Proceedings of the Second Australian International Conference on Industrial Engineering and Operations Management, Melbourne, Australia, November 14-16, 2023

Feasibility of Lean Manufacturing Kaizen Teams' Approach to help the Plastic Manufacturing Industry with Continuous Improvement

Judith Nkuna
Department of Quality and Operations Management
Department of Engineering Management
University of Johannesburg South Africa
jnkuna@uj.ac.za

Andre Vermeulen
Post Graduate School Engineering Management
University of Johannesburg,
Auckland Park, Johannesburg, Gauteng, South Africa
andrevermeulen80@gmail.com

Jan-Harm C. Pretorius
Post Graduate School Engineering Management
University of Johannesburg, Auckland Park,
Johannesburg, Gauteng, South Africa
jhcpretorius@uj.ac.za

Abstract

The purpose of this paper was to determine the feasibility of lean manufacturing Kaizen Teams approach to help the plastic manufacturing industry in terms of continuous improvement. The data was collected from 217 employees working in the plastic manufacturing company. The data was obtained via a survey questionnaire that was developed on a Likert scale. Lean manufacturing focuses on reducing waste and improving efficacy in the manufacturing process whereas, the Kaizen team framework is based on the identification of improvement processes. The findings of the study were obtained via SPSS and it revealed that there is a significant correlation between Kaizen methods and quality improvement, product improvement, customer satisfaction, employee satisfaction, and supplier.

Keywords

Kaizen method, lean manufacturing, plastic manufacturing, Kaizen framework, waste management

1. Introduction

The advancement of technology and the globalisation of Industry 4.0 has gained significant attention and popularity due to rapid and drastic changes in the frameworks of operations. The main factors to trigger the change are social, political, and economic. However, industry 4.0 is associated with technological changes and digitalisation process which includes automation in industrial processes and increases the productivity of industry (Chiarini & Kumar, 2020). The concept of Industry 4.0 has been introduced in Germany and till now it has been greatly researched by researchers and considered to be a game changer in the world. Industry 4.0 is widely used as a strategic model in many industries to achieve competitive advantage in their respective field and the market. It also helps in improving the quality of products, productivity, and costs (Kolberg et al., 2017). Moreover, apart from Industry 4.0 use, many industries also use the Lean Six Sigma methodology that helps in improving manufacturing and productivity efficiency. The major reason to use the Industry 4.0 or Lean Six Sigma model is to increase operational excellence and efficiency.

Various industries' management uses the Kaizen approach that helps to efficiently identify the problems and opportunities or solutions for resolving the problems and to gain a smooth continuous improvement process (Tatarnikova, 2019). The Kaizen system depends on the five key elements that help the complete system to move

smoothly. The elements include personal discipline, teamwork, training and suggestions, and moral state. Many of the already existing research studies have already described the importance of using the Kaizen methodology along with the significance of the Kaizen method. Moreover, the five elements of the Kaizen method help in understanding the process in detail.

The plastic industry in South Africa has developed drastically over time (Figure 1). The plastic industry of South Africa deals with plastics manufacturing in their local region as well as exporting business. The plastic industry value chain system is strong and has a significant role in gaining a competitive advantage in the plastic market (Figure 2). The major plastic market present in South Africa includes construction, automobile industry, building, and packaging. However, there are some secondary industries also that involve the use of plastic such as textile, agriculture, electronics, and electrical (DTIC, 2023). The challenges in the plastic market of South Africa arise due to the increases in competition and prices. Recently, it has been observed that China is one of the largest plastic manufacturers that produces plastic products in large bulk and sold at cheap prices which has a negative and adverse impact on the local plastic market.

