International Journal of Advanced Technology in Engineering and Science www.ijates.com

Volume No.03, Special Issue No. 02, February 2015 ISSN (online): 2348 – 7550

RECYCLING IN PLASTIC INDUSTRIES IN INDIA: AN ANALYSIS OF ITS BARRIERS THROUGH FUZZY-AHP APPROACH

S.Chakraborty[1], K.Das[2], S. Satapathy[3]

[1,2,3]*School Of Mechanical Engineering, KIIT University, Orissa, (India).*

ABSTRACT

In the present age of Sustainable development recycling of plastics is very much crucial and one good reason to recycle plastic is that there is just so much of it.. Plastic recycling happens to be one of the most advantageous ways for re-using plastic products. Another important cause remains hidden in the fact that plastics can take thousand of years to biodegrade. Therefore, analysis of barriers hindering the recycling of plastics in India is a crucial issue. There are a large number of barriers to plastic recycling processes but it becomes very difficult to decide which has the greatest impact. These barriers not only affect plastic recycling processes but influence each other also. This paper makes the use of Fuzzy- AHP for the analysis of the barriers to plastic recycling processes in India. The Fuzzy- AHP is a mathematical technique for multi criteria decision making. This methodology tolerates the vagueness and uncertainty of human judgements.

Keywords Barriers, Fuzzy- AHP, Multi Criteria Decision Making, Plastic Recycling , Sustainable Development.

1. INTRODUCTION

1.1 Background of the study

It is the era of technological advancements and versatile globalization policies, the ability of recycling to contribute to the value addition process is of tremendous importance and beneficial to manufacturers throughout the globe. Adaptation of modernized methods such as process re-engineering , product recovery etc. and the application of other efficient reverse logistics process has taken the concept of supply chain management to whole new level. The very idea of a circular economy has been realized switching from the earlier linear model flow of raw materials. **[1]** Increasing global awareness about resource depletion have resulted in an increased competition among manufacturers leading to an escalated need for the use of recycling process in industries globally. In today's manufacturing scenario manufacturers do not want any of their inputs to be finally termed as waste and hence discarded, so they have channelized their efforts as well as resources into the development of efficient recycling methods. Recycling is very much crucial for preserving and protecting our resources for ourselves and for future generations.

Plastics are a highly versatile category of materials available to manufacturers, their role encompass economical , social and most importantly environmental aspects in the build up to sustainable development. It is one of the top industries where recycling constitutes a major part of all the other reverse logistics methods employed for value addition process to waste or used products. The field of logistics are now increasingly responsible for problems related to waste management, a reflection of which is observed the modern-day growth and popularity of various reverse logistics process. Recycling is a recovery operation (a kind of reverse logistics method) in which reprocessing of waste materials result into products, substances and materials for meeting the original requirements or other needs. When materials such as wood, glass, metal etc are recycled the operation is considered environment friendly due reasons such as energy conservation, reduced raw material extraction, etc. But presence of barriers in plastic recycling supply chains mark them as expensive, logistically inefficient, fragile and even harmful to the environment. Commonly two methods are employed for plastic waste recycle namely-

(a) Mechanical Recycling,

(b) Feedstock recycling.

The process of mechanical recycling involves melting, shredding or granulation of plastic waste, sorting of plastics are a must prior to mechanical recycling. Globally modern technologies have been employed for sorting operations using technique such as X-Ray Fluoroscene, Infrared etc. Post sorting the plastics are either melted down directly or molded into new shapes or melted down after being shredded into flakes and then processed into granules called regranulate. Whereas, feedstock results in the breakdown of polymers into constituent monomers , which in turn can be used again in refineries or petrochemical and chemical production. Feedstock recycling has a better flexibility over composition and is more tolerant towards impurities than mechanical recycling**.[ ]** While plastics have undergone the recycling process since 1970's , but the quantities that are recycled vary geographically according to plastic type and application. Through technological advancements and systems, the collections , sorting and reprocessing of recyclable plastics are creating new oppurtunities for recycling and with the combined actions of public, industries, and governments it may be possible to divert the majority of plastic waste from landfills to recycling in the next few decades.**[2]**

What was observed from the previous researches conducted on this topic was that the work has been done by the information and data collected for developed countries, whereas little or no research work exists on this topic pertaining to developing countries such as India. India is sufficiently endowed with human and technological resources , and over the past decade it has shown tremendous potential for further growth and development. Inspite of the above mentioned fact, when it comes to efficient use of reverse logistics process' such as recycling in plastic sector it is lagging behind by a considerable amount than the developed countries of the globe. Existence of barriers in the recycling process' practiced in the plastic industries in india is proving to be a hindrance for the sustainable development of the country.

