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RANKING REMANUFACTURED PRODUCT CUSTOMER CRITERION FOR MULTI-LIFE CYCLE STRATEGISATION

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Abstract:

The remanufactured product customer is the buyer of functional product as well as seller of the used product. This paper identifies and classifies the key motivating factors in these states of the customer. From instilling value in the product to conserving it in the reverse supply chain to offering it back at competitive advantage vis-à-vis new products, the study examines the factors via survey to provide support to manufacturers for their incorporation into a strategy satisfying all stakeholders.

Keywords: Remanufacturing Strategy, Multiple Life Cycle Design.

I. INTRODUCTION

When a product is used, with time its functionality and aesthetics diminish resulting in it progressing towards its End-of-Life (EoL). It may be possible to restore it back by repairing or replacing some of its parts. The product is said to have been reconditioned or refurbished, if along with its functionality the aesthetics too are reinstated. The used product (core) , if returned to the manufacturer may be brought back to the initial new state such that its every component can be offered the same warranty as when it was first manufactured, then the process it undergoes to achieve such state is called as "remanufacturing". It's the strongest methods of adapting sustainable manufacturing and is taken as a primary objective by Original Equipment Manufacturers (OEM's) in developed countries. OEM's can best implement remanufacturing as they can control the product life cycle from its design stage itself. The concern of the remanufactured product taking away the market share of the new product (product cannibalization) has been a barrier to the wide scale execution of this strategy. However, it has been proved that product development efforts combined with a well-planned product launch timing can help get maximum benefit in such a scenario [1]. The transition to remanufacturing practices requires systematic approach mitigating any risks. However, management of most OEM's are cynical towards the change unless convinced about the competitive advantages they may have with their customers. For this objective to be achieved, the motivators to remanufacturing need to be identified from perspective of the stakeholder who plays a decisive part in the accomplishment of the strategy. The purpose of this study is to identify and classify the factors comparing their relativity and generate inputs for strategy formulation from the inherent sensitivity in the variation of their performance.

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II. REMANUFACTURING DRIVERS AND ASSESSMENT METHODOLOGY

The implementation of remanufacturing requires a revamping of the operations from design thinking at first stage to the product service offered to end-users. Various studies have been conducted on the socio-economic drivers of remanufacturing. Having a company policy aligned to derive profit for all stake holders and reducing environmental impact creates a mutually beneficial situation for all [2]. Often the action is triggered in response to competition and less by a commitment to a vision [3]. It's important to recognize that the management will consider end-user as the sole stakeholder influencing the decisions of remanufacturing. It was illustrated in a study that the end-user transitions through three stages in the process of remanufacturing: i) Buyer of New Product, ii) Seller of Used Product & iii) Buyer of Remanufactured product. The expectations of the end-user change during these phases [4]