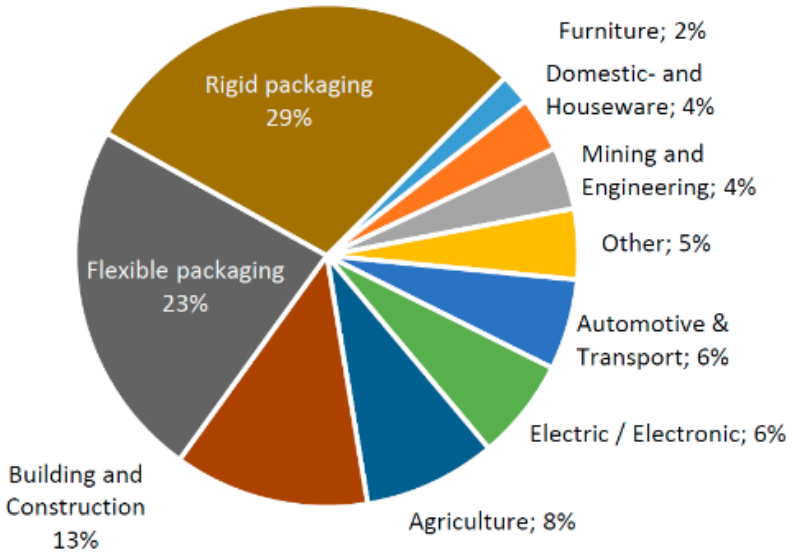


Figure 1. Plastic division of sectors (DTA, 2023)

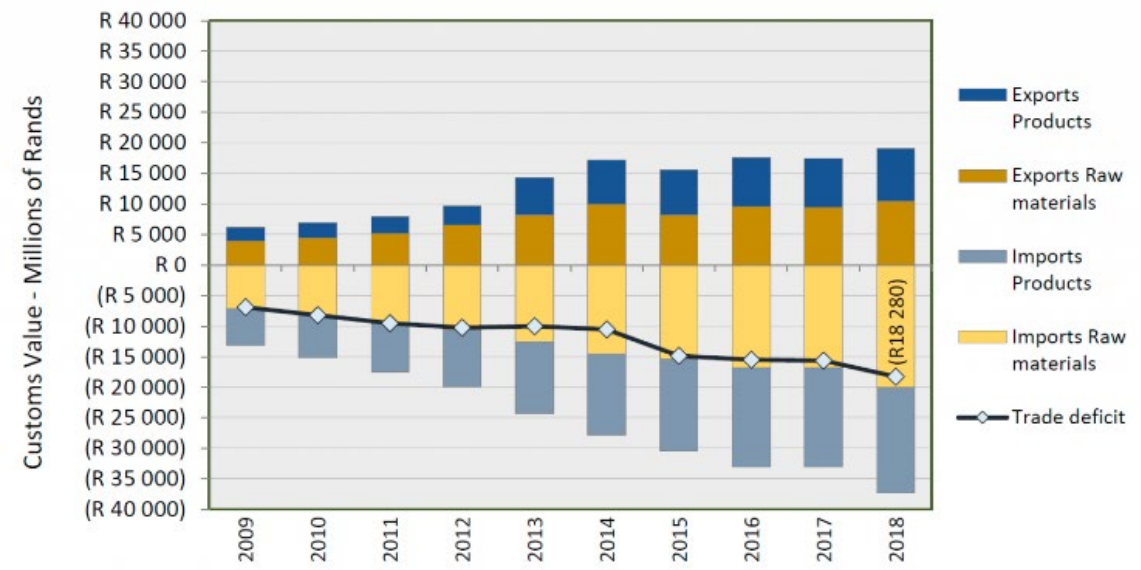


Figure 2. Plastic distribution (DTA, 2023)

1.1 Aim and Research Questions

The primary aim of this research study is to use the Kaizen approach and lean manufacturing to determine the relevant alternatives and solutions for the improvement of plastic manufacturing products. Another aim is to identify the working of plastic manufacturing industry employees working that have an essential role in the management of lean manufacturing method usage. The research questions of this study are given as follows:

RQ1. What is the environmental impact of plastic waste?
RQ2. What is the feasibility of lean manufacturing kaizen teams' approach to help the plastic manufacturing industry with continuous improvement?
RQ3. For the plastic industry to sustain continuous improvements, which approach is most effective to use?
RQ5. What are the key challenges of the lean manufacturing kaizen team's approach?
RQ6. How can the Kaizen Team Approach be used to continuously improve the Plastic industry to help with quality improvement?
RQ7. What is the significance of manufacturing Kaizen in the plastic industry?
RQ8. What evidence suggests that the Plastic industry uses lean manufacturing kaizen teams' approach?
RQ9. What is the importance of lean manufacturing kaizen teams' approach to achieve continuous improvement success similar to another research works?
RQ10. What are the major future concerns if the plastic manufacturing industry does not adapt to the lean systems strategy?

