International Journal of Mechanical Engineering and Technology (IJMET)
Volume 9, Issue 11, November 2018, pp.2380–2388, Article ID: IJMET_09_11_253
Available online at http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=9&IType=11
ISSN Print: 0976-6340 and ISSN Online: 0976-6359

PARETO ANALYSIS OF PRODUCT QUALITY FAILURES AND COST EFFECTS IN BOTTLING MACHINES-A LEAN THINKING SOLUTION FOR ALCOHOL INDUSTRY

Enesi Y. Salawu*, Oluseyi O.Ajayi, Anthony Inegbenebor, S.A Afolalu, Ongbali Samson
Department of Mechanical Engineering, Covenant University, Ota

ABSTRACT

The study focused on sustainable optimization of production process design by employing pareto approach to identify the quality challenges of alcohol beverage packaging. The pareto approach include pareto algorithm step for identification of product defect or nonconformity associated with each line and product, pareto defect chat and cost pareto defect chat. Different nonconformity for product on each line were identified and ranked in descending order of count and cost using the pareto algorithm step. The result showed that particles and bottle chips displayed the highest number of defect count on all the three (lines). The result of the cost pareto chat also showed that the cost of particles and bottle chips occurrence in the product was high with \$16.44, \$14.25 And \$15.44 for lines 1,2 and 3 respectively. Although, other defects contributed to revenue reduction, however the cost associated with particles and bottle chips cannot be overemphasized. The application of cost pareto techniques has played a key role in developing a robust solution for sustainable process design and optimization. The analysis of different defects will help in management in developing sustainable policies for efficient production planning in practical applications.

Keyword: Bottling machines, Failures, Reliability, Production

Cite this Article: Enesi Y. Salawu*, Oluseyi O.Ajayi, Anthony Inegbenebor, S.A Afolalu and Ongbali Samson, Pareto Analysis of Product Quality Failures and Cost Effects In Bottling Machines-A Lean Thinking Solution For Alcohol Industry, International Journal of Mechanical Engineering and Technology, 9(11), 2018, pp. 2380–2388.
http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=9&IType=11

1. INTRODUCTION

Sustainability in quality manufacturing of goods is known to be an important factor in production/manufacturing sector especially in the packaging industries. The problems associated with sustainable quality production of alcohol beverages are quite enormous. To mention a few, this include low strength, high conductivity whichcan be attributed to different principle and quality factors ranging from economic to health objectives (Limleamthong and Guillén-Gosálbez, 2017). Applications of different integrated pareto optimization techniques to processes improves process quality and efficiency (Shang et al.,2016). On this note, Kim and Hong (2018), improved the quality and efficiency of seawater process treatment usingpareto optimal approach. The technique yielded efficient operation of the process, however the presence of small particles is still a great problem using this approach.Recent study showed that the adoption of the multiple objective prioritization as process design optimization technique has resulted in having different pareto points that will eventually lead to cost reductionand energy savings on the part of equipments(Wójcicki et al., 2018; Feng et al., 2016;Antipova et al., 2015; Hu et al., 2014). The development of new processes and product are faced with challenges of high cost variation depending on the processes and the product type especially in a multiple production industry. Implementation of a multi-objective pareto technique in the planning of the processes will yield better product quality(Chakraborty et al 2013;Guo et al., 2013). Further to this, Roriz et al., (2017) employed pareto analysis technique to improve the production processes of a carton manufacturing work station by reducing the set up time by 47%.Obviously, production processes involving different operating procedures can be optimized by modelling the respective procedures based on data in order to reduce reject rate and cost (Jarosz et al., 2018). Thus bringing a reduction in failure between the product and the set specification (Min et al., 2014). According to Salamati et al., (2018), there seems to be a major problem between cost and integrated production planning for a make-to-order production. Situations where an order is received after the machine commenced production becomes an issue to handle with pareto approach. adoptionofpareto efficient allocation and prioritization of the likelihood of failure occurrence has reduced cost and eliminated processes involving purification (Davis et al., 2014; Wang et al., 2017;Liu andPapageorgiou, 2018).According to Basso and Vara, (2017), bottling plants are faced with the challenges of allocating new demand from customers on a production line which have commenced production due to different products and variations in sizes to be produced as well as the set up time involved. Allocating new production plan will eventually hamper the reliability analysis and a better method of identifying failures (Tsarouhas and Arvanitoyannis, 2010). Although effort to employ envelopment technique and multi-objective decision approach has increased the sustainability of processes as well as reliability of production equipment (Theis et al., 2018;Perez-Gonzalez andFraminan). More so, adopting a better production scheduling will create some sustainable management policies that will lead to great savings in production cost and energy consumed (Akbar andIrohara, 2018).Further to this, sustainable management decisions will lead to process improvement and competitive advantage in terms of the market because of loss reduction and stable quality improvement (Silva et al., 2017; Nagy et al., 2018). From previous discourse, sustainability of processes using multiobjectivepareto technique has been the focus of most research. Considerations of failure of material during processing which lead to poor quality and high reject rate of products has not been given due attention. Therefore, the focus of this study is to highlight the major and minor failures associated with packaging of alcohol beverages based on data, analyse the failure rate and economic effect using pareto nonconformity approach. The result will guide management on the need to make adequate policies guiding quality materials acquisition for effective and efficient production.

