Optimal Body-In-White Dimensional Quality Management in the Body Shop Area in a Car Manufacturing Plant

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Abstract

Company X, based in South Africa, has noticed an increase in the number of Body in White (BIW) assembly defects from year to year (2017-2020). A review of historical operational data records revealed that most of the defects recorded were related to BIW dimensional management. The goal of this study was to investigate the theoretical strategies, systems, and success factors for managing BIW dimensional quality and to identify gaps in Company X's BIW dimensional quality management systems and strategies. This study chose a case study as the appropriate research strategy, and questionnaires were developed and distributed to participants from Company X for data collection purposes. For data analysis, descriptive statistics were used in this study. The primary data indicated that there was a good understanding and adoption of BIW quality management critical success factors in the case study company. However, secondary data showed that the number of defects per unit was increasing, with geometric points out of specification, incorrectly built parts, and measurement errors accounting for 80 per cent of the defects affecting BIW quality management. It was recommended that future research compare BIW quality management in the South African automotive industry to that of global car manufacturers.

Keywords
Body in White, Dimensional Quality, Quality Management,

1. Introduction
Car manufacturing and automotive factories use innovative manufacturing techniques to meet and exceed their customers' expectations while also delivering the requisite production volume (Hasic 2006). The highly competitive market growth of the automotive industry has put automobile manufacturers under pressure to provide reliable and high-quality products to maintain their competitiveness (Shalash, 1996). Body in White (BIW) is the most significant process in the automobile production process, as well as the most expensive component of the car because it dictates the overall aesthetic of the vehicle (Enriquez, 2016). Since BIW is the structure before all of hang-on and fit-on panels are installed, it consists of body openings that must be geometrically exact during the BIW building process to obtain appropriate fits (Shalash, 1996). These geometrical apertures are crucial in the construction of BIW structures since any inaccuracy on them might result in costly stoppages, — in other words (Strapping Vehicles on Wheels) (Shalash, 1996).

The BIW dimensional quality of the vehicle shell assembly process must be understood and regulated (Brown et al., 2002). The BIW assembly procedures and geometrical quality are key operations that must be strictly monitored for automobile manufacturing plants to achieve their ultimate goal, which is to reduce the time it takes to create and deliver a good quality car to its customers (Shalash, 1996). This also necessitates monitoring of the subassemblies that are installed in BIW assembly and require geometrical quality management throughout the phases of the automotive production process (Enriquez, 2016). Managing BIW geometrical dimensional variation in the automobile manufacturing process is critical for the plant to maintain manufacturing competitiveness because excessive variation in BIW geometrical dimension quality affects product quality, time to market, and product development cost (Shalash, 1996). Managing and understanding the influence of BIW process inputs on dimensional quality as early as feasible in the product development process helps shop engineers to come up with strong solutions before the finished product is sent to the next stage of the assembly process (Enriquez, 2016).

Company X, situated in South Africa, has recently noticed an escalation in non-conformance due to BIW assembly procedures. These non-conformances prohibit Company X from fulfilling its business and financial objectives. Solving Company X's manufacturing plant difficulties with BIW dimensional quality control is the research problem statement. This research also seeks to assist or support Company X, in reducing quality nonconformance linked with BIW assembly quality, by finding weaknesses in their BIW dimensional quality management systems and strategies. The research team's goal is to generate knowledge that will improve the tools and techniques offered globally for BIW dimensional management in the body shop stage of car manufacturing plants, with a particular emphasis on the design and construction of BIW geometrical dimensional management for higher quality output.

1.1 Objectives

The purpose of this study was to investigate ideal BIW dimensional quality management systems and strategies available in theory for managing BIW quality in the body shop manufacturing area of an automotive automobile production plant to ensure good quality output. Furthermore, the goal of this research is to assist Company X in determining the effectiveness and gaps in the BIW dimensional quality management system and strategy.

2. Literature Review

The body shop manufacturing stage in car manufacturing plants is tasked with putting measures and inspection systems in place to ensure that the entire BIW conforms to all quality measurables and will pass all production stages without affecting delivery targets. At an automotive car manufacturing plant, the BIW assembly stage has a significant impact on the overall plant's products and quality cost implications. The following section provides a detailed summary of the literature reviewed. Table 1 summarizes the BIW dimensional management success factors that the literature reviewed suggests should be in place for any automotive car manufacturing plant to achieve optimal BIW dimensional quality results.

