Complex Decision Making By Use Of AHP: Case Studies Based On Kakda Rolling Mills

SHAIKH MOHD. JAVED[1], G.L.GUPTA[2] and ANKIT GOEL[3]

[1]M.Tech Scholar, Department of Industrial Engineering and Management, BIST, Bhopal, MP, India.
[2]Professor, Department of Industrial Engineering and Management, BIST, Bhopal, MP, India.
[3]Professor, Department of Mechanical Engineering, BIST, Bhopal, MP, India.

(Received: February 10, 2015; Accepted: April 18, 2015)

ABSTRACT

Rather than prescribing a "correct decision", the AHP helps people to determine one solution. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education.KAKDA ROLLING MILLS PVT. LTD. BHOPAL is a leading steel manufacturing company of Central India. It manufactures CR reinforcement steel bars, square bars, ingots etc. This paper presents application of AHP in employee selection at KAKDA ROLLING MILLS PVT. LTD., BHOPAL. There are two phases of the work. In phase one theoretical aspects of AHP are discussed, whereas phase two comprises the implementation of AHP on a firm, looking for efficient manpower. For doing so, the candidates appeared in interview are carefully examined on the anvil of five different criteria; knowledge, experience, competency, temperament and character and interest in job. For comparing candidates on these criteria, basically two types of techniques are used Interview and written test.

After carefully examine their performances, marks are given to them against each criterion and after that these results are converted into priority values. Finally, results obtained from testing of candidate's performances are tabulated in comparison chart made for the candidates and the candidate is suggested for which the total sum of priorities is maximum.

Key words: Analytical Hierarchy Process, decision situations, employee selection, priority values**.**

INTRODUCTION

The Analytic Hierarchy Process (AHP) is a structured technique to help people in deal with complex decisions rather than prescribing a "correct" decision. The AHP helps people to determine one from many. Based on mathematic 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 formatting a problem, for representing and quantify its elements, for relating those elements to overall goals, and for evaluating alternative solution. It is used all over the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education etc[1]

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

Once the hierarchy is build up, the decision makers methodically evaluate its various elements, comparing them to one to another in pairs. In building the comparisons, the decision makers can use existing data about the elements, or they can use their intelligence about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the basic information, can be used in performing the evaluations.

The AHP translate these evaluations to numerical values that can be processed and

compared over the whole range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing dissimilar and often incommensurable elements to be compared to one another in a rational and consistent way. This capability discriminate 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 characterize the alternatives' relative ability to achieve the decision goal, they allow a straight forward consideration of the various courses of action[2].

Analytic Hierarchy Process is most useful where panel of people are working on compound problems, especially those with high risk, involving human observations and judgments, whose resolutions have long-term effects. It has exclusive advantages where important elements of the decision are difficult to quantify or compare, or where communication among team members is delayed by their different specializations, terminologies, or perspectives[4]

The applications of AHP to complex decision conditions have numbered in the thousands, and have produced wide-ranging results in problems involving planning, resource allocation, priority setting, and selection among alternatives.

Company Profile

Kakda rolling mills pvt. Ltd. Bhopal is established in 1996 to manufacture the rolled steel products viz reinforcement steel bars, square bars, ingots etc. The steel manufactured by firm is well accepted in Madhya Pradesh, Uttar Pradesh, Rajasthan, and Maharashtra. The processes involved are TMT quenching system, quenching, self tempering, and atmospheric cooling.

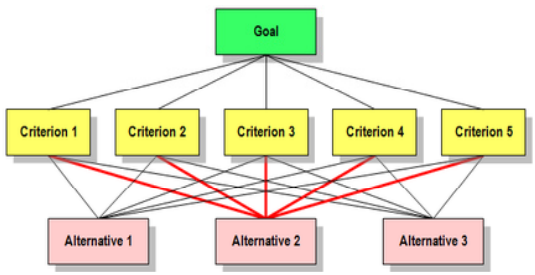

Fig. 1: AHP Hierarchy

METHODOLOGY

Model the problem as a hierarchy

The first step use in the Analytic Hierarchy Process is to model the problem as a hierarchy. In doing this; participants explore the aspects of the problem at levels from general to detailed, then expressed it in the multileveled way that the AHP requires.

Hierarchies defined

We have used a hierarchy to integrate large amounts of information into our understanding of the situation. As we build this information structure, we form a better and better picture of the problem as a whole.

AHP hierarchies explained

The hierarchy can be visualized as a diagram like the one below, with the goal at the top, the alternatives at the bottom, and the criteria filling up the middle. In such diagrams, each box is called a node. The boxes descending from any node are called its children. The node from which a child node descends is called its parent. Applying these definitions to the diagram below, the five criteria are children of the Goal, and the Goal is the parent of each of the five Criteria. Each Alternative is the child of each of the Criteria, and each Criterion is the parent of three Alternatives[4]

Establishment of priorities

Once the hierarchy has been constructed, we use AHP to establish priorities for all its nodes. In doing so, information is elicited from the participants and processed mathematically. This activity is somewhat complex, and the participants have many options on the road to completing it.