1.2 Objective of the study

Given the present Plastic Recycling scenario, the goal of this paper is to contribute to the already available literature on plastic recycling and Plastic Recycling practice by means of a Plastic Recycling case study in Indian Plastic Industries. By drawing on the Plastic Recycling literature and the insights obtained from the case study, the present paper aims to identify the most important drivers and barriers that enable or impede Plastic Recycling development in India through an appropriate Fuzzy-AHP model for evaluation.

1.3 Reason for choosing Fuzzy-AHP instead of AHP

The AHP was developed in the 1980s by Saaty **[3]**. It is a systematic decision making method which includes both qualitative and quantitative techniques. It has been widely used in a variety of fields for a long time. The conventional AHP uses a pair wise comparisons for each level with respect to the goal of the best alternative selection are conducted using a nine-point scale. In application Saaty's AHP has a few shortcomings such as (1) AHP used for nearly crisp decision applications, (2) AHP deals with a very unbalanced scale of judgment, (3) It does not take into account the uncertainty associated with the mapping of one's judgment to a number, (4) Ranking in this method is imprecise, (5) Decision-makers preference have great influence on the AHP results. Additionally evaluation of alternatives by decision makers always contain ambiguity and multiplicity of meaning. Hence, conventional AHP seems inadequate in capturing decision makers requirements explicitly.

For modeling of the uncertaininty of barriers related to Plastic Recycling processes in India, incorporation of fuzzy sets with pairwise comparison could be used as an extension of AHP. Thus , a variant of AHP, called Fuzzy AHP, can be implemented for overcoming the compensatory approach and the inability of the AHP in handling linguistic variables. And thus fuzzy AHP approach provides for a more accurate description of the decision making process.**[4]**

II LITERATURE REVIEW

Studies stressing upon the oppurtunities and importance of plastic recycling and reuse began getting published from the late eighties. Towards the late nineties , marketing aspects of recycle, reuse and extending product life of manufacturing goods(plastic products) acquired significant importance and widely started coming into practice for gaining maximum economic benefits and also due to environmental concerns.

2.1 Literature Review for Plastic Recycling

Graczyk and Withowski explained the role of reverse logistics applicable to value addition process for producers of plastic. They highlighted on the fact that waste management should try to develop intelligent solutions for both material recycling and energy recovery of plastic-rich waste systems. **[5]**

Sharma et al. analyzed the barriers for reverse logistics process from an Indian perspective. Their work utilized Interpretive Structural Modeling (ISM) to understand the mutual influences among the barriers so that the barriers

that are at the root of some more barriers (called driving barriers) and those which are most influenced by others (called driven barriers) were identified. They identified that there was no autonomous barrier. **[6]**

2.2 Literature Review for Fuzzy-AHP

Chatterjee and Mukherjee developed a model using Fuzzy-AHP to search the criteria for the evaluation of best technical institutions which can tolerate vagueness and uncertainity of human judgement. The model was utilized to overcome stakeholders problem in evaluating Technical Institutions.**[7]**

Eickemeier and Rommelfanger provided a new approach for modeling fuzzy values in the paired comparisons and for the utility value analysis. Additionally, they aimed at improving the common procedure for identifying weights to aggregate lower goals to the immediate higher level by weighted addition. matrices we recommend to calculate the weights vector by the arithmetic mean of the normalized column vectors.**[8]**

Mahendran and Mahadevan in their work used AHP for selection of the best plastic recycling process in Indian scenario.**[9]**