Table 1. Summary of Critical Success Factors for BIW Dimensional Management

Success Factor	Description	Reference
1. Training	To meet the demands of the customers, vehicle and design engineers must have access to and training in a wider range of available technologies and components that are superior to those previously used or considered standard.	(Al-Zaher 2013).
	Improving the overall quality of a complete vehicle assembly necessitates advanced experience and knowledge of mechanics involved in the BIW assembly stage of the vehicle manufacturing process.	(Hosseinjani 2018)
	Meeting the needs of a rapidly changing market has led car manufacturing company customers to demand higher standards of safety and quality products, forcing global automakers to recruit and train a highly skilled and capable workforce for their BIW manufacturing stage.	(Hazel 2005)
2. Resource Management	The BIW functional dimension point should be placed in an easily accessible location for testability purposes.	(Hosseinjani 2018)
	The cost of good quality is the cost associated with built-in quality, in which the company uses its resources to ensure that its product is built or processed correctly the first time.	(Doke et al. 2012)
	Automotive car manufacturing plants devote the majority of their resources to improving customer perceptions of their brands, which necessitates the implementation of more quality improvement measures by the plants.	(Fathil,2008)
3. Leadership Involvement	BIW geometrical quality management is one of the manufacturing plant's key processes that requires senior leadership involvement to be properly monitored, gain market share, and satisfy customers.	(Moon et al. 2011).
	Substandard BIW geometrical dimensions quality in automotive car manufacturing plants has a negative impact or influence on complete car	(Doke et al. 2012)

Success Factor	Description	Reference
	quality, time to market, and product development, which harms leadership performance scorecards.	
	BIW dimensional quality management not only helps automotive manufacturers reduce costs and increase customer satisfaction, but it has also become a new tool for managing overall vehicle quality, making it a quality control tool.	(Mohamad 2008)
4. Customer Focus/Satisfaction	Automobile manufacturers use the feedback from their internal and external (Product Consumers) customers to improve their quality and processes.	(Shalash 1996)
	For any business to be globally competitive, two critical and integral criteria must be managed and controlled, namely, cost and quality.	(Teli et al. 2018)
	The cost of quality influences the company's major objective, which is to meet and exceed customers' product expectations at the lowest cost possible.	(Godina et al. 2016).
5. Project Management	When a facility improvement optimisation project in the BIW manufacturing stage is mismanaged, it can have a negative quality impact on the overall BIW dimensional management.	(Al-Zaher 2013)
	The short life span of automobiles, as well as continuous upgrades and modifications, as well as volume demand to meet customer expectations, are cited as reasons for the difficulty in commissioning the BIW manufacturing stage.	(Nagy-Sochacki 2015)
6. Process Management Approach	Setting geometrical dimension control limits in an automotive body shop is an important stage of car production because it necessitates a proper plan that will also accommodate the introduction of new models or upgrades.	(Zhu. Ping et al. 2008).
	The evaluation of BIW dimensional quality in the body shop manufacturing stage is regarded as an important challenge in the process management of BIW assembly quality.	(Ganesh and Kumar 2017)
	Challenging BIW geometries and assemblies necessitate reliable measurement capabilities to aid in final product dimensional quality management and ensure high-quality outputs.	(Sanches, et al., 2008)

Table 2 summarizes the optimal BIW dimensional management strategies that, according to the reviewed literature, must be in place for any automotive car manufacturing plant to achieve optimal BIW dimensional quality results.

Table 2 Summary of BIW dimensional management strategies

Process Input	Key strategy statements from the literature review.	Reference
Incoming Parts Quality	The geometrical dimensional variation and quality non-conformance of the entire BIW are contributed by BIW subassembly processes and incoming parts components.	Hosseinjani (2019)
Subassembly quality	BIW subassembly components (input) also contribute to the geometrical dimensional variation and quality non-conformance of the entire BIW.	Shalash (1996)
Tooling Capability	For a company to successfully manage BIW dimensional quality, all BIW assembly inputs (processes in place, parts, and tooling) must be managed because any flaw in these inputs can affect the overall dimensional quality of the assembly.	Hosseinjani (2019)
Assembly Process Capability	For a company to successfully manage complete BIW dimensional quality, certain dimensional restrictions for tighter process deviation tolerance and error-proofing must be in place to ensure that defective inputs are rejected before affecting the entire product.	Godina et al. (2016)
Robotic Welding Process	When not monitored, spot welding variation during the BIW assembly process can cause overall dimensional quality variation.	

