Vol. XV & Issue No. 11 November - 2022
INDUSTRIAL ENGINEERING JOURNAL

AN EMPIRICAL ANALYSIS OF RE-ENGINEERING STRATEGY USING BEST-WORST METHOD

Ankur Das
Dr. Santanu Das

Abstract

In recent times, Re-engineering or organizational redesign plays an important role in sustainable development of different products. An appropriate re-engineering strategy ensures green product development of a company. In this context, a multi-criteria decision making approach is considered in order to achieve the environmentally sustainable product development of a pump manufacturing organization in India. A strategic frame work is designed to execute the multi criteria decision making approach. Different pump components are considered for the new product development purpose. The best-worst method is applied as a multiple criteria based re-engineering decision making model of the pump manufacturing company. This method is a linear optimization model for decision making approach. Different criteria have effectively been chosen in pump manufacturing context to select green products for pump manufacturing. Among all criteria, 'best' and 'worst' criteria are proposed according to the importance of sustainable developments of industrial pumps. Criteria weights for different pump components have been computed by the best-worst method. In this work, a strategic analysis or 'strategy canvas' is plotted to select the suitable components for pump manufacturing. This methodology offers a systematic method of green components selection in new product development consequences.

Keywords: Re-engineering, green product development, multi criteria, best-worst method, pump manufacturing, strategy canvas.

INTRODUCTION

Manufacturing companies are required to be competitive enough in environmental perspective as well as profitability. Re-engineering or new product development strategy has gained tremendous exposure in the context of sustainable manufacturing. Kwak and Lee (2002) applied multi criteria mathematical programming model to develop business process infrastructure of a health care based organization. Earnawati and Pujawan (2015) proposed a multi criteria decision making model to evaluate the alternative product designs against customer aspirations, manufacturability, supply chain perspective and environmental sustainability. This model was applied to ensure the appropriate alternative design of a home electronics manufacturing company. Zomparelli et al. (2018) described a model for a multiple criteria based re-engineering decision making and simulation of an Italian manufacturing company. The decision making model was computed by AHP technique. The simulation model was solved with flexism software. Mendoza et al. (2014) introduced a business process re-engineering methodology to support the supply chain management system of a company. The re-engineering frame work ensures the supply chain integration also. The business proposes re-engineering accomplished with different simulation studies. Balan (2017) developed a simulation model to evaluate the performance of business process in ceramics manufacturing. Decision makers can implement appropriate re-engineering strategy with the GPSS simulation model. Re-engineering strategy plays an important role in supply chain as well as inventory management system also. It enables to reduce the inventory costs and procurement lead time of raw material inventory items. Dachyar and Novita (2016) designed a business process re-engineering strategy of the inventory management system for a pharmaceutical company.

Product design or alternative design of a product is an important criterion in new product development purpose. Therefore, proper decision making strategy is required in product design consideration to fulfill the demand of today's competitive market. Steiner (2010) proposed a Stakelberg-Nash model for decision making in new product design which optimizes the production cost to achieve more profit in business. Hong et al. (2018) studied a supply chain formation model for environmentally sustainable product development. The supply chain model was solved by spanning tree based algorithm. Furthermore, Particle swarm optimization technique was implemented to select the appropriate supply chain structure. Fraccascia et al. (2018) contributed to the policy making of an eco-friendly product development process. The policy makers offered green product development which was more competitive in business perspective. Nowadays, Sustainable design of a product deals effectively in green product development. Chen (2001) proposed a decision making model to analyze the strategy of economic and environmentally sustainable product development. Jabbour et al. (2014) represented a frame work of green product development considering different technical features of a Brazilian company.