2.0 Literature Review

According to the research study by Shen et al., (2020), plastics are one of the most used materials in every field of life. According to the global economy, the most common material is plastics. Plastics play an important role in everyday life. Plastic is all over nowadays. Masses utilized plastics unceasingly just for their comfortableness. Yet never one concrete how it was damaging their universe. They want to be conscious of the consequences so that they can stop plastic waste. The child should be taught from their immaturity to confront utilizing plastic. Likewise, grownups necessary to examine one and all on the identical. In addition, the authorities must take tight measures to stop plastic waste pollution earlier it gets too belated. Plastics have become an unavoidable part of the world of materials. Plastics play a significant role in human daily life activities such as foods in plastic bags and containers, water bottles in plastic containers, and usually, clothes are mostly packaged in plastic bags, plastics are mostly used for wrapping purposes and plastics are mostly used for packaging of equipment and tools. According to some reports in Europe regarding plastics were that global production of plastics has increased from 2 million tons in the 1960s to around 348 million tons in the year 2017. But they have seen some drastic change in one year only, it was observed that an 11 million tons increase in the year 2018. So, in the year 2018, the global production of plastics increased to 359 million tons. China was the greatest worldwide plastic manufacturer, followed by North America and Europe.

According to the research study by Echchakoui and Barka, (2020). The industry has been growing globally for numerous years. It was observed that in the year 2020, around 654.38 billion industries of plastics will reach the global

market. This global growth of plastics industries has been valuable to Canada, since the plastic industry was nurtured by 2.0 -2.2% between the year 2012- 17, even though such evolution was small compared to further reputable countries, for example, Russia and France where manufacturing showed yearly growth of around 4.1-4.5% in recent years. The growth has not been equally profitable for all corporations. For instance, a case report was managed in the year 2019 on the accomplishment of one of the leading plastics production groups in Canada and observed that only 50% of plastic corporations faced development throughout the earlier decade. Among the most mentioned incentives and causes by supervisors for low growth. It was observed that lower growth was an absence of implementation of Industry 4.0. More particularly, there was a huge shortage of understanding and expertise about 4.0 manufacturing implementation in the industry of plastics. To identify whether this lack of knowledge was also portrayed in the investigation, they judged the state of the overall fourth Industrial Revolution study and contrasted it with comparable research in the industry of plastics.

According to the research study by Shen et al., (2020), Plastics were usually synthesized from natural polymers. Natural polymers acquire an act of courage containing exclusively the bonds C–C and the natural constituents generally derive from oil, coal, fuel, natural gas, and fossil. It was observed that enormous manufacture, widespread purposes, and misconduct of plastics raise their probability of competing with the natural environment. After entering the environment, plastics are more difficult to handle. Because plastics are not easily decomposed, that's why it was harmful to the environment. Plastics have gathered in oceans, freshwater, and land for many years. The public has developed progressively alert of and anxiety about the emergency disaster of plastics in the atmosphere over the past years, especially nano-plastics and micro-plastics. Some new studies stated that microplastics not only collect in the atmosphere or environment but also accumulate in the supplies of water and in the food that is intake by living organisms. nano plastic and micro-plastic atoms can be transported beside the diet to the higher trophic level of living organisms, or into the individual food supply chain through further passageways. Because of the substantial size of microplastics, most smaller plastics will gather in the bowel area of the animals, but a minor expanse of microplastics can pass into the vascular structure through the copious lymphatic system in the alimentary tract. For the bigger size of microplastics, it was hard to enter the body part. In contemporary literature, the nonpoisonous valuation of microplastics is less. But for micro-plastics, they can oppose the barrier of the intestine into the cardiovascular system and ultimately lead to general coverage. Because of their static nature, micro-plastics are easy to collect in cells and tissues, it will cause metabolic illnesses and local swelling. Especially in patients with abdominal diseases, the fluctuations of the porousness of tissues triggered by inflammatory infection will notably raise the absorption and transportation of micro-plastics, thus supplementary raising the danger of revealing.