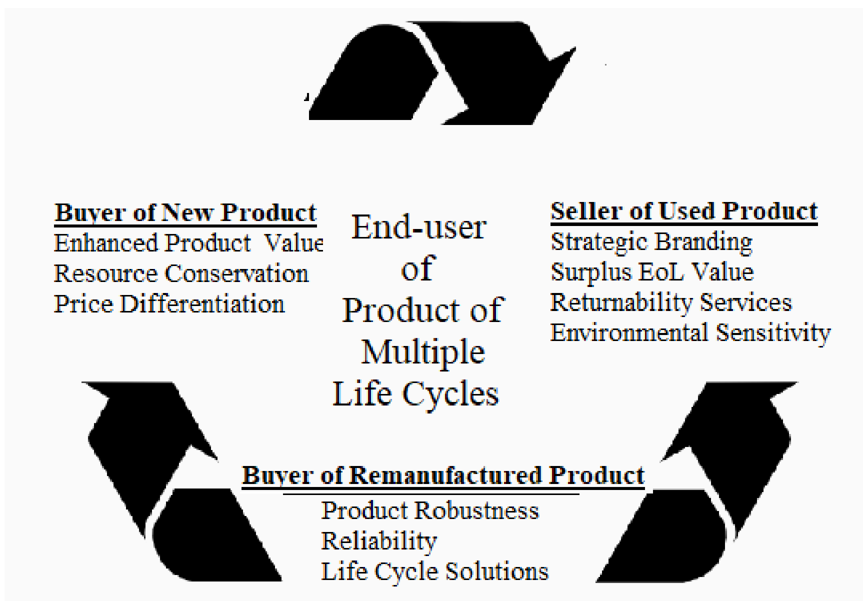

Figure 1: Drivers of Remanufacturers for End-user

From literature the factors motivating remanufacturing from the end-user perspective were investigated. In the manufacture of any physical product the raw material as well as the consumables are scarce. Though non-conventional and renewable energy sources are being utilized recently, the majority of the energy resources used by industry are still limited in nature. Consumption of high energy by the industry can cause the increase in prices of the energy used by other section of the society. Thus buying products offering multiple life cycles saves energy costs and conservation of resources resulting in reduced costs of living [5]. Additionally, the possibility of trading off the product at its End-of-life and the perception that it's designed for multiple life cycles may enhance the value of the product profitably to the buyer of original new products. Various reductions in costs are realized by the management through remanufacturing. Parts of these benefits may be passed on to the end-user in terms of reduced price for the remanufactured product offered. The price differentiation between the new and remanufactured product offered by the OEM is a key

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Criteria to benefit maximum. In a study carried out to investigate the drivers and obstructions in putting remanufacturing in line, viable pricing was derived as the critical economic aspect [6].

The influence of nation-branding associating the origin of the country of remanufactured auto parts was investigated through Indonesian consumers elaborating the role of image of the remanufactured product in global business [7]. While adopting the new remanufacturing strategy into business, it's thus imperative that the OEM use an appropriate branding strategy to project its alignment of remanufacturing efforts to garner goodwill that comes from incorporating sustainable manufacturing into the social order. In certain countries, governments offer subsidies to such organizations which offer buyback options to customers for their used products. When the product when nears its End-of-Life, it may not be desirable for further use and may lay around as a waste. The customer can get advantage from getting value for the surplus product [8]. Used products are generally submitted to 3rd party remanufacturers due to ease of access. If the supply chain services are well in place to ensure core return, it will facilitate the end-user to return the product [9]. For instance, one may use online mode to inspect the product and after deciding the final value order couriering of the core back to the manufacturing facility. The used products when not recycled create pollution, harmful to the environment [10]. Pollution caused by used plastic products is being acknowledged as a potent hazard. End-users who have the sensitivity of responsible citizenship, adhering to government legislations may prefer returning the product displaying sensitivity.

When the product is offered with an assurance of multiple life cycles, the product has to be robust for use offering quality performance [11]. It's imperative that the standards of the new product and remanufactured product match in all respects. The reliability of the remanufactured product may always be in question, when it is offered at a lower price with its origin lying in a used product. Remanufacturing process entails the final testing of the product and its components to ensure that the same warranty on the remanufactured product as that of the new product can be offered [12].

By adopting the remanufacturing strategy the OEM's have the opportunity of reaching out to two new market segments – one of the sellers of used product and secondly buyers of remanufactured products. By profiling the customers in these roles they can find out new avenues to redress their differentiated needs. Third party remanufacturer's may exist in certain product segments to deal with which the OEM's can use their strengths to the best to improve the satisfaction of remanufactured product market, by offering product life cycle solutions [13]. Figure 1 shows the classification of the drivers that may be inferred from the above discussion from the perspective of the transitioning roles of the End-user.

The drivers are useful to the management in aligning the remanufacturing operations. There is a possibility that the drivers are correlated and influence one another. Some aspects may even hinder the performance of the operations.