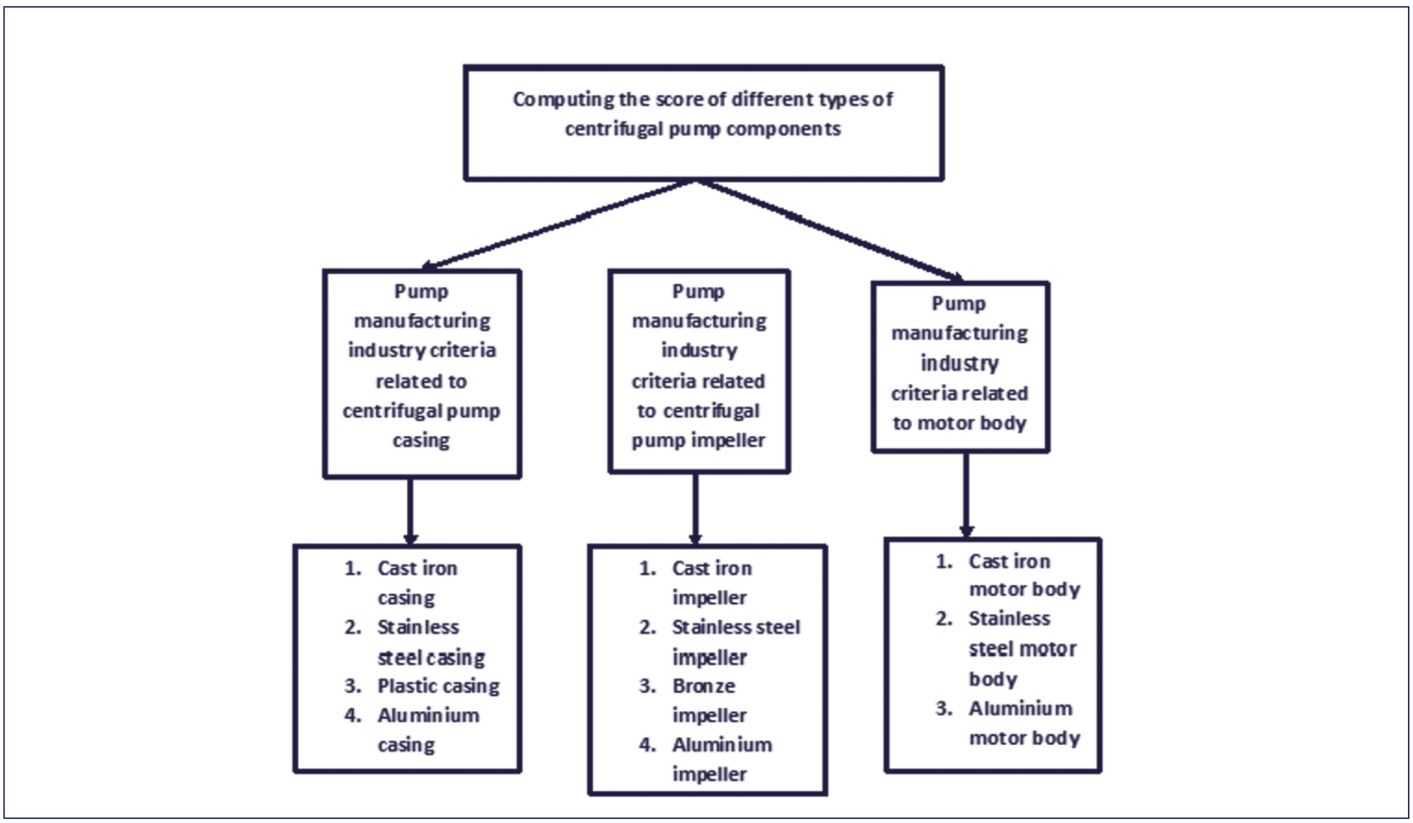
Appropriate Decision making approach plays a vital role in re-engineering or new product development perspective. Rezai (2015) proposed a decision making technique where multiple criteria and different alternatives were considered. The best and worst criteria were chosen among all criteria in decision making problem. A maximization problem was then computed to determine the weights of all criteria. Finally, weights of different alternatives were calculated based on the best and worst criteria were carefully chosen. Furthermore, a linear best-worst method (2016) was implemented in group decision making approach to get more consistent results. Vaan de Ka et al. (2017) applied best-worst method to select the appropriate biomass conversion technology in Netherland based organization. Several factors were considered to develop a strategic frame work in technological domain. Malek and Desai (2019) prioritized the sustainable manufacturing system for an Indian organization where best-worst method was applied as a multi attributes based decision making technique. Khanmohammadi et al. (2019) proposed a strategy making tool for a tire manufacturing company in Ireland. Fuzzy best-worst method was applied to draw a comparison with different components required in the tire manufacturing organization. The comparative analysis of decision making was plotted graphically which was termed as 'Strategy Canvas'.