Kong and Liu applied Fuzzy Analytic Hierarchy Process to develop an evaluation method for E-commerce in order to help researchers and managers to determine the drawbacks and oppurtunities.**[10]**

Tiryaki and Ahlatcioglu applied Fuzzy AHP in portfolio selection application. They applied two methods, namely, RCFAHP(Revised Constrained fuzzy AHP) and the second- method of Enea and Piazza**,** to the problem of choosing stocks on the Istanbul Stock Exchange (ISE). Finally the relative advantages and disadvantag es of these methods in compariso n to existing methods were discussed. **[11]**

Enea and Piazza made use of Constrained Fuzzy AHP for Project Selection. Their study showed demonstrated that by the consideration of all the information derived from the constraints better results in terms of certainity and reliability were observed.**[12]**

Mahendran et al. put to use the Fuzzy AHP approach for the selection of measuring instrument for the selection of engineering college. In their work they applied the AHP technique to prioritize the opinions collected from the students by questionnaire administration.**[13]**

Dagdeviren and Yuksel developed a fuzzy analytic hierarchy process (AHP) model for behavior based safety management. Their model determined the most important factors that may cause faculty behavior and take precautions to correct these factors. Their study employed fuzzy AHP method for determination of the degree of importance of the factors and subfactors used in the model **[14]**

III PROBLEM DESCRIPTION

For Plastic waste management, Recycling is the most commonly practiced procedure. It can be in a variety of forms such as mechanical recycling, feedstock recycling or chemical recycling. But, there are barriers to Plastic Recycling processes in Indian Plastic Industries. Thus criteria taken into consideration in this study are related to the Barriers in Plastic Recycling process. With the selected criteria, the Fuzzy AHP (analytical hierarchy process) has been

implemented to determine the factor weights and finally the alternative with the highest total weighted score is selected as the best alternative.

IV EMPIRICAL STUDY AND METHODOLOGY

Identification of appropriate criteria for barriers to plastic recycling process and selection of suitable multi-criteria decision making methods formed the initial stages of the study. In a multi-criteria evaluation problem, the prospective alternatives and numerous selection criteria are needed to be considered. The Fuzzy Set Theory helps in dealing with the extraction of the possible primary outcome from a multiplicity of information that gets expressed in vague and imprecise terms. The vague data in Fuzzy Set Theory are treated as possibility distributions in terms of set memberships. Application of logical reasoning can be effectively put into use once the set memberships in possibility distributions are determined and defined. Triangular fuzzy numbers and the algebraic operations of fuzzy numbers are two major components of this section. The primary step in Analytical Hierarchy Process is by the layout of overall hierarchy of the decision making problem. The hierarchy structure is from the top (the overall aim of the problem) through the intermediate levels (criteria and sub-criteria on which subsequent levels depend) to the bottom level (the list of alternatives). Each of the criterion in the lower levels of hierarchy is compared with respect to the criteria in the upper level of hierarchy. The criteria in the same level get compared using pair wise comparison.**[15]** Depending upon the decision makers' inputs, weights of criteria are computed using Fuzzy-AHP along with other computations to prioritize the barriers in plastic recycling processes.

4.1 Questionnaire Design

For evaluating the Barriers to Plastic Recycling processes, raw materials supply and heterogenity ,processes involved, waste generation and management, energy consumption, public awareness and technical capability, government policies and incentives are the important criteria which influence the barriers. Thus the aim of the survey is to prioritize the barriers in Plastic Recycling processes from an Indian perspective. Persons involved in the survey involved expert opinion and also workers, operators, supervisors, managers of various plastic as well as plastic recycling based industries. Data collection was primarily done through in person interview followed by email and telephonic conversations. Since the data to be collected for the survey was industry specific and with an aim to cover the population belonging to almost all parts of India, it was mandatory to keep the questions precise and easy to apprehend. An example of the survey question is "Public awareness and commitment lacks for plastic recycling".

TABLE 1. Sample Questionnaires relating to barriers in plastic recycling

SL NO.	QUESTIONS	1	2	3	4	5
1	The heterogenous mixture can be used with polyethylene in mechanical recycling process.					
2	Supply of polyethylene is very important in mechanical recycling.					