Priorities defined

Priorities are numbers associated with the nodes of the hierarchy. If all the priorities in a group of nodes are equal, each member of the group has equal weight. The priority of any child node represents its contribution to the priority of its parent. As we move ahead through the Analytical Hierarchy Process, the priorities will change but will still add to 1.000 for each group of child nodes.

Pair wise comparisons

To perform judgments about the various elements in the hierarchy, we compare the elements two by two. When the pair wise comparisons are as numerous, specialized AHP software can help in making them quickly and efficiently.

For assigning numerical values to the compared results, we use a pair wise comparison scale which may be like the one shown below:

Table. 1: Pairwise Comparison Scale

The Fundamental Scale for Pairwise Comparisons		
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 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

We calculate the CONSISTENCY RATIO. The AHP software also provides a consistency ratio that expresses the internal consistency of the judgments that have been entered. The normal acceptance level for the consistency is that it should be less than 0.1. [4]

Comparing Alternatives

Then we evaluate alternatives against their covering criteria in any order they choose.

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.

Case Study-I

Application of AHP in employee selection process

AHP can be successfully used in selecting the best employee for the firm. With the aid of AHP, we judge the performance of a candidate on the anvil of different criteria. Now, we will consider the case of a firm looking for a right candidate for a G.E.T post. (We will analyze the process for three candidates). Let us assume that only three candidates have appeared in the interview. We are naming them as A, B and C. We are choosing criteria for selection - knowledge, experience, competency, temperament & character and interest in job[13]

Basic Considerations

For selection of an employee, we will follow some basic considerations which are as follows:

1. All the candidates must confirm minimum

fitness level lay down by the organization.

2. All the candidates must confirm the minimum qualification

Criteria lay down by the firm's authority.

3. All candidates should confirm the minimum experience

Criteria lay down by firm's authority.

4. Their maximum salary limitations will be as per firm's rules and regulations.
5. Provision for bond.

Establish Priorities

Once the hierarchy has been constructed, the participants use AHP to establish priorities for all its nodes. In doing so, information is elicited from the participants and processed mathematically. This activity is somewhat complex, and the participants have many options on the road to completing it. This and the following sections describe a simple, straightforward example of establishing priorities.

Priorities Defined

Priorities are numbers associated with the nodes of the hierarchy. By definition, the priority of the Goal is 1.000. The priorities of the Criteria can vary in magnitude, but will always add up to 1.000. The priorities of the children of any Criterion can also vary but will always add up to 1.000, as will those of their own children, and so on down the hierarchy. In our example as it stands, the priorities within every group of child nodes are equal. In this situation, the priorities are called default priorities. As the analytic hierarchy process continues, the priorities will change from their default values to reflect our judgments. The priorities indicate the relative weights given to the items in a given group of nodes. Depending on the problem at hand, "weight" can refer to importance, or preference, or likelihood.

If all the priorities in a group of nodes are equal, each member of the group has equal weight. If one of the priorities is two times another, or three, (or whatever), that member has two, or three, (or whatever) times the weight of the other one. As we move ahead through the Analytical Hierarchy Process, the priorities will change but will still add to 1.000 for each group of child nodes.

Pair Wise Comparisons

To incorporate their judgments about the various elements in the hierarchy, we will compare the elements two by two. How they are compared will be shown later on. Right now, let's see which items are compared. Our example will begin with the four Criteria in the second row of the hierarchy, though we could begin elsewhere if we wanted to. The Criteria will be compared as to how important they are to us, with respect to the Goal. Each pair of items in this row will be compared and it can be seen with the help of table.

The firm's first pair wise comparison is Knowledge/ Experience. They need to decide which of these is more important in choosing the best employee for them all. This can be a difficult decision. On the one hand, "we can't put an experience on education. Nothing is more important than the lack of basic knowledge. But in many cases experience dominates. So, we have to say which criterion is more important to us in reaching our goal, and how much more important it is (to us) than the other one. In making this judgment, we should remember that since the AHP is a flexible process, we can change their judgment later on.

Let's say that we decide that in this case, Experience and Knowledge is of equal importance to us. In the same sense we will compare the other pairs. To find out the importance of a factor relative to other we may take help of the Pair wise comparison scale, which is given below

Table. 2: Pair wise Comparison Scale

The Fundamental Scale for Pairwise Comparisons

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 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.

With the help of above scale, we have assigned intensity factors to different pairs, which may be given in following format:

Table 3: Pair wise Comparison Worksheet

Criteria A	Criteria B	More Important	Intensity
Knowledge	Experience	Both	1
Knowledge	Competency	A	5
Knowledge	Temperament & Character	A	3
Knowledge	Interest in job,	A	4
Experience	Competency	Both	1
Experience	Temperament & Character	A	4
Experience	Interest in job	A	4
Competency	Temperament & Character	A	4
Competency	Interest in job	B	5
Temperament & Character	Interest in job	B	5

The next step is to convert these intensity values into priorities.