RESEARCH BACKGROUND

In today's competitive world, environment sustainability is an emerging issue along with the cost effectiveness for different manufacturing organizations view point. Re-engineering of manufacturing components or new product development in green environment is required to meet the customer's demand. Therefore, re-engineering decision making is important measure in new product development. In this work, several components related to centrifugal pump manufacturing like casing, impeller and motor body are considered in re-engineering decision making for an Indian pump manufacturing organization. There fore,a multi criteria decision making technique is required to ensure the appropriate re-engineering strategy for green development of pump products. Component costs, weight, recyclability and resistivity to corrosion are identified as the criteria for decision making analysis.

This paper aims at a comparative analysis of different centrifugal pump components based on re-engineering decision making, or green product development, of an East Indian pump manufacturing company. Pump components made by different eco-friendly and cost effective materials (cast iron components, stainless steel components, aluminium components, plastic components and bronze components) are chosen for the analysis. A graphical representation is incorporated with the computed results of decision making technique which ensures selection of the best suited components for pump design. The graphical representation is termed as a 'Strategy canvas'.The main motto of this work is represented with a block diagram in Figure 1.

Figure 1: Problem structure of re-engineering decision making for an Indian pump manufacturing company



METHODOLOGY ADOPTED

Linear model of best-worst method is applied in this work in strategic decision making for re-engineering. Decision makers recognize 'n' criteria to analyze the decision making problem.

The best or most important criterion and the worst or least important criterion are chosen for the analysis. The preference of best criterion is given over other criteria, with a number between 1 and 9. The priority vector of best criterionor best-to-others vector is represented as:

$A_B = (a_{B1}, a_{B2, ...,} a_{Bn)}$

Where, a_{Bj} represents the preference of best criterion 'B' over criterion 'j'.

Similarly, the preference of worst criterion is given between 1 to 9 scales. The priority vector of worst criterion or others-to-worst vector is represented as below:

$A_W = (a_{1W}, a_{2W}, \ldots\ldots\ldots, a_{nW})$

Where, preference of criterion 'j' over the worst criterion 'W' is denoted as a_{Jw}.

Optimal weight sare computed with this linear min-max model:

$\min\max j \{|w_B - a_{Bj}\, w_j|, |w_j - a_j w\, w_w|\}$

Stated that, $\sum_j w_j = 1$; where, $w_j \geq 0$

The linear model can be written as:

$|w_B - a_B j\, w_j| \leq \xi L$, for all j

$|w_j - a_j w\, w_w| \leq \xi L$, for all j

Where, $w_j \geq 0$

Where,

The optimum weights $(w_1, w_{2,\ldots\ldots} w_n)\xi^L$ are acquired from this linear decision making model. In this model, ξ^L can be an indicator of consistency level. The minimum positive integer values of ξ^L indicates more consistency level in this decision making approach.

Moreover, a 'Strategy canvas' is plotted with these computed weights of multiple attributes based on the different criteria are considered in this analysis.

RESULTS & DISCUSSION

Four criteria are selected for decision making for new product design for the pump manufacturing organization.The criteria are described in Table 1.