3	Human health is affected by the release of toxic gases in mechanical recycling of plastics(polyethylene) .					
4	Mechanical recycling processes are time consuming.					
5	Mechanical recycling processes involves high amount of Energy consumption.					
6	Waste generated from mechanical recycling is on a higher scale.					
7	Public awareness and commitment lacks for plastic recycling.					
8	Lack of know-how and technical capability.					
9	Proper collection facility for plastic wastes missing.					
10	Proper sorting and segregation facility for various types of plastic wastes unavailable.					
11	Prevalence of lack of knowledge, attitude and perception among common people.					
12	Limited application of recycled plastic in product making.					
13	Absence of proper government policies on plastic recycling in India.					
14	No such Government incentive for use of recycled plastic products.					

1. Strongly Disagree
2. Disagree
3. Neither Agree nor Disagree
4. Agree
5. Strongly Agree.

4.2 Development of Fuzzy-AHP model in multi-criteria decision making (MCDM)

Step 1. Development of a hierarchial structure

Fuzzy AHP methodology is applied to determine the barriers to recycling of plastics in India. the hierarchy is structured from the top (the overall goal of the problem) through the intermediate levels (criteria on which subsequent levels depend) and finally at the bottom most level are the sub-criteria. The criteria in the same level are compared using pair wise comparison. Fig 1 describes the hierarchy of a decision making problem.

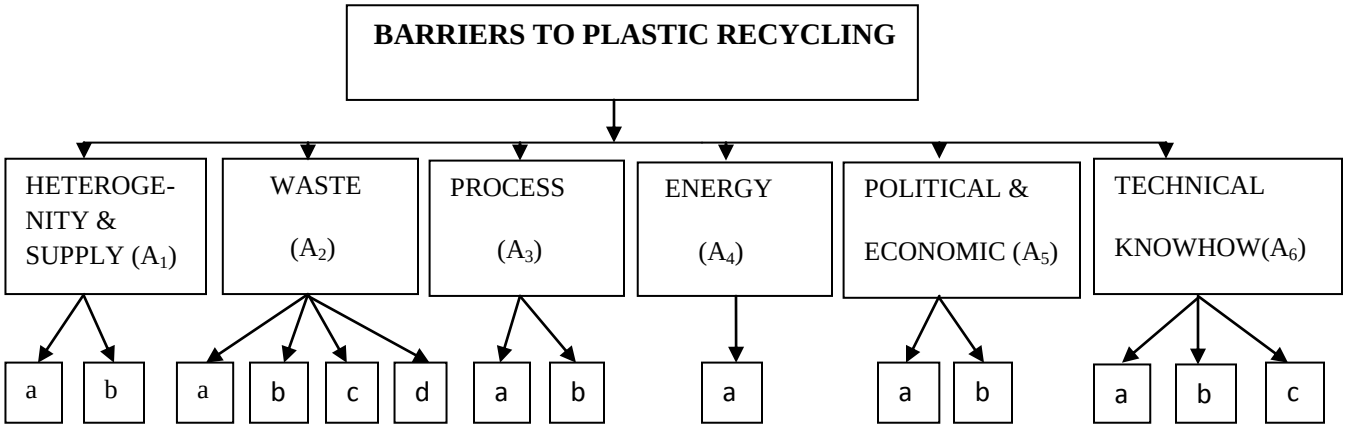

Figure 1: The hierarchy of the criteria and the alternatives

Step 2. Geometric Average and Weightage Statistics of Assessmant Criteria and Sub-Criteria

TABLE 2. Geometric Average of opinions ,overall weightage and ranking statistics for Assessment Criteria