It's important that the effectiveness of the planned processes is made robust and invulnerable to such difficult factors. Taguchi designs is recommended as a useful approach to identify the effect of factors. A methodology to investigate factors influencing service

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Quality satisfaction in a Taiwan hotel was developed by using the questionnaire survey [14]. Statistically the method accounts for the average and variances simultaneously for the categorical data, claiming it to be vigorous [15]. The objective is to develop recommendations for a system that is insensitive to difficult to control noise factors [16]. The success factors of business process improvement in telecom sector through analysis with managers and consultants were identified by the method [17]. Using the S/N ratio approach the traditional IPA (Importance Performance Analysis) Model was modified for gap analysis of ordinal data collected in the repair services of air-conditioning manufacturer. It overcame the restraints of the model reliably [18]. The advantage of the approach in this study was reducing the probability of financial losses and time by recognizing the requirements for success before launching the initiative.

For applying this methodology, in this study a survey was conducted among the marketing personnel of remanufacturing companies. The participant were asked to rank their agreement for each of the ten drivers listed on its importance as a critical factor influencing the remanufacturing adoption decision. The measure used was the 5 point Likert scale (1-Strongly Disagree, 2-Disagree, 3- Neutral, 4-Agree and 5 – Strongly Agree). The questionnaire was sent through mail to 34 on-field experts from companies of three different automotive sector products, receiving 29 completely filled forms through follow up on clarifications sought. 4 responses were rejected and 25 were used for further analysis. The marketing professionals participating in the study had 5 to 15 years of experience of serving the remanufactured product customers.

I. DATA ANALYSIS AND INTERPRETATION

A summary of percentage distribution of data collected is shown in Table I and supported by chart for visual essence. The measure of sampling adequacy - Kaiser-Meyer-Olkin (KMO) value was 0.697 which is high in the acceptable range of 0.5 to 0.7. The significance value of Bartlett's test of sphericity for existence of identity matrix in correlation coefficients with chi-square of 129.303 at df 45 is less than 0.001 rejecting the hypothesis. Both inferences confirmed that the possibility of underlying factors among the different drivers as initially proposed in the classification of drivers.

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TABLE I

CODE DESCRIPTION	STRONGLY DISAGREE (%)	DISAGREE (%)	NEUTRAL (%)	AGREE (%)	STRONGLY AGREE (%)
BNP1- ENHANCED PRODUCT VALUE	4	4	8	52	32
BNP2- RESOURCE CONSERVATION	0	8	24	48	20
BNP3- PRICE DIFFERENTIATION	0	12	28	44	16
SCR1- STRATEGIC BRANDING	0	4	12	64	20
SCR2- VALUE FOR SURPLUS EOL	0	4	8	60	28
SCR3- RETURNABILITY SERVICES	0	4	8	72	16
SCR4- ENVIRONMENTAL SENSITIVITY	0	8	24	52	16
BRP1- PRODUCT ROBUSTNESS	0	4	8	40	48
BRP2- RELIABILITY	0	8	12	36	44
BRP3 – LIFE CYCLE SOLUTIONS	0	4	0	36	60

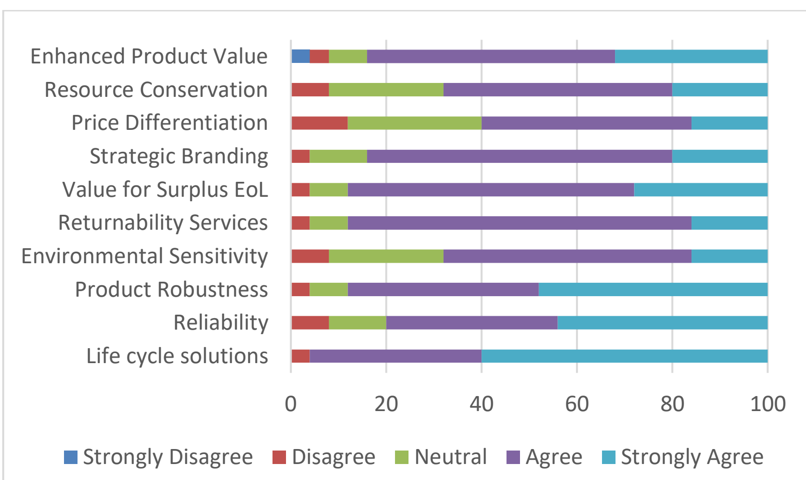

Figure 2: Survey Response Summary for Taguchi Analysis

For determining the reliability of the survey instrument, the Cronbach alpha computed