Table 1: New product design criteria for pump components

Criteria	Description	Centrifugal pump casing	Centrifugal pump impeller	Motor body
Cost	Cost of centrifugal pump components	CC1= Best criterion	CI1= Best criterion	CM1= Best criterion
Weight	Weight of centrifugal pump components	CC2	CI2	CM2
Recyclability	Recyclable characteristics of the centrifugal pump components	CC3= Worst criterion	CI3= Worst criterion	CM3= Worst criterion
Corrosion resistance	Corrosion resistance property of centrifugal pump components	CC4	CI4	CM4

Table 2: Criteria weights computed for each centrifugal pump components

Criteria	Pump casing	Impeller	Motor body
Cost	0.543	0.559	0.484
Weight	0.22	0.152	0.253
Recyclability	0.07	0.084	0.092
Corrosion resistance	0.165	0.203	0.169

Table 2 shows the computed criteria weights by linear best-worst method for centrifugal pump casing, impeller and motor body. The Product cost is more important criterion for all pump components to meet the demand of highly competitive environment of manufacturing organizations as well as customer's perspective. Light weights of products lead to low power consumption in working of a centrifugal pump. Therefore, it enhances the requirement of utilization of minimum resources in green product development view point. Recyclability of pump components is necessary for utilization of minimum resources in manufacturing purpose as well as cost effective also. The corrosion phenomenon in different materials leads to erosion or damage of the products. So, the materials used in centrifugal pump components must have corrosion resistance property. In this context, product weight and recyclability are more important criteria rather than corrosion resistance property in environmentally sustainable product development scenario.

Table 3: Comparison among criteria weights of different pump products

Pump components	Criteria	Cast iron components	Stainless steel components	Aluminium components	Plastic components	Bronze components
Pump casing	Cost	0.559	0.484	0.5	0.484	------------
	Weight	0.152	0.169	0.25	0.253	
	Recyclability	0.203	0.092	0.166	0.092	
	Corrosion resistance	0.084	0.253	0.083	0.169	
Impeller	Cost	0.529	0.5	0.522	-------------	0.544
	Weight	0.137	0.136	0.27		0.154
	Recyclability	0.254	0.09	0.135		0.093
	Corrosion resistance	0.078	0.272	0.072		0.206

Motor body	Cost	0.559	0.513	0.559	-------------	-------------
	Weight	0.152	0.135	0.203		
	Recyclability	0.203	0.081	152.		
	Corrosion resistance	0.084	0.27	0.084		

Table 3 represents the overall results of the decision making technique in different pump components.

Cast iron pump casing is more cost effective and recyclable from casings made by stainless steel, aluminium and plastic. The plastic casing is lighter in weight from other casings. Aluminium casing is lighter in weight from other metal casing like stainless steel casing and cast iron casing. Stainless steel casing and plastic casing have more corrosion resistance characteristics from the casings made by cast iron and aluminium.

Similarly, the importance of impellers made by different materials is analyzed based on the criteria chosen for green product design view point. Here, impeller made by bronze and cast iron is more cost effective. Aluminium impeller is lighter in weight. Cast iron impeller is more recyclable and stainless steel impeller is more corrosion resistive from other impellers.

In this context, motor body made by cast iron and aluminium are more competitive in terms of cost. Aluminium motor body is lighter in weight and cast iron motor body is more recyclable from the motor bodies made by cast iron and stainless steel. The stainless steel motor body has good resistance to corrosion phenomenon from other motor bodies.