According to the research study by Chen et al., (2021), with the quick increase in the universal production of plastic, industries of plastic have developed the most crucial and quickly increasing source of manufacturing greenhouse gas productions. Firstly, greenhouse gases are those gases in the atmosphere of the earth that trap heat. The main greenhouse gases were methane, carbon dioxide, nitrous oxide, and ozone. Some Indication exposed that according to the dispersal of approximately 4-5% of basic oil as the raw substance of the plastics, greenhouse gas production from a well-toward-processing plant in the year 2015 was projected 68 million tons of carbon dioxide equivalents by defining the subjective normal carbon concentration of crude oil well energy manufacture in worldwide on-stream crude oil fields in the 90 countries. Greenhouse gas production does not just come from the manufacture and production process, but similarly from the transportation and extraction of primitive substances of plastics. plastic waste management, to plastics, competing in the atmosphere. It was stated that gas Production from well to production is coordinated by the manufacturing resources themselves, usually dependent on the competence, organization, and maintenance life of tools. It was observed that when plastics were wasted, the impact and effect of plastics on the universal climate would not end. Most of its effects on climatic zones happen after the termination of its life duration. Producers use incineration, recycling, and land load methods to supervise the waste of plastics.

3. Methodology

3.1 Research Design

The research design is described as the blueprint of the study that highlights the methods, techniques, and procedures to follow. The research design is divided into qualitative, quantitative, and mixed methods. The type of design varies and depends on the research objectives and the hypothesis. However, for the current paper, the quantitative research design is selected instead of a mixed or qualitative one. This is because the researcher intended to investigate the feasibility of lean manufacturing Kaizen Teams approach to help the plastic manufacturing industry in terms of continuous improvement. The qualitative or the mixed method was not suitable for answering the research question since the hypothesis needed to be answered.

The quantitative method is a reliable way of testing the hypothesis and using the collected data to answer the research questions (Mohajan, 2020). The survey was conducted with employees working in the plastic manufacturing industry and they filled out the survey form. The rationale behind the selection of these methods is to find how the process can be improved to obtain suitable results for applying the lean manufacturing Kaizen method.

Figure 3. Research Method Honeycomb (Self-created)

Figure 3 above shows the honeycomb method used for preparing the research methodology. Since the current study focuses on the main elements, therefore, only some parts will be discussed.
Furthermore, the survey questionnaire has several benefits for research and the primary benefit is that the results can be quantified and tested through statistical methods whereas, interviews or content analysis of secondary sources cannot be tested or quantified. With the help of this quantitative method, the researcher will be able to examine the relationship between variables and how the Kaizen method is beneficial for lean manufacturing.

3.2 Sampling method and sample size

Sampling methods are defined as the selection of a population from a set of groups for gathering the data regarding the research. The sampling methods are divided into probability and non-probability methods (Berndt, 2020). Probability methods are defined as giving an equal chance of selection to the respondents whereas, in the non-probability method there is no equal chance of selection, and the selection is based on the judgment and choice of the researcher. The probability method includes random sampling whereas, in the non-probability method, the methods are convenience sampling technique and snowball sampling technique.
For the current research, the researcher opted for the non-probability method and convenience sampling technique. The major rationale behind the selection of these methods is that the researcher can approach the respondents by directly contacting the individuals instead of spending time searching for respondents. The participants of this study were willing to share their valuable opinions therefore, they agreed to fill out the survey questionnaire and answer the questions.
In comparison with other methods such as snowball sampling where the referral method is used, the convenience sampling technique is more simple and easier for the researcher to practice. In this research, both males and females participated ages between 28 years to 50 years. All the participants were employees working in plastic manufacturing companies and most of them were aware of the Kaizen method.

The sample size selected for this study was 217. Though the sample was shared with around 300 employees only 217 were filled completely. Some of the forms were not filled completely whereas, some employees marked more options or left most of the questions. Many of the approached respondents refused to fill the questionnaire therefore, only 217 complete survey forms were obtained. Studies that are conducted in similar domains have revealed that the sample size should be large enough to validate the research objective. However, it varies in qualitative studies but for quantitative, the sample size should always be large. It represents the idea or the perception of the entire population.