2. PROBLEM DEFINITION

Packaging machines especially alcohol beverage packagingis faced with numerous quality problems such as presence of bottle chips or particle in already bottled products, low strength, high strength or conductivity, bend labels cut or freewheeling cap and many more. These failures in quality characteristics are either inspected into product or after the product has reached the final stage of production. The failures in materials used for production have associated cost which eventually decreases productivity, loss of customers due to competition and in some situations, ethic crisis set in (Yekini et al 2018). This can lead to an eventual shut down of companies in this category. Therefore, an assessment of the quality issues and the cost involved becomes a necessity using cost pareto approach.

3. METHODOLOGY

Three different lines producing different products were selected for this study. Pareto algorithm charting principles were employed in this study. The number of nonconformity or defects associated with each line were analysed and recorded while. The defect count for each of the defect type was sorted and recorded in descending order. the cost was calculated based on the cost of each material contributing to the product reject rate.

Cost Pareto charting Algorithm steps used for all the defect types

Step1**.** List of costs defects including types or causes were obtained

Step2. The costs of defects type were added together

Step 3. The defects and defect cost were arranged in descending order

Step. 4Bar chart of each defects count and cost associated with it was obtained

Table 1, presents the lines and product defect types.

Table 1 List of Defects

S/No	LINE 1	LINE2	LINE3
1	Product high strength	Product high strength	Product high strength
2	Low strength of product	Low strength of product	Low strength of product
3	Product colour variation	Product colour variation	Product colour variation
4	Presence of particles or bottle chips	Presence of particles or bottle chips	Presence of particles or bottle chips
5	Cut cap or freewheeling cap	Compressed pet bottles	Cut cap or freewheeling cap
6	Bend label	Cut cap or freewheeling cap	Bend label
7		Bend label	

The defect count and cost on each line were evaluated using pareto algorithm while the relationship between the defect count and defects as well as the variation in the cost of each defect are displayed in Figs. 1 to 6.