Figure 2: Strategy canvas for different centrifugal pump casings

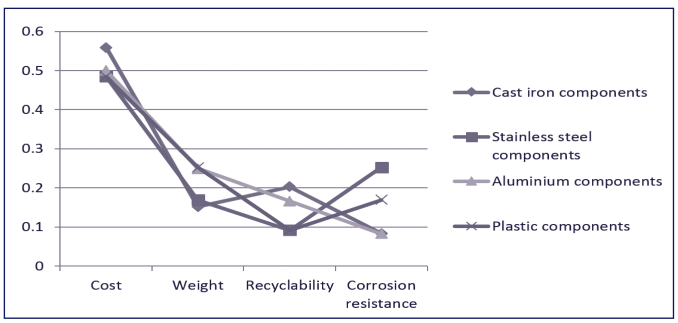


Figure 2 shows the graphical representation of criteria weights of different pump casings. This frame work or 'strategy canvas' suggests the incremental trends of appropriate pump casing items in green product design consequence.

Figure 3: Strategy canvas for different centrifugal pump impellers

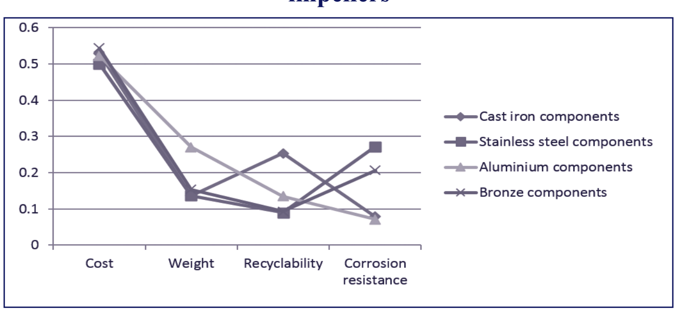
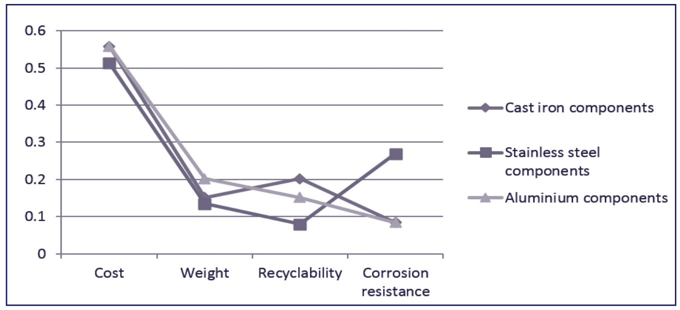


Figure 3 represents the graphical trends of computed weights of different pump impellers. These trends give an indication to the appropriate selection of pump impeller which contributes to the green product development purpose.

Figure 4: Strategy canvas for different motor bodies



The calculated weights for different motor bodies are plotted in Figure 4. The graphical trends represent the cost effective, light weight, recyclable and corrosion resistive motor bodies in the perspective of decision making in re-engineering.

CONCLUSION

In this work, a systematic approach of designing a new product development strategy is proposed. Environmentally sustainable and cost effective pump components are selected for the purpose of green product development. Linear best-worst method is applied in this re-engineering decision making problem. Component cost is selected as one of the decision making criteria with higher importance in re-engineering design. Other criteria like component weight, recyclability and resistivity to corrosion are chosen in the view point of environmentally sustainable product development. Individually, the criteria weights are calculated where 'cost' is selected as the best criterion and 'recyclability' is chosen as the worst criteria. Furthermore, the weights of different casings, impellers and motor bodies are computed considering the four criteria chosen for decision making problem. Cast iron casing is more acceptable from other casings in terms of cost effectiveness and recyclability although it is heavy in weight. Bronze impeller is highly cost effective and corrosion resistive. Therefore, bronze impeller is more suitable in green manufacturing view point of a centrifugal pump. Similarly, the re-engineering design shows that Aluminium motor body is more cost effective and lighter in weight from cast iron and stainless steel motor body. The strategy canvas frame work displays the green characteristics of pump components properly.

Moreover, the present work may be continued with the real time application of other decision making techniques of re-engineering decision making as well as green product development. Re-engineering techniques for the new product development can be proposed with different simulation approaches.