ASSESSMENT CRITERIA	ASSESSMENT SUB-CRITERIA	CODE	GEOMETRIC AVERAGE OF OPINIONS	OVERALL WEIGHTHAGE	RANK
HETEROGENITY AND SUPPLY (A_1)	1	a_1	3.310	0.499	13
	2	a_2	3.348		11
WASTE GENERATION (A_2)	3	b_1	4.505	0.249	01
	6	b_2	2.845		14
	9	b_3	4.204		03
	10	b_4	3.447		09
PROCESS INVOLVED (A_3)	4	c_1	3.352	0.499	10
	12	c_2	3.696		08
ENERGY CONSUMPTION (A_4)	5	d_1	3.320	1.000	12
POLITICAL & ECONOMIC (A_5)	13	e_1	4.240	0.499	02
	14	e_2	3.735		06
TECHNICAL CAPABILITY & KNOWHOW (A_6)	7	f_1	3.815	0.333	05
	8	f_2	3.940		04
	11	f_3	3.729		07

Step 3.Comparison of criteria or alternatives via linguistic terms and transformation of relative importance into triangular fuzzy number

The decision maker compares the criteria via linguistic terms shown in the below Table 3.

. **TABLE 3. Linguistic terms and the corresponding triangular fuzzy numbers**

SAATY SCALE	DEFINITION	FUZZY TRIANGULAR SCALE
1	EQUALLY IMPORTANT	(1, 1, 1)
3	WEAKLY IMPORTANT	(2, 3, 4)
5	FAIRLY IMPORTANT	(4, 5, 6)
7	STRONGLY IMPORTANT	(6, 7, 8)
9	ABSOLUTELY IMPORTANT	(9, 9, 9)
2		(1, 2, 3)
4	The Intermittent Values between	(3, 4, 5)
6	Two Adjacent Scales	(5, 6, 7)
8		(7, 8, 9)

According to the corresponding triangular fuzzy numbers of these linguistic terms, for example if the decision maker states "Criterion 1 (A_1) is Weakly Important than Criterion 2 (A_2)", then it takes the fuzzy triangular scale as (2, 3, 4). On the contrary, in the pair wise contribution matrice of the criteria, comparison of A_2 to A_1 will take the fuzzy triangular scale as (1/4, 1/3, 1/2).

Step 4. Building comparison matrice for criteria

The pair-wise comparison matrice is represented by Eq.1, where $\widetilde{o_{ij}^d}$ indicates the d[th] decision maker's preference of i[th] criterion over jth criterion,with the help of fuzzy triangular numbers. In this case " tilde" represents the triangular number demonstration in each case, for example $\widetilde{o_{ij}^d}$ represents the first decision maker's preference of first criterion over third criterion which equals to, $\widetilde{o_{ij}^d}$ = (1,1,1)

$$\widetilde{M^d} = \begin{bmatrix} \widetilde{o_{11}^d} & \widetilde{o_{12}^d} & \dots & \widetilde{o_{1n}^d} \\ \dots & \dots & \dots & \dots \\ \widetilde{o_{nn}^d} & \widetilde{o_{n2}^d} & \dots & \widetilde{o_{nn}^d} \end{bmatrix} \quad (1)$$

TABLE 4. Comparison matrice for criteria

	A_1	A_2	A_3	A_4	A_5	A_6
A_1	(1,1,1)	(0.16,0.20,0.25)	(1,1,1)	(0.25,0.33,0.50)	(1,1,1)	(0.11,0.11,0.11)
A_2	(4,5,6)	(1,1,1)	(0.16,0.20,0.25)	(0.25,0.33,0.50)	(0.16,0.20,0.25)	(0.11,0.11,0.11)
A_3	(1,1,1)	(4,5,6)	(1,1,1)	(0.25,0.33,0.50)	(1,1,1)	(0.11,0.11,0.11)
A_4	(2,3,4)	(2,3,4)	(2,3,4)	(1,1,1)	(0.25,0.33,0.50)	(0.25,0.33,0.50)
A_5	(1,1,1)	(4,5,6)	(1,1,1)	(2,3,4)	(1,1,1)	(0.11,0.11,0.11)

A_6	(9,9,9)	(9,9,9)	(9,9,9)	(2,3,4)	(9,9,9)	(1,1,1)