Process Input	Key strategy statements from the literature review.	Reference
		(Doshi and Darshak 2016)
Capability	BIW geometrical quality management is a critical process in manufacturing plants that must be properly understood and monitored to gain market share and customer satisfaction.	(Moon et al. 2011)
BIW dimensional Quality Management system	Dimensional management is an engineered process comprised of engineering tools that allow for the study and analysis of product variation from the design specification.	(Moon et al. 2011)

3. Methods

The study used both quantitative and qualitative research methods to gain an in-depth understanding of BIW quality management in the case study company (Bernauer et al., 2013). The research design is exploratory in nature, with the goal of determining the factors influencing BIW quality management in the case study company. The research process began with a review of the literature, which aided in the development of the problem statement and questionnaires distributed by the case study company.

4. Data Collection

The primary data collection tool for the study was a questionnaire, which was distributed to the multi-skilled employees of the case study company. The study included managers, engineers, technicians and operators from the body shop assembly stage. A total of 32 online questionnaires were distributed to 32 participants via Google forms, yielding 29 usable responses (91 per cent response rate). The study only looked at people who worked in the BIW quality management department of the case study company. This study also examined and presented findings from historical operational data obtained from Company X, such as quality and production efficiency (Jobs Per Hour (JPH)) tracking reports.

5. Results and Discussion

The first section of the questionnaire asked participants to provide information about their highest level of education, experience, and job titles (Table 3). Most respondents (38%) had national diplomas and Degrees or B-tech (38%) as their highest qualification, while others (20%) reported having certificates as their highest qualification. In terms of experience, the majority (41%) had less than 5 years of industry experience, while the other larger group (28%) had experience ranging from 5 to 10 years. Most respondents (20%) were quality engineers and technicians (17 per cent).

Table 3. Demographic information (N = 29)

Items	%	Cumulative %
Education		
National Diploma	38%	38%
Degree or B-tech	38%	76%
Certificate	20%	96%
Technical trade test certificate	4%	100%
Total	100%	
Experience		
Less than 5 years	41%	41%
Between 5 and 10 years	7%	48%
Between 10 and 15 years	28%	76%
15 Years and more	24%	100%
Total	100%	

Items	%	Cumulative %
Job Title		
Quality engineer	20%	20%
Technician	17%	37%
Metrologist	13%	50%
Specialist	10%	60%
Production manager	10%	70%
Maintenance Manager	8%	78%
Area manager	10%	88%
Production engineer	12%	100%
Total	100%	

5.1 Numerical Results

This section presents the numerical results and is divided into five subsections, with section 5.2.1 discussing the results related to training and 5.2.2 covering resource management. Section 5.2.3 discusses leadership involvement, while section 5.2.4 discusses the outcome of customer focus, and section 5.2.5 discusses quality management strategies.

5.2.1 Training

The training concept was evaluated using five items (Table 3), and it had a high level of internal consistency (Cronbach's Alpha = 0.905). According to the respondents, leadership has been trained and is up to date on BIW dimensional management knowledge (mean = 4.13; Sdt Dev = 1.09). Employees are similarly trained on the equipment used to assemble BIW (mean = 4.03; Sdt Dev = 1). Employees are taught how to use the quality technical tools required to assess BIW dimensional quality, according to respondents (mean = 3.97; Sdt Dev= 0.81). According to the respondents, continuous learning is provided (mean = 3.97; Sdt Dev = 0.78), and all employees who work with BIW dimensional quality management are trained in quality problem-solving courses (mean = 3.77; Sdt Dev = 0.94).