3.3 Data Analysis Technique

The data analysis technique involved in this study is a quantitative analysis using SPSS. The statistical testing involves correlation for checking the association between the Kaizen method and quality improvement, product improvement, customer satisfaction, employee satisfaction, and suppliers. The correlation analysis will show the association between two or more variables. Other tests include Cronbach Alpha and Demographic statistics.

3.4 Hypothesis

H1: Kaizen team analysis is positively related to quality improvement.
H2: Kaizen team analysis is positively related to product improvement.
H3: Kaizen team analysis is positively related to Customer satisfaction.
H4: Kaizen team analysis is positively related to Employee satisfaction.
H5: Kaizen team analysis is positively related to the Supplier.

4. Results and Discussion

The following section provides detailed results and discussion based on the statistical tests applied. SPSS was used to obtain the results of the survey questionnaire. These include basic demographics, descriptive statistics, and correlation.

Table 1: Public and private sector percentage

Demographic statistics

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Private sector	131	60.4	60.4	60.4
	Public sector	86	39.6	39.6	100.0
	Total	217	100.0	100.0	

The demographic statistics display the gender and the basic information of the respondents. These are presented to understand participants. Based on Table 1 above, the total sample size of this study was 217; 131 were Private, and 86 were public. The data were obtained from the respondents employed in the plastic manufacturing industry.

Table 2: Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Kaizen Method	217	.00	3.71	1.3733	.85325
Quality Improvement	217	.00	4.00	1.6083	1.03011
Product Improvement	217	.00	4.00	1.4823	.99060
Customer Satisfaction	217	.00	3.50	1.3537	.80627
Employee Satisfaction	217	.00	4.00	1.5751	.95118
Supplier	217	.00	3.50	1.5484	.81612
Valid N (listwise)	217				

Table 2 shows the descriptive statistics that provide a comprehensive summary of the dataset. The main features of this data include the average and standard deviation values. The standard deviation is the deviation of the data from the mean values whereas, the mean indicates the average responses. From the table above, it is evident that the mean or the average values lie from 1.3 to 1.5 which means that most of the respondents answered as strongly agree and agree options. On the other hand, the standard deviation also shows closeness to the mean value, and less deviation is observed in the data set. This also means that most of the points are close to the dataset.

Table 3: Correlation

Correlations

		Kaizen Method	Quality Improvement	Product Improvement	Customer Satisfaction	Employee Satisfaction	Supplier
Kaizen Method	Pearson Correlation	1	.853**	.883**	.129	.155*	.400**
	Sig. (2-tailed)		.000	.000	.057	.023	.000
	N	217	217	217	217	217	217
Quality Improvement	Pearson Correlation	.853**	1	.954**	.087	.097	.361**
	Sig. (2-tailed)	.000		.000	.199	.155	.000
	N	217	217	217	217	217	217
Product Improvement	Pearson Correlation	.883**	.954**	1	.081	.110	.398**
	Sig. (2-tailed)	.000	.000		.235	.107	.000
	N	217	217	217	217	217	217
Customer Satisfaction	Pearson Correlation	.129	.087	.081	1	.892**	.806**
	Sig. (2-tailed)	.057	.199	.235		.000	.000
	N	217	217	217	217	217	217
Employee Satisfaction	Pearson Correlation	.155*	.097	.110	.892**	1	.934**
	Sig. (2-tailed)	.023	.155	.107	.000		.000
	N	217	217	217	217	217	217
Supplier	Pearson Correlation	.400**	.361**	.398**	.806**	.934**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	217	217	217	217	217	217