Step 6. Calculation of Geometric Mean for fuzzy comparison matrices

According to Buckley **[16]**, the geometric mean of fuzzy comparison values of each criterion is calculated as shown in Eq.2. Here, $\tilde{g}_i$ represents the triangular values

$$\tilde{g}_i = \left(\prod_{j=1}^{n} \tilde{o}_{ij}\right)^{1/n} \quad \textbf{(2)}$$

TABLE 5. Geometric means of fuzzy comparison values

CRITERIA	**GEOMETRIC MEAN($\tilde{g}_i$)**		
A_1	0.405	0.44	0.489
A_2	0.378	0.440	0.523
A_3	0.692	0.753	0.831
A_4	0.890	1.200	1.587
A_5	0.978	1.087	1.175
A_6	4.586	5.196	5.451
SUMMATION	7.929	9.116	10.056
REVERSE(power of -1)	0.13	0.11	0.10
INCREASING	0.10	0.11	0.13

Step 7. Calculation of Relative fuzzy weights (ω_i) and non-fuzzy weight (ω_{di}) for each criterion.

Determination of relative fuzzy weights and non-fuzzy weights for each criterion can be obtained with Eq.3 and Eq.4, following the below mentioned substeps.

Step 7a. Calculate vector summation of $\tilde{g}_i$.

Step 7b. Calculate the (-1) power of vector summation. After that replace the fuzzy triangular number, to make it in an increasing order.

Step 7c. To calculate the fuzzy weight for criterion i (ω_i), we multiply each $\tilde{g}_i$ with this reverse vector.

$$\omega_i = \tilde{g}_i \otimes (\tilde{g}_1 \oplus \tilde{g}_2 \oplus \ldots\ldots \oplus \tilde{g}_n)^{-1} \quad \textbf{(3)}$$

$$= (l\,\tilde{g}_i, m\,\tilde{g}_i, u\,\tilde{g}_i)$$

Step 7d. As $\tilde{g}_i$ are still fuzzy triangular numbers, they are required to be de-fuzzified represented by Eq.4

$$(\omega_{di}) = \frac{(l\widetilde{g}_i + m\widetilde{g}_v + u\widetilde{g}_i)}{3} \quad (4)$$

TABLE 6. Relative fuzzy weights and non-fuzzy weights of each criterion.

	Relative fuzzy weight (ω_i)			Non-fuzzy weight(ω_{di})
A_1	0.405	0.048	0.050	0.050
A_2	0.037	0.048	0.030	0.030
A_3	0.069	0.082	0.108	0.086
A_4	0.089	0.132	0.206	0.142
A_5	0.097	0.119	0.152	0.122
A_6	0.458	0.571	0.708	0.579

Step 8. Normalization of non-fuzzy relative weights

ω_{di} is a non fuzzy number, it is normalized by following Eq.5

$$\omega_N = \frac{\omega di}{\sum_{I=1}^{N} \omega di} \quad (5)$$

TABLE 7. Normalized relative weights of criteria

CRITERIA (BARRIERS)		Normalised	RANKING OF THE
A_1	HETEROGENITY AND SUPPLY	0.086	5
A_2	WASTE GENERATION	0.051	6
A_3	PROCESS INVOLVED	0.148	4
A_4	ENERGY CONSUMPTION	0.245	2
A_5	POLITICAL & ECONOMIC	0.210	3
A_6	TECHNICAL CAPABILITY & KNOWHOW	1.00	1

V DISCUSSION AND CONCLUSION

Plastics have a huge role to play in our day to day lives as a result of its huge number of applications owing to its versatile nature. Developments in the field of plastic recycling is very much crucial for the growth of plastic industries in India. There is a large variety of challenges involved during the recycling of plastics in the country. From the above analysis of Barriers for Plastic Recycling processes using Fuzzy- AHP methodology it is seen that the technical capability and knowhow is the most important barrier to the recycling of plastics in Indian Plastic industries followed by energy consumption, political and economic factors and so on.. Since the decision makers preferences depend on both tangible and intangible criteria, these vague linguistic variables are represented by Fuzzy Set Theory. The advantage of the analysis presented in this study will help the plastic industries in the country to identify the barriers as a result of realistic representation of the problem and make efforts to combat the negative effects of the barriers during plastic recycling processes. Although plastic recycling is being practiced in the country since long but the industries in India should more often entertain the application of recycled plastic products.