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whose results are shown in Table II. All the values were found to be acceptable and above the value of 0.7. was 0.7916 which is greater than the threshold of 0.7 [19]. The data is thus reliable to proceed for calculation of the Signal to Noise Ratio.

TABLE II

CODE	DESCRIPTION	CRONBACH ALPHA	RESULT
BNP1	ENHANCED PRODUCT VALUE	0.72221	Valid
BNP2	RESOURCE CONSERVATION	0.75285	Valid
BNP3	PRICE DIFFERENTIATION	0.75302	Valid
SCR1	STRATEGI BRANDING	0.76520	Valid
SCR2	VALUE FOR SURPLUS EOL	0.76889	Valid
SCR3	RETURNABILITY SERVICES	0.76193	Valid
SCR4	ENVIRONMENTAL SENSITIVITY	0.75069	Valid
BRP1	PRODUCT ROBUSTNESS	0.79425	Valid
BRP2	REILABILITY	0.82868	Valid
BRP3	LIFE CYCLE SOLUTIONS	0.81131	Valid

The average and standard deviation results obtained from Minitab software are demonstrated in table II. The factors are ranked in the ascending order of standard deviation. Further the Relative Importance Index (RII) is the for each factor calculated by the 5 point Likert scale by using the formula:

$$RII_i = \frac{1\,x\,r_1 + 2\,x\,r_2 + 3\,x\,r_3 + 4\,x\,r_4 + 5\,x\,r_5}{5\,x\,r}$$

Where r_i represent the frequency of the response "i" for the respective factor and n is the no, of respondents.

Return ability service values showed the least variability while enhanced product value showed the maximum.

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TABLE III

CODE	DESCRIPTION	AVG.	Std. Dev.	Ranking (Std. Dev.)	RII	Ranking (RII)
BNP1	ENHANCED PRODUCT VALUE	4.04	0.978093	10	0.808	3
BNP2	RESOURCE CONSERVATION	3.8	0.866025	7	0.76	8
BNP3	PRICE DIFFERENTIATION	3.64	0.907377	8	0.728	10
SCR1	STRATEGI BRANDING	4	0.707107	2	0.8	6
SCR2	VALUE FOR SURPLUS EOL	4.12	0.725718	4	0.824	4
SCR3	RETURNABILITY SERVICES	4	0.645497	1	0.8	7
SCR4	ENVIRONMENTAL SENSITIVITY	3.76	0.830662	6	0.752	9
BRP1	PRODUCT ROBUSTNESS	4.32	0.802081	5	0.864	2
BRP2	REILABILITY	4.16	0.943398	9	0.832	3
BRP3	LIFE CYCLE SOLUTIONS	4.52	0.714143	3	0.904	1

The formulae for disagreement coefficient (P_{di}), agreement coefficient (P_{ai}) and the S/N ratios of corresponding coefficients n_{ai} and n_{di} are shown below:

$$p_{d_i} = \frac{r_1 + r_2}{2} \qquad p_{a_i} = \frac{r_4 + r_5}{2}$$

$$S/N_{di} = n_{d_i} \equiv -10 \log\left(\frac{p_{di}}{1 - p_{di}}\right) \qquad S/N_{ai} = n_{a_i} \equiv -10 \log\left(\frac{1 - p_{ai}}{p_{ai}}\right)$$

The last column in table IV presents the ranking of the S/N ratio from highest to lowest value of the resources. The ranking and standard deviation in table III helps to resolve the ranking dilemma for factors having same S/N ration. The ranking for factors SCR2, SCR3 and BRP1 is determined by preferring lesser variance as an attribute for better rank.