**. Correlation is significant at the 0.01 level (2-tailed).

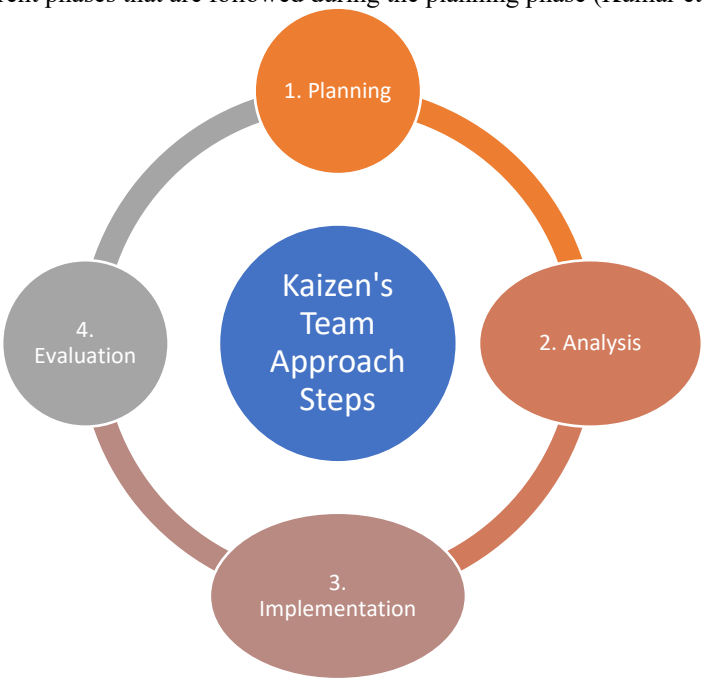
*. Correlation is significant at the 0.05 level (2-tailed).

Based on the above Table 3, it indicates the correlation values obtained after testing the association between variables. The independent variables in this study include quality improvement, product improvement, customer satisfaction, employee satisfaction, and supplier whereas, the dependent variable is the Kaizen method. The Pearson correlation value indicates the association whereas, the significance values show the Alpha value obtained. If the significance value is below 0.05 it means significance exists whereas, if the value exceeds 0.05 then, it means that there is no significance between the variables and no association exists. The Kaizen method has a high correlation with Quality improvement, with an 85.3% Pearson correlation value and 0.000 significance value. On the other hand, a low correlation exists between customer satisfaction and employee satisfaction with the Kaizen method.

4.1 Discussion

Based on the findings of the study, it was found that the researcher was successful in determining the relationship between the Kaizen technique and lean manufacturing approaches. The study was conducted with the help of the employees working in the plastic manufacturing industry. The responses were obtained from 217 respondents. The main aim of the researcher was to address and determine how the plastic manufacturing industry is able to improve its lean method implementation. The tests applied in the previous section revealed insights about the relationship or the association between the variables.

The topic was not limited but it was more focused on the feasibility of Kaizen teams and how it helps the plastic manufacturing industry with the help of continuous improvement. The process of lean manufacturing is adopted by the plastic manufacturing industry so that efficiency and productivity can be increased. Kaizen's team framework consists of four different phases that are followed during the planning phase (Kumar et al., 2022). These include:



1. Planning phase

During the planning phase, this includes the development phase for the improvement plan to meet the objectives and the goals of this process.

2. Analysis

During this phase, the analysis of the improvement process is done so that the managers or the teams ensure that the improvement process is well aligned with the Kaizen framework.

3. Implementation

The implementation phase means that the improvement opportunities are integrated well and the changes are planned accordingly.

4. Evaluation

Once the framework is implemented, it is also evaluated whether it is done correctly or not. The goal of the evaluation process is to ensure that changes made are right and on track.

5. Conclusion

This research study concluded that the use of the Kaizen team approach framework in plastic manufacturing moves towards industry 4.0 and lean Six Sigma integration in South Africa. In this research, various studies have been identified and discussed to conclude that the Kaizen framework works smoothly based on five elements. However, this study has also identified the various challenges and problems related to the plastic industry, The major challenge observed is the manufacturing of plastic products in China which sells products at cheap prices and increases the competition in the market.

References

Berndt, A.E., Sampling methods. Journal of Human Lactation, 36(2), pp.224-226, 2020.

Chen, H.L., Nath, T.K., Chong, S., Foo, V., Gibbins, C. & Lechner, A.M. 2021. The plastic waste problem in Malaysia: management, recycling, and disposal of local and global plastic waste. *SN Applied Sciences*, *3*, 1-15, 2021.