REFERENCES

1) *Chen C (2001), "Design for the Environment: A Quality-Based Model for Green Product Development", International journal of management science,Vol.47(2), 2001 pp250-263.*

2) *Jabbour C J C, Jugend D, Jabbour A B L S, GunasekaranA & Latan H (2014), "Green product development and performance of Brazilian firms: measuring the role of human and technical aspects", Journal of cleaner production,2014 pp1- 10.*

3) *Ernawati D, Pujawan I, Batan I M L & Anityasari M (2015), "Evaluating alternatives of product design: a multi criteria group decision making approach", International journal of services and operations management, Vol.20, 2015 pp 271-288.*

4) *Khanmohammadi E, Zandieh M & Tayebi T (2019), "Drawing a Strategy Canvas Using the Fuzzy Best–Worst Method". Global journal of flexible system management, Vol.20, 2019 pp 57-75.*

5) *Vaan de Kaa G, Kamp L & Rezaei, J (2017), "Selection of biomass thermochemical conversion technology in the Netherlands: a Best Worst Method approach", Journal of cleaner production, Vol.166, 2017 pp 32-39.*

6) *Rezaei J (2015), "Best-worst multi-criteria decision-making method", Omega, Vol.53, 2015 pp 49-57.*

7) *Rezaei J (2016), "Best-worst multi-criteria decision-making method: Some properties and a linear model", Omega, Vol.64, 2016 pp126-130.*

8) *Malek J & Desai T N (2019), "Prioritization of sustainable manufacturing barriers using Best Worst Method", Journal of cleaner production, Vol.226, 2019 pp 589-600.*

9) *Mendoza J, Neailey K, & Roy R (2014),"Business process re-design methodology to support supply chain integration", International journal of information management, Vol.34,2014 pp 167-176.*

10) *Fraccascia L, Giannoccaro I & Albino V (2018), "Green product development: What does the country product space imply?", Journal of cleaner production,Vol.170,2018 pp1076-1088.*

11) *Dachayar M & Novita G (2016), "Business process re-engineering of logistics system in pharmaceutical company", ARPN journal of engineering and applied sciences, Vol.11(7), 2016 pp4539-4546.*

12) *Zomparelli M, Petrillo L, Salvo B D & Petrillo A (2018), "Re-engineering and Relocation of manufacturing process through a simulative and multicriteria decision model", Proceedings of International federation of automatic control, Vol.51(11), 2018 pp1649-1654.*

13) *Kwak N K & Lee C W (2002), "Business process reengineering for health-care system using multicriteria mathematical programming", European journal of operational research, Vol.140, 2002 pp447-458.*

14) *Balan S (2017), "Using simulation for process reengineering in refractory ceramics manufacturing—a case study", International journal of advance manufacturing technology, Vol.93, 2017 pp1-10.*

15) *Raghunathan V, Ranganathan R & Palanisamy M (2021), "An efficient supplier selection model for the pump industry through best-worst method", International Journal of Services and Operations Management, Vol.38(3), 2021 pp360 – 378.*

16) *Steiner W J (2010), "A Stackelberg-Nash model for new product design", OR spectrum, Vol.32, 2010 pp21-48.*

17) *Hong Z, Dai W, Luh H & Yang C (2018), "Optimal configuration of a green product supply chain with guaranteed service time and emission constraints", European journal of operational research, Vol.266(2), 2018 pp663-677.*

AUTHORS

Ankur Das, Assistant Professor, Department of Mechanical Engineering, Global Institute of Management & Technology, Krishnanagar- 741102, West Bengal, India.

Research Scholar, Department of Mechanical Engineering, Kalyani Govt. Engineering College, Kalyani - 741235, West Bengal, India.

Dr. Santanu Das, Professor and Head, Department of Mechanical Engineering, Kalyani Govt. Engineering College, Kalyani - 741235, West Bengal, India.
Email: sdas.me@gmail.com