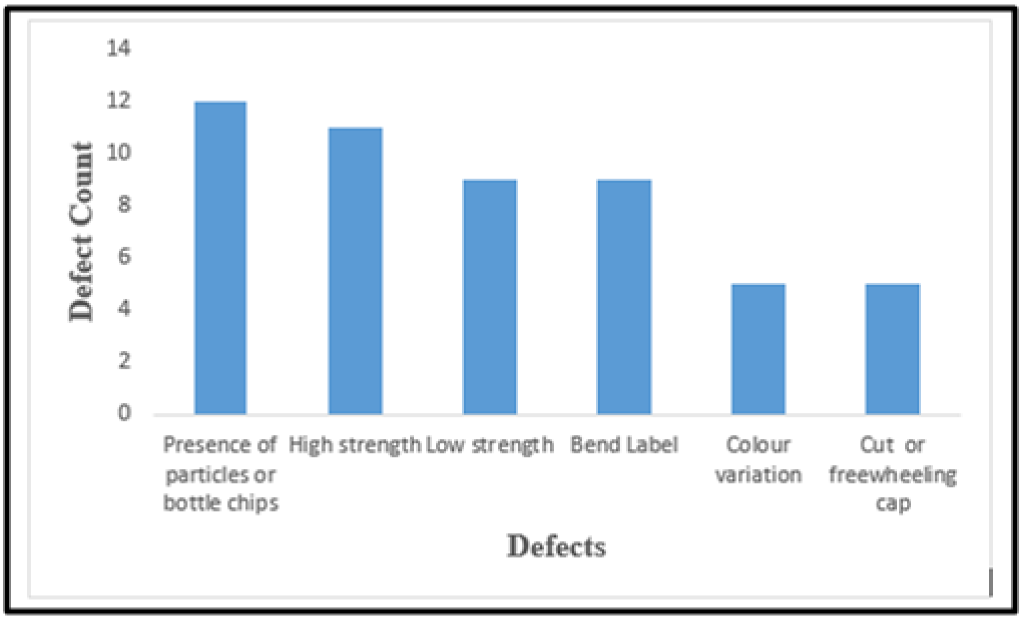

Fig1. Pareto chart of Defect count for Line 1

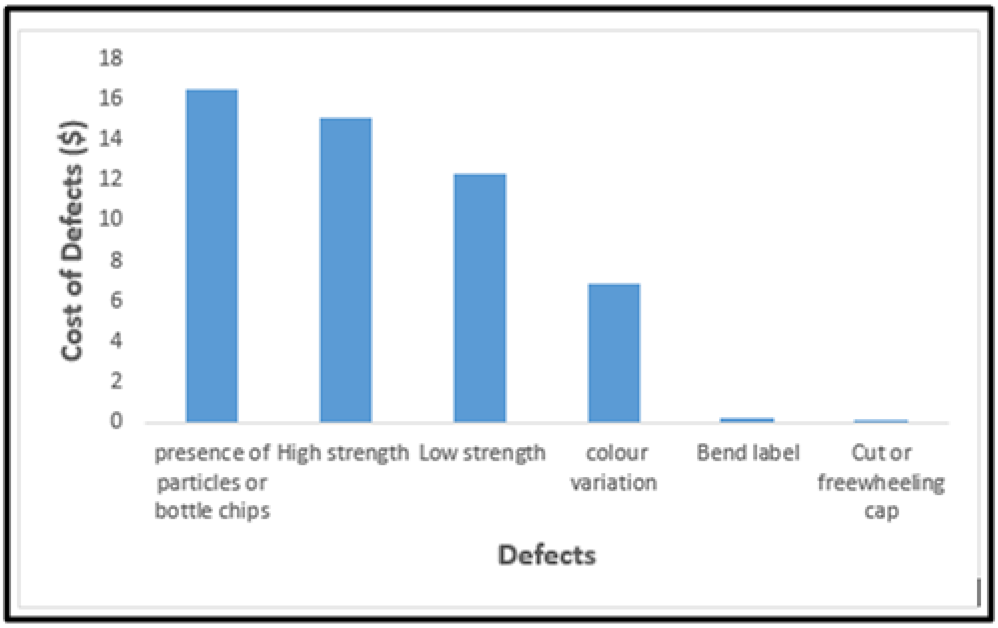

Fig2. Cost Pareto chart of Defects for Line1

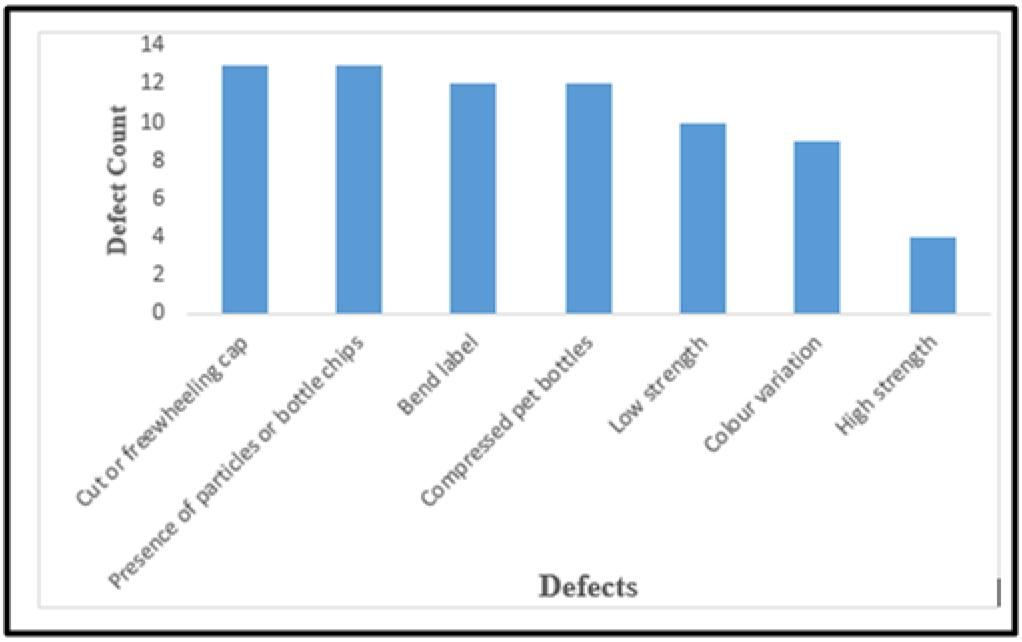

Fig 3. Pareto chart of Defect countfor Line 2

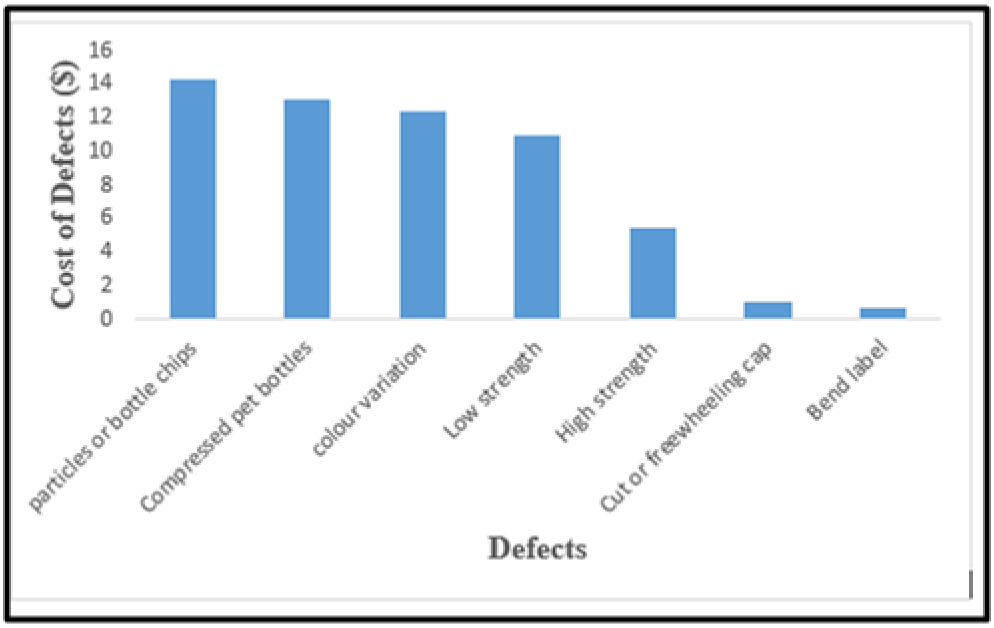

Fig 4. Cost Pareto chart of Defectsfor Line 2

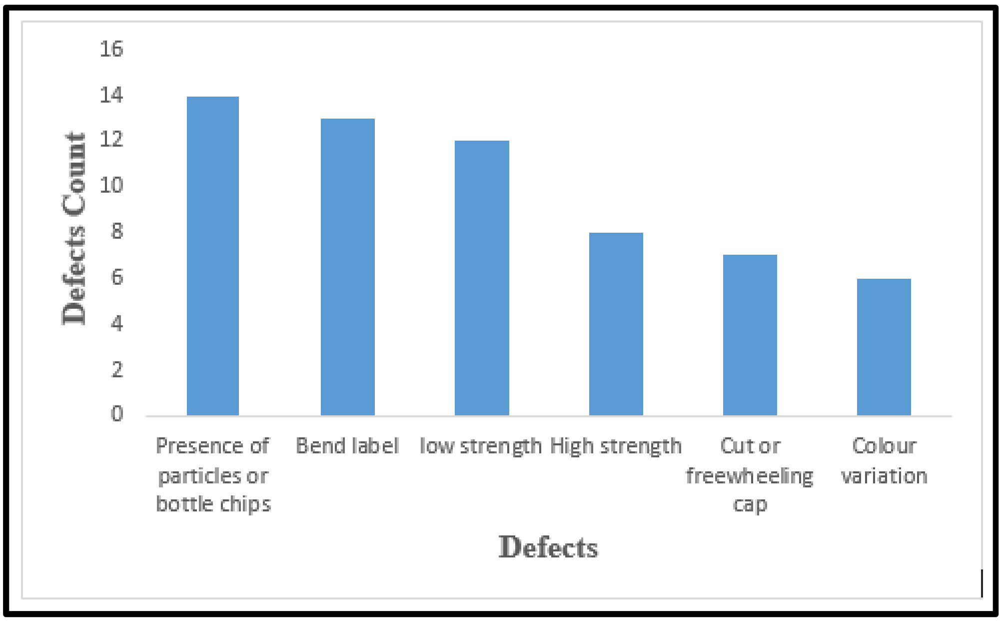

Fig 5. Pareto chart of Defect count for Line 3

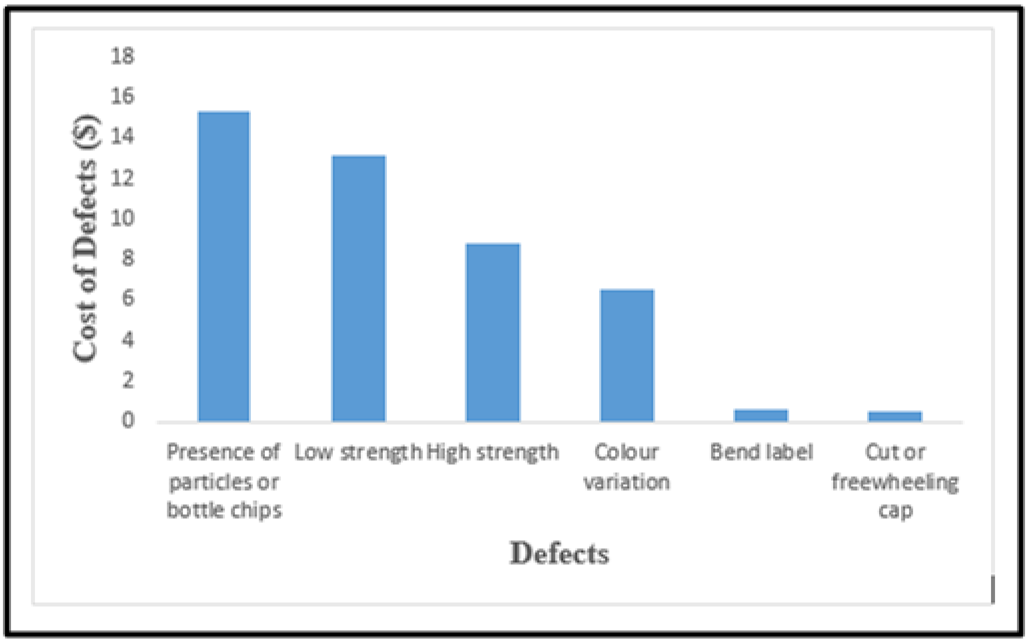

Fig 6. Cost Pareto chart of Defectsfor Line 3

4. RESULTS AND DISCUSSION

Figures1, presents the plot of defects count against the defect types while fig2.presents variation of cost of defects with the defect types for line 1. From fig1, it could be depicted from the chart that particles or bottle chips contributed the highest defect count on the line which is about 12followed by high strength with a defect count of 11 while the least was cut cap problem having5 count. The particle problems can be attributed to blending processing techniques or filtration problems during product transport while the high strength was due to improper selection of blending process parameters. Also the bottle chips were due to materials not meeting the standard as requested by the quality control and this also poses a great challenge to the packaging machines. More so, it can be seen from figure2 that particles and bottle chips presence had the highest cost of about $16.44 owing to the defect count and the cost of each count.