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TABLE IV

CODE	DESCRIPTION	P_{ai}	P_{di}	η_{di}	η_{ai}	η	Rank
BNP1	ENHANCED PRODUCT VALUE	0.84	0.08	10.6069784	7.201593034	17.80857	6
BNP2	RESOURCE CONSERVATION	0.68	0.08	10.6069784	3.273589344	13.88057	9
BNP3	PRICE DIFFERENTIATIO N	0.6	0.12	8.6530142	1.760912591	10.41393	10
SCR1	STRATEGI BRANDING	0.84	0.04	13.8021124	7.201593034	21.00371	5
SCR2	VALUE FOR SURPLUS EOL	0.88	0.04	13.8021124	8.653014261	22.45513	3
SCR3	RETURNABILITY SERVICES	0.88	0.04	13.8021124 2	8.653014261	22.45513	2
SCR4	ENVIRONMENTAL SENSITIVITY	068	0.08	10.6069784	3.273589344	13.88057	8
BRP1	PRODUCT ROBUSTNESS	0.88	0.04	13.8021124 2	8.653014261	22.45513	4
BRP2	REILABILITY	0.8	0.08	10.6069784	6.020599913	16.62758	7
BRP3	LIFE CYCLE SOLUTIONS	0.96	0.04	13.8021124 2	13.80211242	27.60422	1

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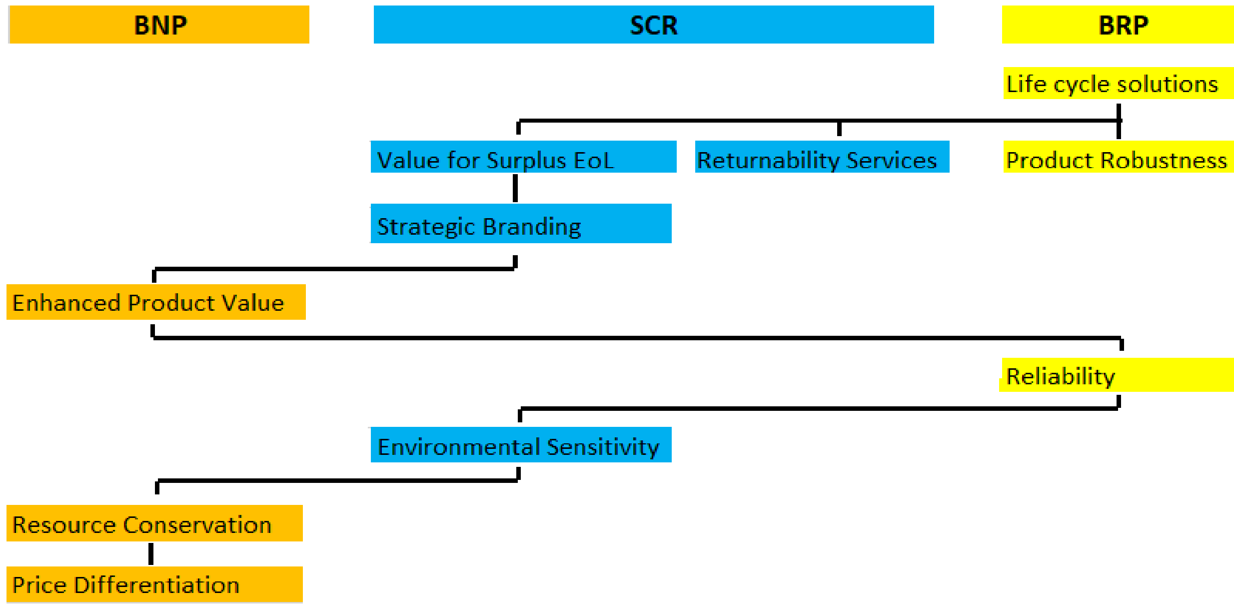

