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Material Handling Equipment Selection for a Galvanizing Steel Industry using Combined AHP-GRA Model

Santosh Patel, Rupesh Chourasiya, Vimal Ku Dixit

Department Mechanical, S.V.I.T.S, Indore, Madhya Pradesh, India

ABSTRACT

India has emerged as a fast developing country in 21st century. From the beginning of this century country has experienced many inventions and developments in its industrial sector. During these years, export capacity of the country has increased a lot. Keeping all this factors in mind one can easily understand the importance of industries in India. In industries material handling plays very important role, because handling of material using conventional manual practices needs a huge expenditure of time, money as well as energy of the workers. For this reason, many types of material handling equipments have been suggested in the literature. As we all know, in last ten years, India has reported a remarkable progress in global market and is progressing continuously; importance of material handling facilities increases a lot.

Present research work is based on material handling equipment selection for a steel industry. Yet there are many types of steel industries are present in the country but here in this research work emphasis is made on galvanizing steel manufacturing industry. One of the basic reasons of choosing this industry is that in literature very less or almost nil research has been reported by various researchers in this field. Also it has been observed by the candidate the workers in a galvanizing steel industry work in very adverse conditions which ultimately, may affect their life.

In the present research work, zinc pot section of hot dipped galvanizing steel manufacturing industry which is having manual delivery system for pouring zinc and aluminum slabs has been considered as the research frame. For this system first of all criteria has been finalized with the help of industry personnel as well academicians. After that prioritization of criteria has been made with the help of Analytical Hierarchy Process, and finally scores of the alternatives (Automatic system, Conveyer's delivery and Manual delivery) are reported using Grey Rational Analysis (GRA) model, the ranking of which has determined the best alternative.

Keywords: Material Handling Equipment, Material Handling Methods, MCDM Techniques, Grey Rational Analysis, AHP.

I. INTRODUCTION

To manufacture any product, it is necessary either that materials move from one step of the manufacturing process to another or that operators move to the materials. The most common practice, of course, is to move the move the materials. This movement of materials from one processing area to another and from department to department necessitates the use of many personnel and equipment and the handling of treatment tonnages of materials.

Consideration for the handling of work-in-processes materials, as well as raw material and finished goods, has always been a part of the production systems design process. Basic cost accounting evaluation of the cost of manufacturing products reveals that when materials handling costs are separated from other costs, they can be seen to be significant.

Recently, the materials handling function has been undergoing significant changes in concept and implementation. Management has been changing its view of materials handling as the routine transfer of materials from place to place and is beginning to think of it as part of a total materials flow system. This change in thinking has come about largely as a result of new automatic handling and storage equipment and systems that are integrated closely with automatic processing and sophisticated management information and control systems.

II. METHODS AND MATERIAL

Objectives of Materials Handling

- Lower the unit materials handling costs
- Reduce the manufacturing cycle time
- Contribute toward a better control of the flow of goods
- Provide for improved working conditions and greater safety in the movement of materials
- Provide for fewer rejects
- Achieve decreased storage requirement
- Gain higher productivity at lower manufacturing cost

A. Literature Review

A manufacturing enterprise strives to be competitive through its ability to adapt swiftly to any sudden changes in the global manufacturing climate by applying new methods and advanced technologies. Black (1996) referred to Sir John Harvey-Jones's message that "for a production organization to survive in the long term it must aim to be the best in the world at its chosen activity. If it does not, some other competing organization in the world having the same aim will eventually win the customers for the product or services. To meet this aim, organizations have continuously to review their designs, manufacturing processes, and various procedures within the organizations." Gould (1997) was more specific by addressing the issue of manufacturing paradigms and the need to move away from cultures that have existed for around 100 years to updated ones to gain competitiveness in the global market. A major factor now is that the rate of change that is required of an enterprise is reaching the limits at which the enterprise can respond. It is the contention of this thesis that material handling could become either the bottleneck that restricts change or the means to enable change within the production environment. Whichever is the case, the belief is that selection of the most appropriate material handling method may occupy a position of far greater significance in the future than it does at present.
The aim of this research work is to develop an improved method for material handling equipment selection. This method will tackle the complexity of selecting handling equipment in view of the rapid changes occurring in the new manufacturing era. Also it will aid the decision maker in selecting the best equipment which suits their production requirements.