On the same hand, figures3-4 presents the defect counts and cost of defects for the production line2. Obviously, cut or freewheeling cap contributed to the highest defects on the line as well as particles or bottle chips having a cumulative of 26 counts. However, fig4 showed that particles or bottle chips presence and compressed pet bottles contributed to a total cost of $27.40 on production line 2. On average the line had revenue reduction of about $58.84 in less than two hours' operation considering all the identified defects. Furthermore, figures5-6 represents the pareto plot of defect counts and cost of each defect for production line 3. The frequency of particles or bottle chips occurrence in the product was recorded to be 14times followed by bend label which gave a total count of 13times.Further to this, figure3 presented the cost effects of the defects and it can be seen that particles and bottle chips contributed to revenue reduction by $15.44 as well as low strength having a total cost of about $13.15.

The study first analyse the defects and the frequency of defect occurrence on each line before presenting the result in pareto defect chart and cost pareto defect for each line. The contribution of each defect to the quality process have been presented. As seen from the figures, presence of particles and bottle chips has the highest count of defects and this had affected the quality inbuilt of the process and overall product quality. The implication is that, particles or bottle chips constitute a major process downtime and product waste, especially in situations where the product have been completely packaged. This will also constitute ethical issues to the company if customers detect the defect.

5. CONCLUSION

In this study, we employed the concept of paretooptimization techniques in robust analysis of quality defects associated with alcohol beverage packaging. This include pareto algorithm steps, pareto defect count chat and the cost pareto defect chat. The pareto algorithm has played a key role in making it easy to identify the product defects and its effects while the pareto chart helped in achieving the defect or nonconformity that contributed to the variation in product quality and revenue reduction. Application of the technique has revealed a robust quality issues on each line and the result showed that presence of particles and bottle chips contributed the highest defect count and cost. Cost Pareto technique has given a clear comprehension of different quality problems associated with packaging processes and solutions. Invariably, understanding of cost pareto technique provides access to better production process optimization and this has key role in quality sustainable process design and decision making.

ACKNOWLEDGEMENT

The authors appreciate the financial support of Covenant University towards the success of the research.

REFERENCE

[1] Akbar, M., &Irohara, T. (2018). Scheduling for sustainable manufacturing: A review. *Journal of Cleaner Production*.

[2] Antipova, E., Pozo, C., Guillén-Gosálbez, G., Boer, D., Cabeza, L. F., & Jiménez, L. (2015). On the use of filters to facilitate the post-optimal analysis of the Pareto solutions in multi-objective optimization. *Computers & Chemical Engineering*, *74*, 48-58.

[3] Basso, F., &Varas, M. (2017). A MIP formulation and a heuristic solution approach for the bottling scheduling problem in the wine industry. *Computers & Industrial Engineering*, *105*, 136-145.

[4] Chakraborty, S., Pal, M., &Nayak, P. K. (2013). Intuitionistic fuzzy optimization technique for Pareto optimal solution of manufacturing inventory models with shortages. *European Journal of Operational Research*, *228*(2), 381-387.

[5] Davis, K. O., Brooker, R. P., Seigneur, H. P., Rodgers, M., Rudack, A. C., &Schoenfeld, W. V. (2014). Pareto analysis of critical challenges for emerging manufacturing technologies in silicon photovoltaics. *Solar Energy*, *107*, 681-691.

[6] Feng, L., Mears, L., Beaufort, C., & Schulte, J. (2016). Energy, economy, and environment analysis and optimization on manufacturing plant energy supply system. *Energy Conversion and Management*, *117*, 454-465.

[7] Guo, Z. X., Wong, W. K., Li, Z., & Ren, P. (2013). Modeling and Pareto optimization of multi-objective order scheduling problems in production planning. *Computers & Industrial Engineering*, *64*(4), 972-986.

[8] Hu, X. B., Wang, M., Ye, Q., Han, Z., & Leeson, M. S. (2014). Multi-objective new product development by complete Pareto front and ripple-spreading algorithm. *Neurocomputing*, *142*, 4-15.