ACKNOWLEDGEMENTS

The author would like to thank four anonymous referees for their excellent suggestions and valuable advice in this paper.

REFERENCES

[1] Wong Chee, *A Study Of Plastic Recycling Supply Chain , University of Hull Business School and Logistics Institute*, Hull, North Humberside,2010.

[2] J. Hopewell, R. Dvorak and E. Koisor, Plastics recycling: Challenges and oppurtunities, *Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526),* 2009, 2115–2126.

[3] T. L. Saaty, *The Analytical Hierarchy Process* (Mc Graw Hill, New York, 1980).

[4] G. Kabir and M.A.A. Hasin, Comparative Analysis of AHP and FuzzyAHP Models For Multicriteria Inventory Classification, *International Journal of Fuzzy Logic Systems, 1(1),* 2011, 1-16.

[5] M. Graczyk and K. Witkowski, Reverse Logistics Processes in Plastic Supply Chains, *Total Logistic Management, 4*, 2011, 43-55.

[6] S.K. Sharma, B.N. Panda, S.S. Mahapatra. and S. Sahu, Analysis Of Barriers for Reverse Logistics: An Indian Perspective, *International Journal Of Modeling And Optimization,1(2),* 2011, 101-106

[7] D. Chatterjee and B. Mukherjee, Study Of Fuzzy-Ahp Model To Search The Criterion In The Evaluation Of The Best Technical Institutions: A Case Study, *International Journal of Engineering Science and Technology, 2(7)* , 2010, 2499-2510

[8] S. Eickemeier and H. Rommelfanger, Fuzzy Utility Value Analysis and Fuzzy Analytic Hierarchy Process, EUROFUSE PM'01 Granada, 2001, 139-146.

[9] S. Mahendran, and M.L. Mahadevan, Prioritization of Plastic Recycling Process Using Analytical Hierarchy Process, International Colloquium on Materials, Manufacturing and Metrology, IIT Madras, Chennai, 2014.

[10] H. Liu and F. Kong, Applying Fuzzy Analytic Hierarchy Process to Evaluate Success Factors Of E-Commerce, *International Journal Of Information and Systems Sciences, 1(3-4),* 2005, 406-412.

[11] F. Tiryaki and B. Ahlatcioglu, Fuzzy portfolio selection using fuzzy analytic hierarchy process, *Information Sciences, 179,* 2009, 53-69.

[12] M. Enea and T. Piazza, Project selection by constrained fuzzy AHP, *Fuzzy Optimization and Decision Making ,3,* 2004, 39–62.

[13] P. Mahendran, M.B.K. Moorthy, S. Saravanan, A Fuzzy AHP Approach for Selection of Measuring Instrument for Engineering College Selection, *Applied Mathematical Sciences, 8(44),* 2014, 2149 – 2161.

[14] M. Dagdeviren and I. Yuksel, Developing a fuzzy analytic hierarchy process (AHP) model for behavior- based safety management, *Information Sciences, 178* , 2008, 1717–1733.

[15] J. Ding, Partner Selection Of Strategic Alliance For A Linear Shipping Company Using Extent Analysis Method Of Fuzzy AHP, *Journal of Marine Science and Technology, 17(2),* 2009 , 97-105 .

[16] J.J. Buckley, Fuzzy hierarchical analysis, *Fuzzy Sets Systems, 17(1),* 1985, 233-247.

Bibilography

S Chakraborty is a research scholar in School of Mechanical Engg in KIIT University,he has currently published two papers in various conferences and journals.His intrest area of research is TQM,Sustainability MGMT etc.

K Das is a research scholar in School of Mechanical Engg in KIIT University,She has currently published two papers in various conferences and journals.Her intrest area of research is TQM,Sustainability MGMT,Service operation MGMT. etc

S Satapathy is a research scholar in School of Mechanical Engg in KIIT University,She has currently published three papers in various conferences and journals.Her intrest area of research is TQM,Sustainability MGMT,Service operation MGMT,Supply chain MGMT. etc.