

Factors influencing the remanufacturing of electrical and electronics products in India: A SWOT-AHP approach

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Abstract. Electronic waste (e-waste) in India is increasing rapidly which may cause severe health hazard and environment problems. Remanufacturing seems to be one of the method which may lead to sustainable production. The concept of remanufacturing is well recognized and practiced in the countries like UK,USA and Japan. In India it is still in nascent stage. This provide the opportunities for researchers to analyze the factors which may influence the remanufacturing in India. A hybrid model based on SWOT analysis and AHP is formed to identify the critical and most critical factors affecting remanufacturing of electrical and electronics products (EEP) in India after surveying the EEP companies and taking the inputs from experts.

1. Introduction

Remanufacturing is a process of converting the end-of-use (EOU) and end-of-life (EOL) product to at least its original performance with a warranty that is equivalent or better than that of brand new product supplied by the Original Equipment Manufacturer (OEM).Figure 1 shows the steps involved in remanufacturing. The returned product is dismantled, cleaned, inspected, refurbished, reassembled and tested to be used again [1]. The present method of taking out raw material from earth, manufacturing them into products and then disposing of them into landfills or incineration after use is not sustainable[2]. In the light of increasing environmental consciousness, social awareness, stricter legislation and economical advantage, remanufacturing becomes inevitable.

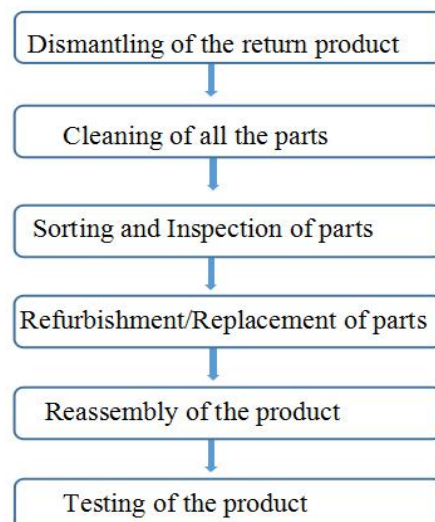


Figure-1. Steps involved in remanufacturing



Remanufacturing is well-developed in the USA and UK occurring across a diverse range of industry sectors. Remanufacturing business in US is more than \$ 53 billion annually while in UK it is greater than £5 billion annually. Companies like Xerox, IBM Europe, Fuji film, Kodak, Caterpillar, BMW, Volkswagen, and Ford Motors are adopting remanufacturing practices[3].

India is emerging as one of the world's major e-waste producer, causing serious problems to public health and environment. India generates roughly 18 lakh metric tons of electronic waste each year which makes him fifth largest producer of e waste. India's 'production' of e-waste may increase from the existing 18 lakh metric tons to 52 lakh metric tons per annum by 2020 at a compound annual growth rate (CAGR) of about 30% [4]. Top 10 states of India which produced maximum of e-waste in 2015 are Andhra Pradesh (AP), Maharashtra (MH), Tamilnadu (TN), Uttar Pradesh (UP), West Bengal (WB), Karnataka (KN), Gujarat (GJ), Delhi (DL), Madhya Pradesh (MP) and Punjab (PB)[5]. Percentage e-waste generation by top 10 states of India is shown in Figure-2.

According to notification issued from the ministry of environment regarding e-waste management rules 2016, producers will be first time covered under extended producers' responsibility (EPR). Rules suggests that 30 percent of the waste generated under EPR should be collected in the first two years, moving to 70 percent in the seventh year of the rule[6].

From the literature, it is observed that remanufacturing practice is at evolving state in India and exploration opportunities are very high in the remanufacturing system[7]. This motivates us to study about the current status and major influencing factors in adoption of remanufacturing practices by Indian manufacturing industry with special reference to electrical and electronics products (EEP). To the best of our knowledge, this has not been addressed in the existing literature. Hence the study address the following research question.

- What are the opportunities and threats in remanufacturing business in India especially for EEP?
- What is the perception of manufacturer towards remanufacturing in India?