Chiarini, A. and Kumar, M., Lean Six Sigma and Industry 4.0 integration for Operational Excellence: evidence from Italian manufacturing companies. Production planning & control, 32(13), pp.1084-1101, 2021.

DTIC, South Africa plastic industry, 2023. [Online]. Available at: http://www.thedtic.gov.za/sectors-and-services-2/industrial-development/plastics/ [Accessed 8.3.2023.

Echchakoui, S. & Barka, N., Industry 4.0 and its impact in the plastics industry: A literature review. *Journal of Industrial Information Integration, 20,* p.100172, 2020. [Online]. Available at: https://doi.org/10.1016/j.jii.2020.100172.

Kolberg, D., Knobloch, J. and Zühlke, D.,. Towards a lean automation interface for workstations. International journal of production research, 55(10), pp.2845-2856, 2017.

Kumar, P., Singh, D. and Bhamu, J., Application of the Kaizen Lean approach to reduce rejections and failure costs at the Shop floor of a wire harness manufacturing company. *Indian Journal of Engineering and Materials Sciences (IJEMS)*, *29*(1), pp.116-123, 2022.

Mohajan, H.K., Quantitative research: A successful investigation in natural and social sciences. Journal of Economic Development, Environment, and People, 9(4), pp.50-79, 2020.

Shen, M., Huang, W., Chen, M., Song, B., Zeng, G. & Zhang, Y., (Micro) plastic crisis: un-ignorable contribution to global greenhouse gas emissions and climate change. *Journal of Cleaner Production*, *254*, 120138, 2020.

Shen, M., Song, B., Zeng, G., Zhang, Y., Huang, W., Wen, X. & Tang, W., Are biodegradable plastics a promising solution to solve global plastic pollution? *Environmental Pollution*, *263*, p.114469, 2020.

Tatarnikova, L.I., July. Deployment of Kaizen in the framework of implementing lean production in passenger transportation companies. In " Humanities and Social Sciences: Novations, Problems, Prospects"(HSSNPP 2019) (pp. 758-763). Atlantis Press, 2019.

Biographies

Judith Nkuna is currently a full-time Lecturer and a prospective Ph.D. student in the Department of Engineering Management at the University of Johannesburg, South Africa. She received a master's in operations management from the University of Johannesburg, her research interests include Production Engineering, Production Planning, Lean Manufacturing, Production Management, Inventory Management, Scheduling, Linear Programming, Simulation, Process Improvement, and Sustainable Management.

Andre Vermeulen is a Senior Research Associate at the Post-Graduate School of Engineering Management in the Faculty of Built and Engineering Management at the University of Johannesburg, South Africa. He earned a DPhil in Engineering Management from the University of Johannesburg and presently supervises numerous doctoral and master's students. Dr. Vermeulen completed the research project in An Analytical Instrument to Measure the Status of An Organisation Business Process Capability. His research interests include manufacturing, simulation, optimization, reliability, scheduling, manufacturing, lean, Lean-Six Sigma, and Business Process Capability. He has presented numerous papers and articles over the years at IEOM, IAMOT, PICMET, and IEEE.

Jan-Harm Pretorius obtained his BSc Hons (Electrotechnics) (1980), MIng (1982), and DIng (1997) degrees in Electrical and Electronic Engineering at the Rand Afrikaans University and an MSc (Laser Engineering and Pulse Power) at the University of St Andrews in Scotland (1989), the latter cum laude. He is a trained Baldrige (USA) and South African Excellence Foundation (SAEF) assessor. He worked at the South African Atomic Energy Corporation (AEC) as a Senior Consulting Engineer for 15 years. He also worked as the Technology Manager at the Satellite Applications Centre (SAC) of the Council for Scientific and Industrial Research (CSIR). He is currently a Professor and Head of School: Postgraduate School of Engineering Management in the Faculty of Engineering and the Built Environment. He has co-authored over 240 research papers and supervised 50 PhD and over 260 master's students. He is a registered professional engineer, professional Measurement and Verification (M&V) practitioner, a senior member of the Institute of Electrical and Electronic Engineering (IEEE), a fellow of the South African Institute of Electrical Engineers (SAIEE), and a fellow of the South African Academy of Engineering.