Material Handling

Manufacturing industries are on the verge of a new approach to manufacturing which is expected to accompany them into the 21st century. The agile manufacturing concept is predicted to replace the old manufacturing concepts (mass production, lean manufacturing, just-in-time and flexible manufacturing). The agile manufacturing concept has not appeared overnight. This new concept evolved over time as a result of the development of many previous manufacturing cultures with the aid of advanced manufacturing methods and technologies just like the lean manufacturing concept. The lean manufacturing paradigm addressed some limitations of the mass production concept like long lead time and inflexibility. Manufacturing aims to achieve quick response to global market changes and produce a variety of products with mass production prices (mass customization) which the lean manufacturing concept lacks.

The aim is to create a manufacturing business which is able not only to produce in volume but to deliver into a wide variety of market niches simultaneously (Booth, 1995). The fast pace of this type of manufacturing to rapidly meet market and customer demand in the shortest possible lead time in order to maintain competitiveness is producing great pressures on manufacturing enterprises. One of the major problems is developing organizational structures that support the rapid changes needed in administrative procedures. This is largely being addressed by software solutions. However software alone cannot deal with hardware changes that are needed to deal with physical differences in the types of products and the quantities to be produced and handled.

Selection of Material Handling Equipment

Selecting appropriate material handling equipment plays an important part in the design of material handling system. This is because the selection process requires careful and thorough analysis of various issues (e.g. flexibility, equipment features and characteristics, facility constraints) or else the handling equipment will impose a limit on the system's performance.

The expected manufacturing 'metamorphosis' for the next century places greater responsibilities on the material handling system. This is because agile manufacturing means that we must either have amazingly flexible systems that can make anything we want it to efficiently, or be able to reconfigure our systems very quickly to create different arrangements of cells to meet the new requirements.

B. Research Methodology

The various stages involved in research methodology are as follows:

- **i.** Data collection
- **ii.** Questionnaire design, and
- **iii.** Establishment of scores of different material handling equipment

The above mentioned stages were executed in the following manner:

1. First of all a brief survey of available material handling equipments and their merits and limitations was made with the help of available literature and a series of informal discussions with the industry personnel and academicians
2. The list of criteria, prepared from the extensive literature survey and informal discussions, then circulated among various industry personnel and academicians for the purpose of generalization of the criteria of material handling equipment selection. A five point Likert Scale was used for the evaluation of material handling equipments and pair wise comparison scale was used for comparison of criteria of material handling equipment selection.
3. Now, priorities of the criteria involved were calculated with the help of super decision software. For this purpose, pair wise comparison between the criteria was made by the firm's personnel. For this purpose, saaty's scale was used.
4. After getting the priorities of different criteria, values were assigned by the firm's personnel to different equipments for different criteria (according to their performances).
5. Finally, equipment's values (assigned by main firm personnel) were multiplied by corresponding criteria values and their summation gave the final GRA score for different material handling equipments. The material handling equipment had chosen for which GRA score was the maximum.

GREY RATIONAL ANALYSIS:

Grey relational analysis uses a specific concept of information. It defines situations with no information as black, and those with perfect information as white. However, neither of these idealized situations ever occurs in real world problems. In fact, situations between these extremes are described as being grey, hazy or fuzzy. Therefore, a grey system means that a system in which part of information is known and part of information is unknown. With this definition, information quantity and quality form a continuum from a total lack of information to complete information – from black through grey to white. Since uncertainty always exists, one is always somewhere in the middle, somewhere between the extremes, somewhere in the grey area.

The black box is used to indicate a system lacking interior information (W.R. Ashby, 1945). Nowadays, the black is represented, as lack of information, but the white is full of information. Thus, the information that is either incomplete or undetermined is called Grey. A system having incomplete information is called Grey system. The Grey number in Grey system represents a number with less complete information. The Grey element represents an element with incomplete information. The Grey relation is the relation with incomplete information. Those three terms are the typical symbols and features for Grey system and Grey the Grey relational analysis uses information from the Grey system to dynamically compare each factor quantitatively. This approach is based on the level of similarity and variability among all factors to establish their relation. The relational analysis suggests how to make prediction and decision, and generate reports that make suggestions for the vendor selection. This analytical model magnifies and clarifies the Grey relation among all factors. It also provides data to support quantification and comparison analysis (*Shi, 1997*). In other words, the Grey relational analysis is a method to analyze the relational grade for discrete sequences. This is unlike the traditional statistics analysis handling the relation between variables. Some of its defects are: (1) it must have plenty of data; (2) data distribution must be typical; (3) a few factors are allowed and can be expressed functionally. But the Grey relational analysis requires less data and can analyze many factors that can overcome the disadvantages of statistics method.