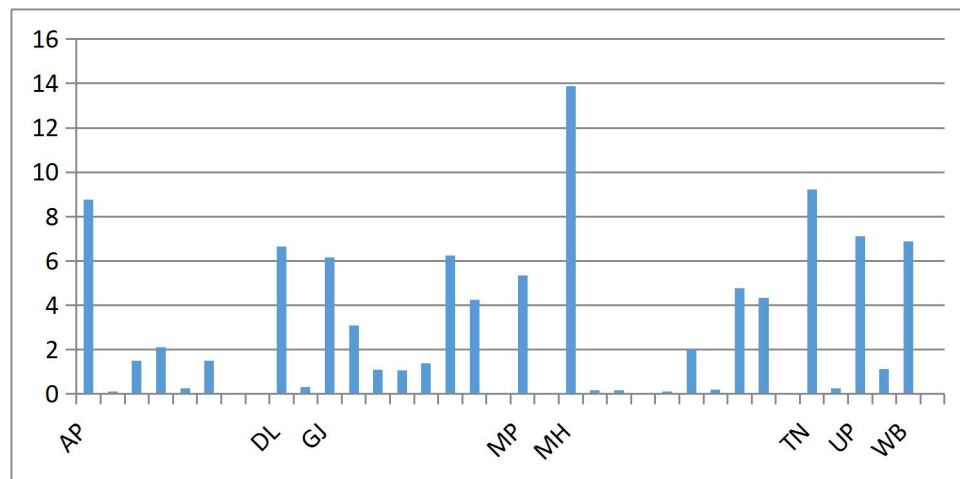


Figure-2. Percentage e-Waste production by top 10 states of India in 2015

Based on the research questions, the aim of the paper is to study the factors affecting strengths, weaknesses, opportunities and threats in remanufacturing of electrical and electronics products and determine their importance. The paper has been organized as follows. Section 2 represents the methodology used. Section 3 explains the SWOT analysis and AHP approach. Section 4 and section 5 entails the discussion and conclusion derived from it.

2. Methodology

To find out the factors which influences the remanufacturing system, we have searched electronic database like Google scholar, Scopus and Science Direct by putting the keywords like remanufacturing, closed loop supply chain, reverse logistic. Then we have gone through the journals where articles related to remanufacturing are likely to appear frequently. We have also gone through offline literature available in books, proceedings of conferences and newspaper articles to know more about the factors related to remanufacturing system. After thorough review of required journals, we visited nine Electrical and Electronics Companies in India to inquire about the awareness of remanufacturing. We tried to find out the various opportunities and threats that are being perceived by these industries through SWOT analysis. We also asked the experts to make a pairwise comparison among the factors included in SWOT analysis for implementation of AHP technique to find the most important factor in each quadrant of SWOT matrix.

3. AWOT (SWOT+AHP) Analysis

SWOT(strengths, weaknesses, opportunities and threats) analysis is a powerful technique which is used widely to critically analyze internal factors (strengths and weaknesses) and external factors (opportunities and threats) which helps the organizations in planning business strategies and decision making[8]. Since this technique only pin point the factors but no information is provided which factors are more important. Therefore AHP(analytic hierarchy process) can be integrated with SWOT analysis to find out the factors which are more significant. This hybrid approach is known as AWOT analysis[9].

SWOT-AHP technique is preferred and widely used in many applications because of its simplicity and ability to analyze complex decision problems in structured form[10]. This technique is used for analysis of recycling practices[11], selection of green manufacturing strategies [12], reverse logistic model analysis [13], identification of critical factors in e-governance[14] and in developing strategies for safer transportation of chemicals [10].

3.1 SWOT Analysis

After having the discussion with the Electrical and Electronics companies in India, we have examined the remanufacturing system of EEP through SWOT is given in Table 1. A brief description based on published literature is also done regarding the SWOT factors.

Table 1: SWOT analysis

Strength (S)	Weakness (W)
Reduction in Energy consumption(S1) Environment protection(S2) Material consumption reduction(S3) Economical Advantage(S4)	Acquisition of used product(W1) Quality of the returned product(W2) Production planning(W3)
Opportunities (O)	Threats (T)
Employment generation(O1) Not so many competitors(O2) Government incentive(O3) Access to Low income group(O4) Sustainable production(O5)	Purchase intention of customers(T1) Return intention of customers(T2) Cannibalization(T3)

3.1.1 Strengths Remanufacturing is a environment friendly method which lowers the emission of greenhouse gases [15].Carbon footprint emissions from Laser direct deposition remanufacturing of turbine blades are less in comparison to manufacturing of new one[16].Remanufacturing helps in the reduction of consumption of both energy and material. One can make from 7 to 11 units more by remanufacturing from same amount of energy and material used for manufacturing [17].Remanufacturing is also a cost effective method due to reduction in material and effort[7].The cost of remanufactured product is between 40% to 80% of the new manufactured product[17].

3.1.2 Weaknesses Uncertainty in quantity and timing of availability of used product makes the acquisition of the used product difficult[2]. Quality of the return product also matters because a worst quality returned product will consume more time and money. Production planning also becomes complex because of variable process time required to repair the components[18].

3.1.3 Opportunities USITC report states that 180000 peoples are employed in the remanufacturing in USA[19].Huge opportunities of employment in India will be generated once remanufacturing is done in large scale. Currently very few competitors in Indian remanufacturing market exists which enhances the chances of a growth of a company[7].Rapid rise in e-waste may force the Indian government to frame policies and provide incentives to the company who want to spearhead the remanufacturing in India. Products may be available to the people who belongs to low income group because of low cost of remanufactured product[12]. It will be the opportunities for the company to think of design of remanufacturing from product design phase itself to have sustainable production[20].