Table 4. Training

Label	**Description**	**Mean**	**Std. Deviation**	**N**
Q19	Leadership has been trained and is up to date on BIW dimensional management knowledge.	4.13	1.09	29
Q18	Employees receive training on the equipment used to assemble BIW.	4.03	1.00	29
Q17	Employees are taught how to use the quality technical tools that are needed to assess BIW dimensional quality.	3.97	0.81	29
Q20	Continuous learning is provided.	3.97	0.78	29
Q16	All employees who work with BIW dimensional quality management are trained in quality problem-solving courses.	3.77	0.94	29

5.2.2 Resources Management

Table 5 shows the descriptive statistics (mean, standard deviation, and a total number of respondents) for the items designed to evaluate the concept of resource management, which had high reliability (Cronbach's Alpha = 0.908). According to respondents (mean = 3.93; Std Dev = 0.87), employees are given opportunities to learn skills that will help them do their jobs more effectively. Employees are also constantly involved in activities aimed at improving the quality of the company's products (mean = 3.93; Std Dev = 0.93). The respondents also claim that material resources are effectively managed and safeguarded (mean = 3.87; Std Dev = 0.77). Overall, all of the items had a high mean and a standard deviation of less than one, indicating a high level of agreement among the respondents.

Table 5. Resource Management

Label	Description	Mean	Std. Deviation	N
Q21	Employees are given opportunities to learn skills that will help them do their jobs more effectively.	3.93	0.87	29
Q25	Employees are involved in activities to improve the quality of the company's products continuously.	3.93	0.93	29
Q24	Material resources are effectively managed and safeguarded.	3.87	0.77	29
Q23	Launch department quality-related facility optimization projects are provided with all the needed resources.	3.77	0.82	29
Q22	All employees in the BIW manufacturing department are continually trained.	3.60	0.91	29

5.2.3 Leadership Involvement

Table 6 displays the descriptive statistics (mean, standard deviation, and total number of respondents) for the items designed to assess the concept of leadership involvement. The items designed to assess the concept of leadership involvement had a high internal consistency (Cronbach's Alpha = 0.905), indicating that they were measuring the same thing. The results show that senior management was very committed to improving quality (mean = 4.17; Std Dev = 1.08). The respondents also confirmed that the company's leadership supports BIW's dimensional quality management activities for continuous improvement (mean = 4.07; Std Dev = 0.95). The respondents further believed that employees are coached on overall plant quality performance regularly by management(mean = 4.03; Std Dev = 0.98). The findings also demonstrated that company leaders place a high role on BIW dimensional management and are actively involved in it (mean = 4; Std Dev = 1). Senior management also ensures that everyone in the organization understands the organization's overall quality objectives (mean = 3.93; Std Dev = 1).

Table 6. Leadership involvement

Label	Description	Mean	Std. Deviation	N
Q30	Top management is committed to improving quality.	4.17	1.08	29
Q28	The company's leadership supports BIW's dimensional quality management activities for continuous improvement.	4.07	0.95	29
Q29	Employees are coached on overall plant quality performance regularly by management.	4.03	0.98	29
Q27	Company leaders place a high role on BIW dimensional management and are actively involved in it.	4.00	1.00	29
Q26	Senior management ensures that everyone in the organization understands the overall quality objectives of the organization.	3.93	1.00	29

5.2.4 Customer focus

The concept of customer focus was also assessed using five items (Table 7), and it had a high internal consistency (Cronbach's Alpha = 0.823). Respondents stated that processes are in place to manage customer expectations (mean = 4.50; standard deviation = 0.51) and that customer feedback drives continuous improvement (mean =4.47; standard deviation = 0.57). The respondents also stated that the company uses a data-driven approach to improve quality, as evidenced by the use of plant overall quality data as a BIW assembly quality continual improvement tool (mean = 4.13; Std Dev = 0.78).

Table 7. Customer focus

Label	Description	Mean	Std. Deviation	N
Q31	There are processes in place to manage customer expectations.	4.50	0.51	29

Q32	Customer feedback drives continuous improvement.	4.47	0.57	29
Q33	Plant overall quality data is used as a BIW assembly quality continual improvement tool.	4.13	0.78	29
Q34	The company has systems in place to manage costs related to quality activities.	4.10	0.61	29
Q35	Leadership takes the lead in company overall quality drive meetings.	4.03	0.89	29

5.2.5 Quality Management Strategies

In this section, respondents were asked to identify which strategies the company used to manage BIW quality. According to Table 8, respondents claimed that the company uses an off-line metrology measurement system to monitor BIW dimensional quality (mean = 4.47; Std Dev = 0.56) and that the company uses part confirmation fixtures to assist suppliers in improving the quality of incoming parts (mean = 4.40; Std Dev = 0.61). The company has processes in place to manage process stability (mean = 4.33; standard deviation = 0.47) as well as a process monitoring system for continuous improvement (mean = 4.23; standard deviation = 0.42). Except for the two items (Q7 and Q8), the majority of the quality management strategies in Table 8 had a mean greater than 3.5 and a standard deviation less than one, indicating that the company was not using a 10% BIW dimensional measurement sampling frequency and BIW dimensional measurement sampling frequency. The scale had a high level of internal consistency (Cronbach's Alpha = 0.874).