The Grey theory and method are described in the following:

Influence Space, Measurement Space, and Grey Relational Space

Let P(X) represent the factor set of a specific topics, Q is the influence relation, then {P(X); Q} is influence space. It must have the following properties (*Chiang, 1997*):

1. **Existence of key factors:** for example, the key factors of basketball player are height, weight, and rebound.
2. **Numbers of factors are limited and countable:** for example each of the height, weight, and rebound are countable.
3. **Factor undependability:** each factor must be independent.
4. **Factor expandability:** For example, besides the height, weight, and rebound, the free throw attempt can be added as a factor.

The series formed by P(X) is:

$$x_i^{(0)}(k) = (x_1^{(0)}(1), ?, ??, x_i^{(0)}(k)) ? X;$$
$$\text{where } i = 0, \mathrm{L}, m. k = 1, \mathrm{L}, n. ? N$$

If the following conditions are satisfied:

1. **Non dimension:** the numeric value for all factors must be non-dimension.
2. **Scaling:** the factor value for various series must be at the same level.
3. **Polarization:** if the factor value in the series is described as the same direction, the series is comparable. Then the measurement space is expressed as {P(X); x_i*(k)}, the Grey relational space formed by the satisfaction of both factor space and comparability is termed by {P(X); Γ}.

Generation of Grey Relation

Under the principle of series comparability, to achieve the purpose of Grey relational analysis, we must perform data processing. This processing is called generation of Grey relation or standard processing. The expected goal for each factor is determined by *Wu and H.H (1996)* based on the principles of data processing. They are described in the following:

1. If the expectancy is larger-the-better (e.g., the benefit), then it can be expressed by

$$x_{ij} = \frac{X_{ij} - (X_{ij})_{\min}}{(X_{ij})_{\max} - (X_{ij})_{\min}} \qquad (1)$$

2. If the expectancy is smaller-the-better (e.g., the cost and defects), then it can be expressed by

$$x_{ij} = \frac{(X_{ij})_{\max} - X_{ij}}{(X_{ij})_{\max} - (X_{ij})_{\min}} \qquad (2)$$

3. If the expectancy is nominal-the-best (e.g., the age), and when the targeted value is X_o : $(X_{ij})_{\max}$? X_o ? $(X_{ij})_{\min}$, then it can be expressed by

$$x_{ij} = \frac{\left| X_{ij} - X_O \right|}{(X_{ij})_{\max} - X_O} \qquad (3)$$

The Grey Relational Grade

In the Grey relational space, {P(X);Γ}, there is a series

$$x_i = (x_i(1), x_i(2), ?, ??, x_i(k)) ? X$$

where $i = 0$,L,m. $k = 1$,L,n.? N

If the grade of local Grey relation is brought to define the Grey relational coefficient, $\gamma(x_i(k), x_j(k))$, it can be expressed as following:

$$\gamma\ (x_i(k), x_j(k)) = \frac{\Delta \min. + \alpha\Delta \max.}{\Delta_{0i}(k) + \alpha\Delta_{\max.}} \qquad (4)$$

where i = 0, L,m. k = 1,L,n.j?i;

x_0 is a referenced series, x_i is a specific comparative series;

$\Delta_{0i} = \left\| x_0(k) - x_i(k) \right\|$; Representing the *k's* absolute value of the difference of x_0 and x_i;

$$\Delta = \min . \min . \left\| x(k) - x^j(k) \right\|;$$

$$min.\ \forall j ? i \forall k \quad \| \ 0 \quad \|$$

$$\Delta_{max} = max\,.\,max\,.\ \forall j ? i \forall k \left\| x_0(k) - x_j(k) \right\|$$

After obtaining the Grey relational coefficient, we normally take the average of the Grey relational coefficient as the Grey relational grade:

The measurement formula for quantification in Grey relational space is called the Grey relational grade. When we are determining Grey relation and taking only one series, $x_0(x)$, as a referenced series, it is called the grade of local Grey relation. If anyone of the series, $x_i(x)$, is referenced series, it is called the grade of global Grey relation. Additionally, the Grey relational coefficient must first be determined before we obtain the Grey relational grade.