Figure 3: Hierarchy ranking level as per S/N Ratio

By the scrutiny of S/N Ratio computed for each driver of three different end-user roles, it's possible to segregate the drivers based on their effect to be in control of the system. Figure 3 shows the levels of drivers derived as per the S/N Ratio ranking. RII on the other hand measures the significance of the factor in contributing to drive remanufacturing practices better from end-user perspective irrespective of their sensitivity. Both the S/N Ratio and RII methods result (Figure 4), in Product Life cycle solutions (BRP3) as highest and Price differentiation (BNP3) as the lowest ranking factors. However, though reliability (BRP2) seems to be of rank third in relative importance, it has comparatively low control on the response of the system as per S/N ratio analysis. On the other hand, better regulation may be obtained through Returnability services (SCR3) which ranks second in SN ratio may result in a better robust system even if it may rank seventh as per RII.

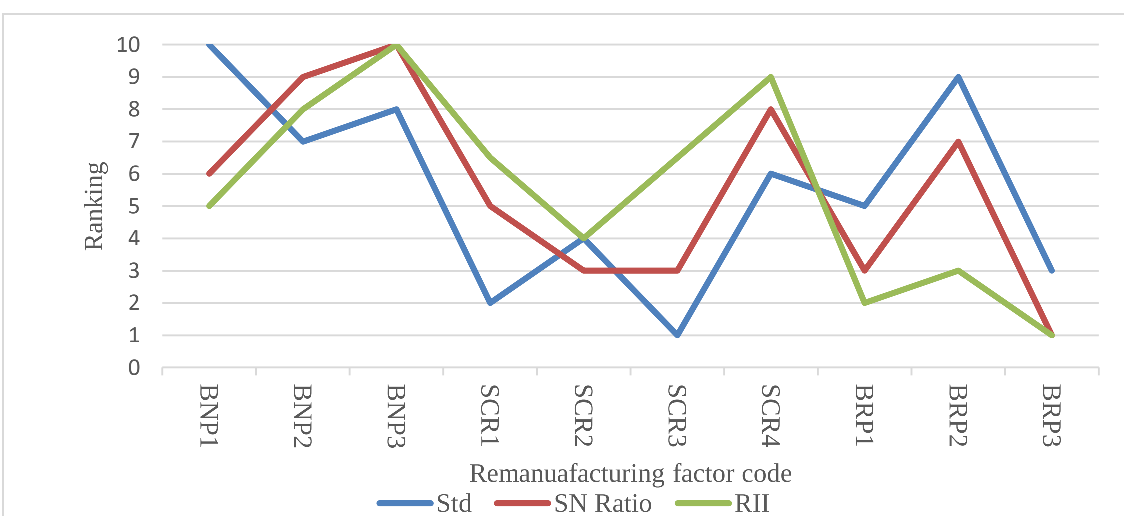

Figure 4: Ranking Analysis

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To lure the buyer of the new product increasing the perception of enhanced product value emerges as a better approach comparatively. Environmental sensitivity may not work for the seller of core unless it's matched by a strategic branding intended to may be creating a compassionate view of the organization working towards sustainability. Getting the right value of the End of Life surplus product will meet the purpose. Offering and improving the services for evaluation and return of the EoL product will help the OEM's ensure that the sellers are not compelled to opt for local 3rd party remanufacturers who generally have the advantage of easy access. For the end-user as a buyer of remanufactured product, robustness of the product to perform well is more important than offering a reliability warranty.

III. CONCLUSION

This study has thus successfully proposed a new approach of having a closer look at the comparison of the rankings of standard deviation, relative importance index and S/N ratio simultaneously to fulfil the objective of Taguchi Design methodology to recognize the factors affecting the variability (control factors), mean response (signal factors) and none of the two (weak factors). "Life cycle solutions" proves to be the best signal factor. Return ability services may also be considered an equally good control factor as Life cycle solutions whereas price differentiation is identified as the weakest factor.

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