[9] Jarosz, P., Kusiak, J., Małecki, S., Morkisz, P., Oprocha, P., Pietrucha, W., &Sztangret, Ł. (2018). An attempt of optimization of zinc production line. *Archives of Civil and Mechanical Engineering*, *18*(4), 1116-1122.

[10] Kim, J., & Hong, S. (2018). Optimizing seawater reverse osmosis with internally staged design to improve product water quality and energy efficiency. *Journal of Membrane Science*.

[11] Limleamthong, P., &Guillén-Gosálbez, G. (2017). Rigorous analysis of Pareto fronts in sustainability studies based on bilevel optimization: Application to the redesign of the UK electricity mix. *Journal of Cleaner Production*, *164*, 1602-1613.

[12] Liu, S., &Papageorgiou, L. G. (2018). Multi-objective Optimisation for Biopharmaceutical Manufacturing under Uncertainty. *Computers & Chemical Engineering*.

[13] Min, B., Kang, J. M., Chung, S., Park, C., & Jang, I. (2014). Pareto-based multi-objective history matching with respect to individual production performance in a heterogeneous reservoir. *Journal of Petroleum Science and Engineering*, *122*, 551-566.

[14] Nagy, B., Farkas, A., Magyar, K., Démuth, B., Nagy, Z. K., &Marosi, G. (2018). Spectroscopic characterization of tablet properties in a continuous powder blending and tableting process. *European Journal of Pharmaceutical Sciences*, *123*, 10-19.

[15] Perez-Gonzalez, P., &Framinan, J. M. (2014). A common framework and taxonomy for multicriteria scheduling problems with interfering and competing jobs: Multi-agent scheduling problems. *European Journal of Operational Research*, *235*(1), 1-16.

[16] Roriz, C., Nunes, E., & Sousa, S. (2017). Application of Lean Production Principles and Tools for Quality Improvement of Production Processes in a Carton Company. *Procedia Manufacturing*, *11*, 1069-1076.

[17] Salamati, H., Zhang, Z. H., Zarei, O., &Ramezanian, R. (2018). Trade-off between the costs and the fairness for a collaborative production planning problem in make-to-order manufacturing. *Computers & Industrial Engineering*.

[18] Shang, K., Feng, Z., Ke, L., & Chan, F. T. (2016). Comprehensive Pareto Efficiency in robust counterpart optimization. *Computers & Chemical Engineering*, *94*, 75-91.

[19] Silva, A. S., Medeiros, C. F., & Vieira, R. K. (2017). Cleaner Production and PDCA cycle: Practical application for reducing the Cans Loss Index in a beverage company. *Journal of Cleaner Production*, *150*, 324-338.

[20] Sunday A. Afolalu, Enesi Y. Salawu, KehindeOluyemi , Samuel U. Ayuba, Ikechi V. Ihebom and Remilekun R. Elewa. (2018). Failure Mode and Effect Analysis a Tool for Reliability Evaluation: Review. *European Journal of Engineering Research and Science Vol. 3, No. 4, April2018*

[21] Thies, C., Kieckhäfer, K., Spengler, T. S., &Sodhi, M. S. (2018). Operations Research for sustainability assessment of products: A review. *European Journal of Operational Research*.

[22] tool energy optimization. *Journal of Cleaner Production*.

[23] Tsarouhas, P. H., & Arvanitoyannis, I. S. (2010). Assessment of operation management for beer packaging line based on field failure data: A case study. *Journal of food engineering*, *98*(1), 51-59.

[24] Wang, H., Zhang, R., Peng, J., Wang, G., Liu, Y., Jiang, H., & Liu, W. (2017). GPNBI-inspired MOSFA for Pareto operation optimization of integrated energy system. *Energy Conversion and Management*, *151*, 524-537.

[25] Wójcicki, J., Bianchi, G., &Tolio, T. (2018). Hierarchical modelling framework for machine

[26] Yekini, S. E., Okokpujie, I. P., Afolalu, S. A., Ajayi, O. O., &Azeta, J. (2018). Investigation of production output for improvement. *International Journal of Mechanical and Production Engineering Research and Development*, *8*(1), 915-922.