x_0 is a referenced series, x_i is a specific comparative series;

$\Delta_{0i} = \| x_0(k) - x_i(k) \|$; Representing the k's absolute value of the difference of x_0 and x_i;

$$\Delta_{min} = min\,.\,min\,.\ \forall j ? i \forall k \left\| x_0(k) - x_j(k) \right\|;$$

$$\Delta_{max} = max\,.\,max\,.\ \forall j ? i \forall k \left\| x_0(k) - x_j(k) \right\|.$$

$$\Gamma = \gamma (x_i, x_j) = \frac{1 ?^n_{k=1}}{n} \gamma (x_i(k), x_j(k))$$

(5)

However, since in real application the effect of each factor on the system is not exactly same, Eq. (5) can be modified as:

$$\Gamma = \gamma (x_i, x_j) = ?^n_{k=1} \beta_k \ \gamma (x_i(k), x_j(k)) \qquad (6)$$

Where β_k represents the normalized weighting value of a factor and $?^n_{k=1} \beta_k = 1$ when both the equations (5) and (6) are equal.

The Grey Relational Series

The Grey relational grade represents the correlation between two series. It is not important in a decision-making. Rather, the ranking order of the relational grade is the most important information. Therefore, *m's* comparative series with its corresponding Grey relational grade is rearranged according to the order of their magnitudes. A Grey relational series is defined as following:

In the Grey relational space, {P(X); Γ}, referenced series, x_0, and comparative series, x_i and x_j:

$x_0 = (x_0(k))$, $k=1, \ldots, n.$
$x_i = (x_i(k))$, $k=1, \ldots, n;\ i$? I $x_j = (x_j(k))$,
$k=1, \ldots, n;\ j$? I

If $\gamma(x_0, x_i)$? $\Gamma(x_0, x_j)$, the situation indicating the relational grade of x_i vs. x_0 is greater than that of x_j vs. x_0, or represented by $\Gamma_{0i} > \Gamma_{0j}$. This is the relational series for x_i and x_j (*Wu & H.H, 1998*).

Decision For Grey Multiple Attributes:

To solve problems, if many ways or feasible methods exist, we normally make a complete evaluation on those resolutions. Then decision is made based on the evaluation results. It is noted that the multiple attributes decision -making (*Luo and Kuhnell, 1993*) is defined when more than one-evaluation factors are considered. Hence, the application of Grey relational analysis to multiple purposes and attributes is called as Grey multiple attributes decision (*Wu & H.H, 1998)*. Moreover, this method regards each comparative series as a feasible solution, and the numeric score for each evaluation factor becomes the numeric value for each comparative value. The relational grade between comparative series and standard series is then determined. Finally, the decision can be made based on the ranking of each feasible solution.

AHP APPROACH:

The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions. Rather than prescribing a "correct" decision, the AHP helps people to determine one. Based on mathematics and human psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education *(Saaty,1991)*.

To solve our problem by AHP, first we decompose our decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well- or poorly-understood—anything at all that applies to the decision at hand.

Once the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations.

The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques.

In the final step of the process, numerical priorities are derived for each of the decision alternatives. Since these numbers represent the alternatives' relative ability to achieve the decision goal, they allow a straightforward consideration of the various courses of action *(Saaty, 1980)*.

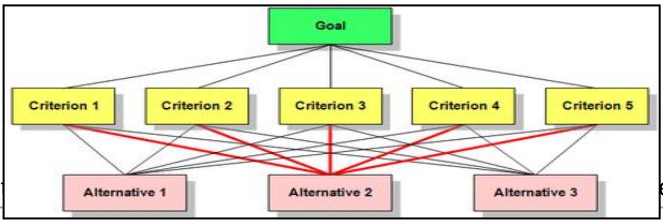


Figure 1: General AHP Hierarchy Structure

Table 1: Pair wise Comparison Scale

The fundamental scale for paire wise comparision		
Intensity of Importance	**Definition**	**Explanation**
1	**Equal importance**	Two elements contribute equally to the objective
3	**Moderate importance**	Experience and judgment slightly favor one element over another
5	**Strong importance**	Experience and judgment strongly favor one element over another
7	**Very strong importance**	One element is favored very strongly over another; its dominance is demonstrated in practice
9	**Extreme importance**	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6 and 8 can be used to express intermediate values. Intensities	**Intensities 1.1, 1.2, 1.3, etc., can be used for elements that are very close in importance**	