Table 8. Quality Management strategies

Label	Description	Mean	Std. Deviation	N
Q5	To monitor BIW's dimensional quality, the company employs an off-line metrology measurement system. (System of the Metrology Lab.)	4.47	0.56	29
Q14	The company uses part confirmation fixtures to assist suppliers to improve the quality of the incoming parts.	4.40	0.61	29
Q2	The company has a process in place to manage process stability.	4.33	0.47	29
Q9	The company has a defined process monitoring system in place for continuous improvement purposes (Process/Quality Audits).	4.23	0.42	29
Q13	The company has a clearly defined BIW welding spot quality capability and stability process in place.	4.23	0.67	29
Q3	The company has a process in place to manage BIW dimensional management quality.	4.20	0.54	29
Q10	The company has a robust metrology measurement system in place.	4.17	0.69	29
Q12	The company uses modern dimensional management engineering tools to monitor BIW dimensional data (Hint: SPC, DDC).	4.13	0.72	29
Q15	The company BIW dimensional management team frequently has BIW dimensional continuous improvement meetings with incoming parts quality.	4.10	0.60	29
Q1	The company has a process in place to monitor the quality of incoming parts in the production line.	4.03	0.66	29
Q11	The company has a defined quality management process for monitoring and measurement of subassemblies.	3.77	0.88	29
Q4	The company uses an in-line metrology measurement system to monitor BIW's dimensional quality.	3.67	1.22	29
Q7	The company uses a 10 % BIW dimensional measurement sampling frequency.	3.37	1.02	29
Q8	The company uses 100% BIW dimensional measurement sampling frequency.	3.27	1.26	29

5.2 Graphical Results

This section presents the graphic results, which are primarily comprised of secondary data from the case study company. The outcome includes quality performance, production performance, and types of defects identified from operational data.

5.2.1 Result from operational records

The purpose of this section is to present the findings from Company X's operational data. Quality and production efficiency (jobs per hour (JPH)) tracking reports from Company X's BIW manufacturing stage, collected between 2017 and 2020 production, were among the historical data. As illustrated in Figure 1, the company experienced exponential growth in the total number of units produced from 2017 to 2019, before experiencing a significant drop in 2020 due to Covid-19 restrictions. The results also show that as the number of units produced increased, so did the number of defects. The number of defects per unit increased steadily from 2017 to 2019, with a significant increase in 2020. In addition, the result indicated a significant change in jobs per hour in 2020, moving from an average of 27.5 to 30 jobs per hour.

