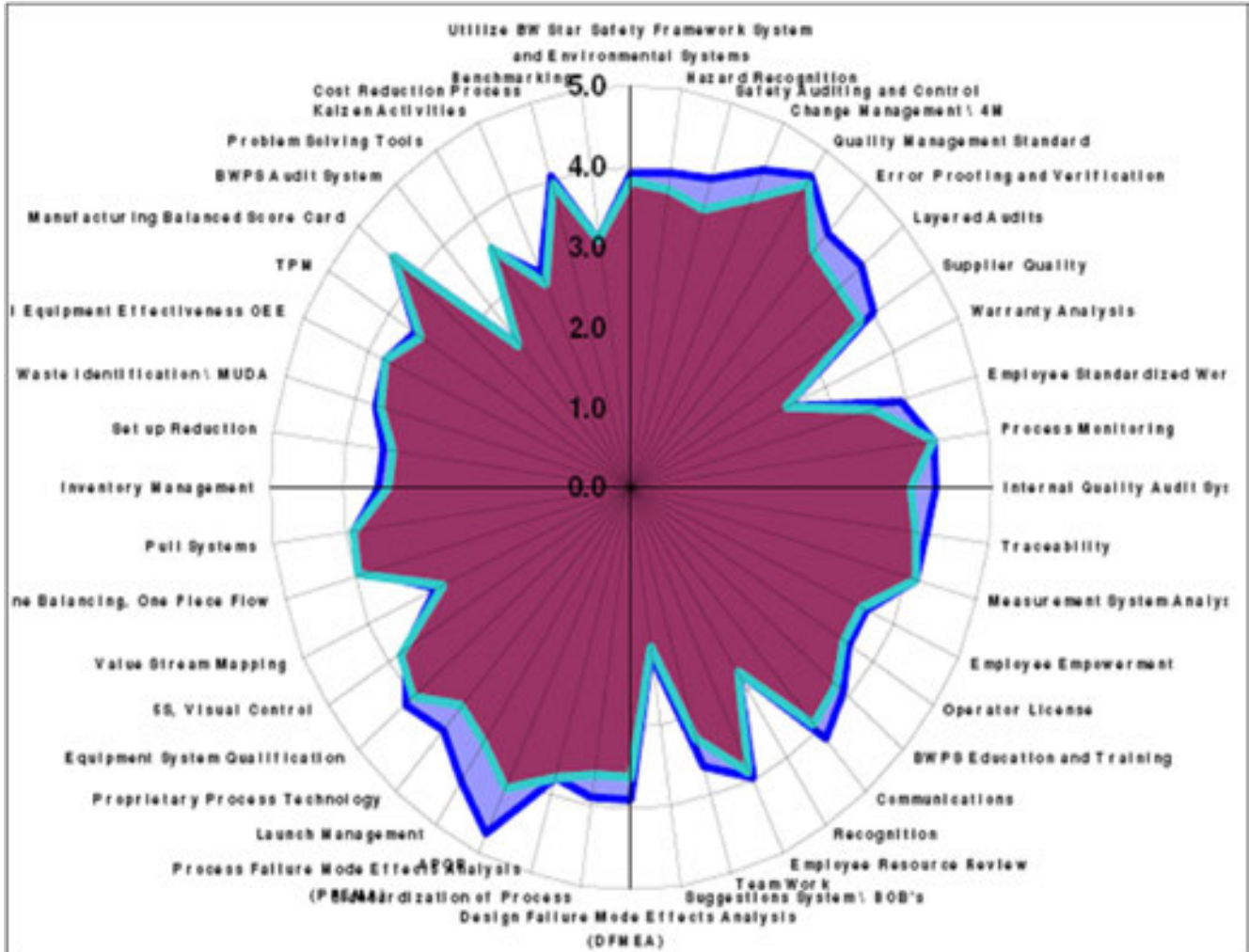
**LPA** - Layered Process Audits

**KPI** - Key Performance Indicator




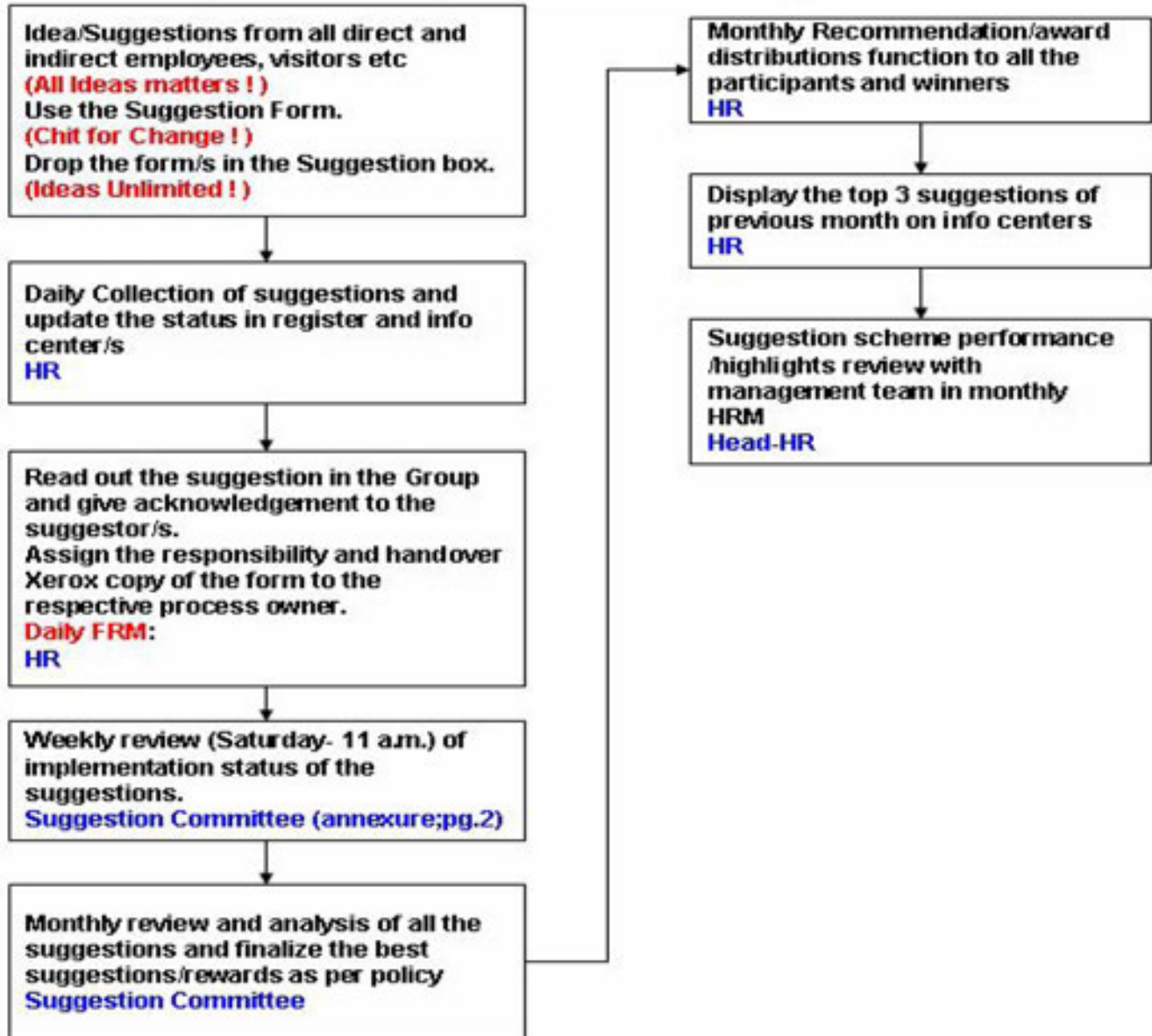
## APPENDIX

### APPENDIX 1: STRUCTURE OF EARLIER BWPS MODEL



## APPENDIX 2: SUGGESTION SCHEME PROCESS FLOW DIAGRAM

 <b>Divgi - Warner</b>	<b>Process: Suggestions/Ideas Management</b>		
	Process Owner	Head-HR	Control Number: - OP-HRD-005
	Short Description	How suggestion scheme is performed in the organization	
	Original Release	00/ 25-Dec-2011	
	Latest Revision	00/ 25-Dec-2011	Page of : 1 of 2



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