Make the decision

In the end, we arrange and total the priorities for each of the alternatives. Their grand total is 1.000. Each alternative has a priority corresponding to its "fit" to all the family's judgments. Saaty has defined the following steps for applying AHP (Kumar, 2006 and Saaty, 1980, 1977):

- **i.** Define the problem and determine its goal,
- **ii.** Structure the hierarchy with the decision maker's objective at the top with the intermediate levels capturing criteria on which subsequent levels depend and the bottom level containing the alternatives, and
- **iii.** Construct the set of n× n pair wise comparison matrices for each to the lower levels with one matrix for each element in the level immediately above. The pair wise comparisons are made suing the relative measurement scale. The pair wise comparisons capture a decision maker's perception of which element dominates the other.
- **iv.** There are n× (n-1)/2 judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pair wise comparison.
- **v.** The hierarchy synthesis function is used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.
- **vi.** After all the pair wise comparisons are completed, the consistency of the comparisons is assessed by using the Eigen value, **λ**, to calculate a consistency index, CI:

  $$C.I. = (\lambda - n)/(n-1) \quad \textbf{(1)}$$

  Where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (C.R.).

  $$C.R. = C.I./R.I. \quad \textbf{(2)}$$

where R.I. stands for Random Consistency Index, which with the appropriate value is given in Table 2. Saaty (1980) suggests that the C.R. is acceptable if it does not exceed 0.10. If the CR is greater than 0.10, the judgment matrix should be considered inconsistent. To obtain a consistent matrix, the judgments should be reviewed and repeated.

Table 2 : Average Random Consistency Index (Saaty, 1980)

size of metrics	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Random consistency index	**0.00**	**0.00**	**0.58**	**0.90**	**1.12**	**1.24**	**1.32**	**1.41**	**1.45**	**1.49**

The AHP uses relative values instead of actual ones. Thus, it can be used in single- or multi-dimensional decision making problems (Saaty, 1977), and hence is used in the following problem.

AHP Calculations (Zhang, 2010)

Let n be the number of criterion and $z_1, z_2, \ldots z_n$ be their corresponding relative priority given by on decision maker. Then the judgment matrix A which contains pair wise comparison value a_{ij} for all i, j ϵ {1,2,… ,n} is given by (3).

$$A = \begin{bmatrix} a11 & a12 \ldots & a1n \\ a21 & a22 \ldots & a2n \\ an1 & an2 \vdots & ann \vdots \end{bmatrix} = \begin{bmatrix} 1 & \frac{z1}{z2} \ldots & z1/zn \\ z2/z1 & 1 \ldots & z2/zn \\ zn/z1 & \frac{zn}{z2} \ldots & 1 \end{bmatrix} \quad \textbf{(3)}$$

For multiple decision makers, let h be the number of decision maker and aijk be the pair wise comparison balue of criteria I and j given by decision maker k, where k = 1,2,…,h. then by using geometric mean of the aijk conducted by each decision maker, we have a new judgment matrix with element given by (4).

Aij = (aij1*aij2* … aijk* … aijh)1/h = (∏h k-1aijk)1/h **(4)**

The basic procedure for AHP approach by the mean of normalized values method is given as follows:

(i) Normalize each column to get a new judgment matrix A'

$$A' = \begin{bmatrix} a11' & a12' \ldots & a1n' \\ a21' & a22' \ldots & a2n' \\ an1' & an2' \ldots & ann' \end{bmatrix} = \begin{bmatrix} \frac{a11}{\sum_{i=1}^{n} ai1} & \frac{a12}{\sum_{i=1}^{n} ai2 \ldots} & a1n/\sum_{i=1}^{n} ain \\ \frac{a21}{\sum_{i=1}^{n} ai1} & \frac{a22}{\sum_{i=1}^{n} ai2 \ldots} & a2n/\sum_{i=1}^{n} ain \\ \vdots & \vdots & \vdots \\ an1/\sum_{i=1}^{n} ai1 & \frac{an2}{\sum_{i=1}^{n} ai2} \ldots & ann/\sum_{i=1}^{n} ain \end{bmatrix} \quad \textbf{(5)}$$

Where $\sum_{i=1}^{n} aij$ is the sum of column j of judgment matrix A.