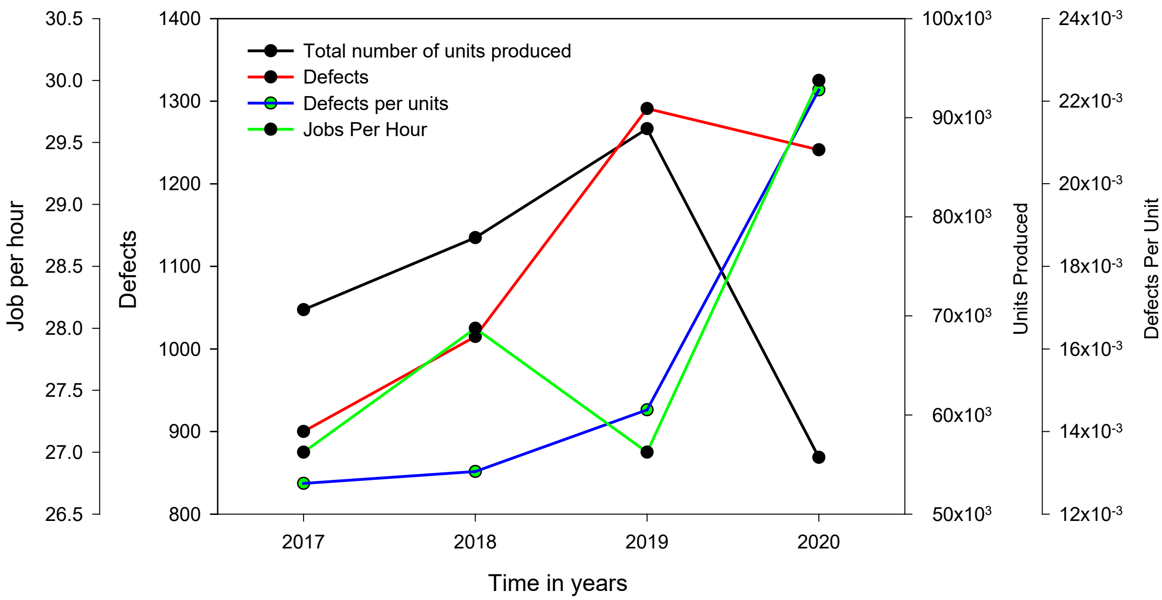

Figure 1. Secondary data

Figure 2 depicts the various types of defects identified in the quality inspection reports. The geometric points that were found to be out of specification had the highest rate of occurrence (15.2%), followed by incorrectly built parts (13.1 percent). Unable to fit parts (11.2%), measurement errors (9.6%), out-of-spec parts (9%), tooling wear and tear (9%), and missing parts (9%) were all among the defects that accounted for 80 per cent of BIW quality issues.

5.3 Proposed Improvements

The reviewed literature identified training, resource management, leadership involvement, and customer focus as critical success factors for BIW dimensional quality management systems that must be followed to achieve optimal results (Doke et al., 2012). Furthermore, incoming part quality, tooling integrity, complete BIW dimensional quality system, process capability and stability, measurement system, robotic welding capability, and subassembly quality monitoring system management were identified as critical success factors for BIW dimensional quality management strategies in the literature review (Godina, et al., 2016). The majority of the critical success factors for optimal BIW quality management identified in this study were discovered in company X, but the results revealed an increase in the number of defects per unit year on year, with a significant increase observed in 2020. The findings also show that the majority of the defects were caused by incorrectly built parts and unspecified geometric points. It was suggested that the case study company improve measurement system management and analysis to eliminate errors caused by geometric points and out-of-spec parts. It was also suggested that the company invest in root cause analyses to gain a thorough understanding of the factors that contribute to incorrect build and non-fitting parts. The company should invest in tooling maintenance to prevent wear and tear, as well as investigate the causes of missing parts.

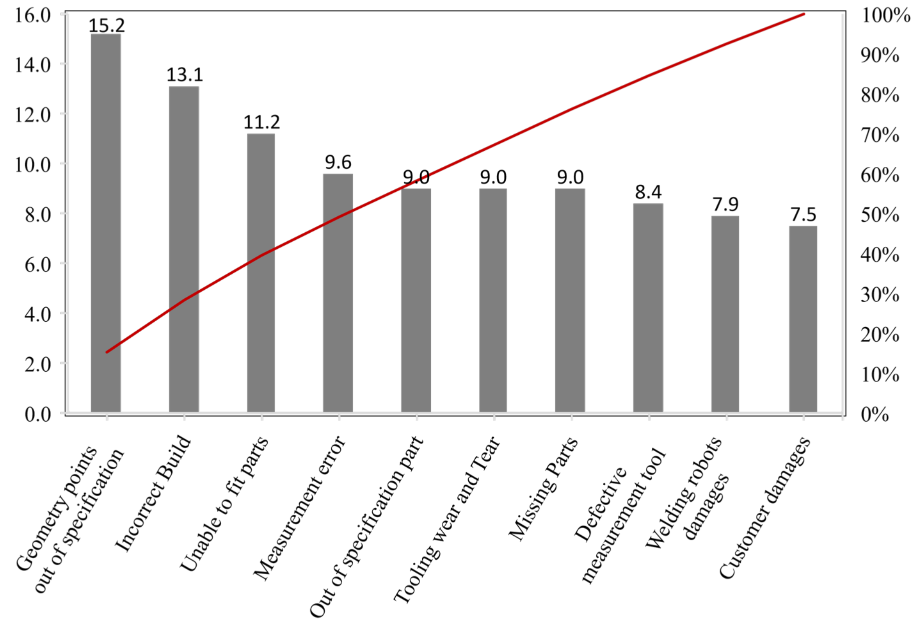

Figure 2. Defects

5.4 Validation

This study used two data sources (questionnaire and secondary data) and triangulation to assess similarities and differences. Audit trails were used to ensure reliability, and Cronbach's Alpha was used to determine internal consistency. Table 9 shows the differences and similarities between the primary and secondary data.