3.1.4 Threats Purchase intention of a consumer towards the remanufactured products may be low due to ignorance about the advantages of remanufacturing and misunderstanding about quality of product due to low cost[21]. People may be reluctant to return the used product because of lack of social awareness, environment awareness and return attitude[2].Sale of new product may be cannibalized or decreased due to the introduction of remanufactured product in the market by the OEM (original equipment manufacturer) or Independent manufacturer [22].

3.2 AHP Analysis

It is a technique which is used for multicriteria decision making by comparing the factors pairwise based on the experts opinion[23].Therefore, to prioritize the factors of SWOT analysis, experts from nine electrical and electronics company were asked to make a pairwise comparison among factors on 1 to 9 scale. Scale followed is given in Table 2.

Table 2. Scale and rating used for AHP analysis

Scale	Rating	Scale	Rating
Equally preferred	1	From equally to moderately preferred	2
Moderately preferred	3	From moderately to Strongly preferred	4
Strongly preferred	5	From strongly to very strongly preferred	6
Very strongly preferred	7	From very to extremely preferred	8
Extremely preferred	9		

Table 3 to 6 represents the comparison matrix and normalized matrix with weight obtained from AHP analysis of strengths, weaknesses, opportunities and threats quadrant factors of SWOT matrix.

Table 3. Comparison matrix and normalized matrix with weight for Strength factors

Comparison Matrix					Normalized Matrix				
	S1	S2	S3	S4	S1	S2	S3	S4	Weight
S1	1	0.142	3	0.2	0.075	0.09	0.166	0.045	0.094
S2	7	1	9	3	0.525	0.63	0.5	0.68	0.58
S3	0.33	0.11	1	0.2	0.024	0.07	0.05	0.045	0.04
S4	5	0.33	5	1	0.375	0.22	0.277	0.22	0.268

Table 4. Comparison matrix and normalized matrix with weight for weakness factors

Comparison Matrix				Normalized Matrix				Weight
	W1	W2	W3	W1	W2	W3		
W1	1	7	3	0.677	0.583	0.706		0.655
W2	0.142	1	0.25	0.096	0.083	0.058		0.079
W3	0.33	4	1	0.226	0.333	0.235		0.265

Table 5. Comparison matrix and Normalized matrix with weight for opportunity factors

Comparison Matrix						Normalized Matrix						Weight
	O1	O2	O3	O4	O5	O1	O2	O3	O4	O5		
O1	1	6	2	4	0.33	0.203	0.25	0.209	0.26	0.189		0.222
O2	0.166	1	0.25	0.33	0.11	0.039	0.041	0.02	0.021	0.063		0.061
O3	0.5	5	1	3	0.166	0.101	0.21	0.10	0.195	0.095		0.14
O4	0.25	3	0.33	1	0.148	0.050	0.125	0.034	0.065	0.082		0.071
O5	3	9	6	7	1	0.61	0.375	0.629	0.456	0.573		0.528

Table 6. Comparison matrix and normalized matrix with weight for threat factors

Comparison Matrix				Normalized Matrix				Weight
	T1	T2	T3	T1	T2	T3		
T1	1	2	5	0.588	0.6	0.555		0.581
T2	0.5	1	3	0.294	0.3	0.333		0.309
T3	0.20	0.33	1	0.117	0.99	0.111		0.109

4. Discussion

After forming the SWOT matrix and applying AHP technique to factors of each quadrant of SWOT matrix, Environment protection is emerged as a most important strength factor with a weight of 0.58. It is so because remanufacturing concept is thought to be a step towards sustainable production and green environment. Acquisition of used product, a weakness factor, with a weight of 0.655 seems to be major problem because remanufacturing can take place only when timing and quantity of return products are certain. Those Companies which are more conscious about green closed supply chain thinks sustainable production as a major opportunities for them with a weight of 0.528 among

opportunities factors. Major threat that is perceived by companies is purchase intention of customers because people of India do not know about remanufacturing and may have negative attitude towards remanufactured product due to its low cost. Purchase intention of customers has a weight of 0.581 in the threat quadrant of SWOT matrix.

5. Conclusion

After having the on-site discussion with electrical and electronics companies in India, we observed that remanufacturing business in India is in rudimentary state. There is huge potential for research in adopting successful practice of the remanufacturing in India. It is a time when manufacturers should understand their responsibilities towards environment and should be worried about future generations. Government should frame strict rules and regulations regarding remanufacturing practices to be adopted in India. This study enables the managers to think of spearheading the remanufacturing practices to capture the market space of electrical and electronics remanufactured products for the benefit of organization, environment and society. Consumers should be motivated by the organization and government policies to purchase remanufactured products. A proper planning and execution is needed by the managers for the acquisition of the used product to maximize the supply chain profit.

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