(ii) Sum up each row of normalized judgment matrix A' to get weight vector V.

$$V = \begin{bmatrix} v1 \\ v2 \\ vn \end{bmatrix} = \begin{bmatrix} \sum_{j=1}^{n} a1j' \\ \sum_{j=1}^{n} a2j' \\ \sum_{j=1}^{n} anj' \end{bmatrix} \quad \textbf{(6)}$$

(iii) Define the final normalization weight vector W.

$$W = \begin{bmatrix} w1 \\ w2 \\ wn \end{bmatrix} = \begin{bmatrix} v1/\sum_{i=1}^{n} vi \\ v2/\sum_{i=1}^{n} vi \\ vn/\sum_{i=1}^{n} vi \end{bmatrix} \quad \textbf{(7)}$$

III. RESULTS AND DISCUSSION

MODEL FORMULATION:

Material handling equipment selection problem identification for a galvanizing line is an uncommon task. In order to understand the problems generated first of all let us understand the process of galvanizing. The details of galvanizing process are as follows:

Galvanizing Process consists in 3 sections. **1.** Entry **2.** Process **3.** Exit

- **Entry Section:** It consists of the major equipments like Pay of real, Welding machine, steering unit and accumulator.
- **Process section:** Process section consists major equipments are Heating furnace for annealing, Zinc bath & cooling after galvanizing. Tension leveler and skin pass is also added in process section.
- **Exit Section:** Exit Accumulator, Shear edge guider and Tension real along with Belt wrapper.
- In present research work emphasis is made on the ***process section*** of the galvanizing line. This is the most critical as well as most important section of the line. Material handling problem was originated in zinc pot section where material transferred was zinc and aluminum slabs and the handling medium used were workers.
- At the zinc pot section temperature maintained is around 440ºC to 510ºC. At this very high temperature, hot cold rolled sheet comes from annealing furnace to the zinc pot, gets coated with zinc and aluminum (a preferred combination) and then goes to the cooling section. Provision of air knife controls the amount of coating.

Other than manual pouring, the alternatives identified are:

- Conveyer pouring
- Automatic system

Now we have total three alternatives;

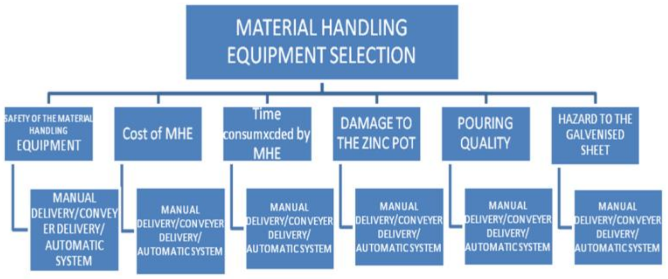
- Manual Delivery,
- Conveyor Delivery,
- Automatic system

The approaches used for selection of best material handling equipment were Multi criteria decision making (MCDM) techniques. The basic reason behind of selection of multi criteria decision making techniques is that these techniques permit easy understanding of the problem and yield practical results. The selected MCDM techniques were:

- Grey Rational Analysis, and
- Analytical Hierarchy Process

In order to solve the problem using above two methods different criteria were needed. For this reason again a series of informal discussions were made with company personnel and academicians who finally yield the following list of criteria:

- Safety of the material handling equipment (MHE)
- Cost of MHE
- Time consumed by MHE
- Damage to the zinc pot
- Pouring quality
- Hazard to the galvanized sheet



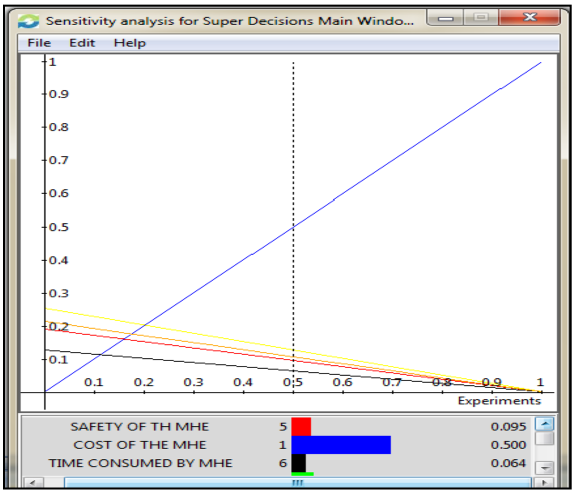
SOLUTION TO THE MODEL

For the solution of above mentioned model a hybrid Grey Rational Analysis (AHP- GRA) approach was proposed. In this approach, weights for different criteria were calculated using AHP software and for evaluation of alternatives grey rational analysis was used.