Table 9 Similarities and differences

Factors	**Primary data**	**Secondary data**
Training	The primary data confirmed that the company had training programs to improve BIW quality.	The secondary data did not provide evidence to support the primary data results, and the company was found to have an increasing number of defects per unit year after year.
Resource Management	The items designed to assess resource management received a high mean score of more than 3.5 demonstrating that the company had a good resource management strategy.	The results showed that the company had errors related to measurement errors, incorrect construction, unable to fit parts, and missing parts, all of which are indicators of poor resource management.
Leadership Involvement	The items designed to measure the concept of leadership involvement had high mean scores of greater than 3.5 indicating the strong involvement of the senior management team in quality improvement.	Although assessing leadership involvement from secondary data was difficult, the results showed a unit increase produced year on year and an increase in jobs per hour, both of which are attributes of committed leadership to increase production volumes and profit.
Customer focus	According to the primary data, the company had a strong customer focus, with all the items designed to measure	Secondary data did not provide enough evidence to support the existence of a strong customer focus.

Factors	Primary data	Secondary data
	the concept of customer focus receiving a mean score of above 4 and a standard deviation less than one.	
Use of metrology measurement system	The primary data indicated that the company was using a metrology measurement system.	The secondary data revealed several flaws related to measurement system analysis, indicating the need for further improvement in the use and management of measurement analysis.
Use part confirmation fixtures to assist suppliers to improve the quality of the incoming parts	The primary data indicated that the company was using pat confirmation fixtures to assist suppliers to improve the quality of the incoming parts.	According to secondary data, 13.1 per cent of the defects were due to incorrectly built parts, and 11.2 per cent were due to unable to fit parts, both of which were indicators of poor management of incoming parts in the production lines.
The company has a defined process monitoring system in place for continuous improvement purposes.	The primary results show that the company had defined processes to monitor continuous improvement.	According to the secondary data, the monitoring processes were unable to reduce the number of defects per unit year after year.
The company has a clearly defined BIW welding spot quality capability and stability process in place	Primary data shows that the company has BIW welding spot quality capability and stability.	According to secondary data, there were approximately 7.9 per cent of defects related to welding issues, demonstrating the need to improve welding processes.
The company uses modern dimensional management engineering tools to monitor BIW dimensional data	According to the primary data, the company was using modern tools to manage BIW quality.	Secondary data did not provide enough evidence to support the claim that modern technology was used to manage BIW quality.
The company BIW dimensional management team frequently has BIW dimensional continuous improvement meetings with incoming parts quality	According to the respondents, the company held meetings for continuous improvement.	The secondary data did not provide enough evidence to support such meetings.

6. Conclusion

The goal of this study was to investigate ideal BIW dimensional quality management systems and strategies that are available in theory for managing BIW quality in the body shop manufacturing area of an automotive automobile production plant to ensure high-quality output. Furthermore, the purpose of this research is to help Company X determine the effectiveness and gaps in the BIW dimensional quality management system and strategy. To gain an in-depth understanding of quality management practice in the case study company, this study used a case study as the appropriate research strategy, as well as questionnaires and secondary data as sources of information. The primary data indicated that there was a good understanding and adoption of BIW quality management critical success factors in the case study company. However, secondary data showed that the number of defects per unit was increasing, with geometric points out of specification, incorrectly built parts, and measurement errors accounting for 80 per cent of the defects affecting BIW quality management. It was suggested that the company invest in system measurement analysis and measurement tool maintenance. It also suggested that future research could compare BIW quality management in the South African automotive industry to that of global car manufacturers.

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Biography

Sivuyile E Gayiya is currently working as a quality manager (Stamping) at Ford Motor Company South Africa (FMCSA). He obtained his undergraduate Mechanical Engineering Diploma and Btech in Quality from the Nelson Mandela University. He has 16 years of experience working in the automotive car manufacturing with General Motors South Africa (10 years) and FMCSA (6 years). His research interest includes engineering management and press tooling engineering.

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