For entering the values in AHP software (Super decision software), a systematically designed questionnaire was circulated to the employees of the firm and their results were mentioned in the pair wise comparison matrix shown in Figure given below.

Table 3: Priority values/Weights of criterion

S. No	Criteria	Priority Value
1	Cost of MHE	0.136
2	Damage to the zinc pot	0.184
3	Hazard to the galvanized sheet	0.184
4	Pouring Quality	0.219
5	Safety of the MHE	0.164
6	Time consumed by MHE	0.110
C.R = 0.065< 0.10		



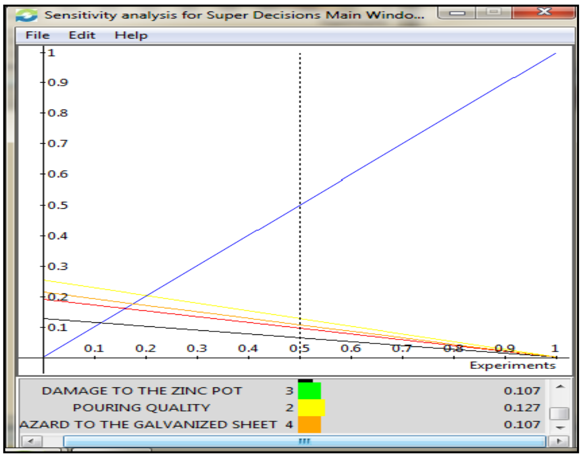


Figure 2 : Sensitivity Analysis for Criterion

The above sensitivity analysis shows that cost increases while other criteria decreases simultaneously. Next step is to calculate Gray Rational Grate of GRA Score, the calculation procedure for which is given as follows:

First of all nature of attributes (criteria) was decided with the help of expert's opinion. Next step is to calculate Gray Rational Grate of GRA Score, the calculation procedure for which is given as follows:

First of all nature of attributes (criteria) was decided with the help of expert's opinion. The details are given in Table 4:

Table 4: Nature of Attributes

S.No	Attribute	Nature of Attribute
1	Cost of MHE	Lesser is better
2	Damage to the zinc pot	Lesser is better
3	Hazard to the galvanized sheet	Lesser is better
4	Pouring Quality	Greater is better
5	Safety of the MHE	Greater is better
6	Time consumed by MHE	Lesser is better

Table 5: Ranking of Alternatives on the Basis of Grey Rational Grades of GRA Score

S.No	Alternative	GRA Grade	Rank
1	**Automatic System**	0.678	I
2	**Conveyer's Delivery**	0.340	III
3	**Manual Delivery**	0.567	II

As the result of above analysis candidate suggests Automatic System as the best material handling equipment as its score is 0.678, after that manual delivery and conveyer's delivery are suggested as second and third alternatives with scores of 0.567 and 0.340 respectively.

DISCUSSIONS

Choosing a MHE has always become a difficult task for a firm as it may involve many criteria of opposite nature. Many a times cost determines the MHE. However, now days, this trend is shifting towards other parameters also. In many firms, emphasis on quality, on time delivery and safety are also considered as determining criteria. Selection of criteria and number of criterion may vary from industry to industry and even from person to person. In this research, selection of criteria was done on the basis of literature survey and a series of informal discussions with the industry personnel. Sometimes the industry personnel become unable to give the right definition of the criteria he is using. In such cases, research may go in wrong direction.

In present research work, all the necessary attempts were made for investigating criteria for MHE selection and originality of the work, yet extensive research may be done in this field.

Sometimes, it becomes very difficult for company personnel to give numerical values to the criteria. A MHE selection criterion is a qualitative term and for the purpose of calculations it must be quantifiable. In order to quantify the criteria we assign the numerical values to the criteria. At this point human behavior interferes. Many a times, due to fuzziness of our mind we cannot assign the numerical values to the qualitative terms.

IV. CONCLUSION

- There must be a robust MHE selection model that fit a particular class of industries.
- Extreme care must be taken for model development and analysis procedure selection.
- in order to get proper response of the respondents a great emphasis should be made on the methodology adopted and questionnaire design.
- There may be many reasons for less scoring of options, but these reasons must be carefully analyzed and must be avoided.

As the result of this result of this research work the candidate has observed that there may be great diversity in the model development, selection procedure, criteria finalization etc., for the material handling equipment selection but there must be a universally versatile model which must be applicable for all classes of industries. An extensive research on the universal model development in this field is still awaited.

V. REFERENCES

[1] Allegri, T.H, (1981), "Materials Handling: Principles and Practice", CBS Publishers & Distributors, New Delhi.

[2] Allred, J., (1996), "Taking A New Direction In Factory Logistics And Material Handling", HE Solutions, Pages 21-25.

[3] Apple, J. M., (1977), "Plant Layout and Material Handling", Third Edition, John Wiley & Sons.

[4] Black, R,(1996), "Design & Manufacture An Integrated Approach", Macmillan Press Ltd.

[5] Booth, R. (1995), "In the Market", Manufacturing Engineer, Pages 236-239.

[6] Chan WK and Tong TKL, (2007), "Multi-criteria material selections and end-of-life product strategy: Grey relational analysis approach", Materials & Design, Volume 28, 5, Pages 1539-1546

[7] Chang, Y.C. (1996), "The Application of Grey Theory to Purchasing-Decision," Knowledge of Military Supplies, Vol. 94.

[8] Chiang, K.S. (1997), "The Introduction of Grey Theory," Gauli Publishing Co., Taipei.

[9] Deng, J.L. (1989), "The Introduction to Grey System Theory," The Journal of Grey System, Vol. 1, 1, Pages 1-24.

[10] Esmail, K, and Saggu J. (1996), "A Changing Paradigm", Manufacturing Engineer, Pages 285-288.

[11] F. T. S. Chan, R. W. L. lp, and H. Lau (2001), "Integration of expert system with analytic hierarchy process for the design of material handling equipment selection system", Journal of

Material Processing Technology, Vol. 116, 2-3, Pages 137-145.

[12] G. Tuzkaya, B. Gulsun, C. Kahraman, and D. Ozgen (2010), "An integrated fuzzy multi-criteria decision making methodology for material handlingequipment selection problem and an application", Expert Systems with Applications, Vol. 37, Pages 2853-2863.

[13] H. R. Sayarshad,(2010)"Using bees algorithm for material handling equipment planning in manufacturing systems", International Journal of Advanced Manufacturing Technology, Vol. 48, Pages 1009-1018

[14] Handfield, R., S. V. Walton & Sroufe, R. (2002), "Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process", European Journal of Operational Research, Vol.141, Pages 70-87.

[15] Hsu T.H. (1997), "The Study on the Application of Grey Theory to the Evaluation of Service Quality," Proceeding of Conference of Grey System and Application, Pages 1-15.

[16] Iacocca Institute (1991), "21st Century Manufacturing Enterprise Strategy". An Industrial- Led View. Vol, 1&2, Bethlehem, PA: Iacocca Institute.

[17] Kidd, P. (1994), "Agile Manufacturing Forging New Frontiers", Addison-Wesley Publishers Ltd.

[18] Kumar, P. (2006). "Integrated Project Evaluation and Selection using Multi Attribute Decision Making Technique", International Journal of Production Economics, Vol.103, 1, Pages 90-103.

[19] Liang, M., Dutta, S.P., and Abdou, G. (1989), "A New Approach to Material Handling Equipment Selection in A Manufacturing Environment", International Industrial Engineering Conference Proceedings, Pages 255-230. Luo, M. and Kuhnell, B.T. (1993), "Fault detection using Grey relational grade analysis," The Journal of Grey System, Vol.5.4, Pages 319-328.

[20] Macharis, C and Springael, J, (2004), "Promethee and AHP: The design of operational Synergies in Multicriteria Analysis", Strengthening Promethee with ideas of AHP, European Journal of Operational Research, Vol. 153, Pages 307-317.

[21] Wu, B. (1992), "Manufacturing Systems Design And Analysis", Chapman & Hall.

[22] Wu, J.H. and Chen, C.B. (1998), "The Discussion of Distinguish coefficient," Third National Conference on Grey Theory and Applications.

[23] Zahir, S., (1999), "Clusters in Group: Decision Making in the Vector Space Formulation of the Analytic Hierarchy Process", European Journal of Operational Research, 112, Pages 620-634.

[24] Zhong Hua Yang and Jing Tu. (2009). "Evaluation of Information Sharing Capability of Supply Chain Partners", Proceedings of IVth International Conference on Computer Science & Education, IEEE, Pages 651-655.