Prepare the problem matrix

For this, we need to enter all the criteria in a matrix form. As there are five criteria with which we are dealing with, the matrix will of order 5X5.

On the basis of knowledge following matrix is prepared:

From/To	K	E	C	T & C	I
K	1	1	5	3	4
E	1	1	1	4	4
C	1/5	1	1	4	5
T & C	1/3	1/4	1/4	1	5
I	¼	1/4	1/5	1/5	1

And on solving we get

From/To	K	E	C	T & C	I	Total/5	Σ
K	60/167+	2/7+	100/149+	15/61+	4/19	1.772/5	0.3545
E	60/167+	2/7+	20/149+	20/61+	4/19	1.3176/5	0.263
C	12/167+	2/7+	20/149+	20/61+	5/19	1.0828/5	0.21656
T & C	20/167+	1/14+	5/149+	5/61+	5/19	0.5698/5	0.1139
I	15/167+	1/14+	4/149+	1/61+	1/19	0.2571/5	0.05142
Total	1	1	1	1	1	1	1.00

Finally, knowledge got 0.3545, experience obtained 0.263, competency got 0.21656, temperament & character got 0.1139 and interest in job obtained 0.05142 priority values.

Comparing alternatives

Knowledge

For the sake of comparison of knowledge of candidates both the written test and technical interviews were conducted. Both the written test and technical interview were of 25 marks each. Results obtained are

Candidate	Written Test	Technical Interview	Total Marks
A	15	20	35
B	17	19	36
C	21	18	39

On preparing pair wise worksheet

Comparison B/W		Marks		Better	Marks are better by	Ratio
I	II	I	II			
A	B	35	36	B	1	1.028
A	C	35	39	C	4	1.114
B	C	36	39	C	3	1.083

On comparing these values with pair wise comparison scale priority matrix is obtained and on solving priority matrix results obtained are:

Candidates	Priorities (local)	Priorities (global)
A	0.106	0.037577
B	0.2604	0.09231
C	0.633345	0.22452

Experience

Now we will compare all the candidates on the criteria of Experience. For this comparison we will focus on their résumés. On analyzing resumes we will find that candidate a has around 12 months of experience of a steel manufacturing company, B has3 months of experience of an automobile part manufacturing industry and candidate C is a fresher one. We can also notice that out of these candidates no one has previous experience of the same kind.

Summary of Experience

Table 4: Summary of Experience of Candidates

Candidate	Experience	Industry
A	12 months	Gear Industry
B	3 months	Automobile Part Industry
C	NIL	NA

On the basis of their valid experience certificates and some questions asked to them regarding their experience, with the help of pair wise comparison scale we can assign the intensity values and priority matrix is obtained and values obtained are

Candidates	Priorities (local)	Priorities (global)
A	0.70708	0.1859
B	0.20141	0.05297
C	0.0915	0.0240

Competency

Competency means ability to learn something new. Competency is very close term to the interest which makes it difficult to be evaluated. In order to judge the competency of candidate's interviews were taken by the HR personnel.

Following results are obtained for competency

Candidates	Priorities (local)	Priorities (global)
A	0.2014	0.043615
B	0.6806	0.147390
C	0.1179	0.025532

Temperament & Character

Specifically this criteria tells about the behavior if the employee on the shop floor. Observations reveal that a person with a cool temperament level and nice character cooperates well with his boss, collogues and sub ordinates. In order to judge the temperament and character of candidates, interviews were taken by the HR personnel.

Candidates	Priorities (local)	Priorities (global)
A	0.6893	0.07851
B	0.2437	0.02775
C	0.0666	0.00758

Interest in job

Interviews were taken by the HR personnel and results obtained are as follows

Candidates	Priorities (local)	Priorities (global)
A	0.6486	0.03335
B	0.2946	0.015148
C	0.0567	0.00291

Comparison of candidates: comparative analysis chart is made and different priorities are obtained against each candidate and results obtained are:

Candidates	Priorities Values	Priorities Number
A	0.6486	1
B	0.2946	2
C	0.0568	3

Based on the above analysis, Candidate A should be chosen for KAKDA ROLLING MILLS for the post of G.E.T.

Case Study-II

Application of AHP in location selection process

Units concerning both manufacturing as well as the assembling of the products are on a very large scale affected by the decisions involving the location of the plant. Location of the plant itself becomes a very important factor concerning service facilities, as the plant location decisions are strategic and long-term in nature. AHP can be successfully used in selecting the best location selection for the firm. With the aid of AHP, we judge the performance of a location on the anvil of different criteria. Now, we will consider the case of KAKDA ROLLING MILLS looking for a new location to expand its production. (We will analyze the process for three locations). Let us assume that firm wants to select best location from three locations. We are naming them as A, B and C. We are choosing criteria for selection– price, distance, labor, wages.

Basic Considerations

For selection of a location, we will follow some basic considerations which are as follows:

1. All the locations must have required space.
2. All the locations must have transportation facility like road and rail.
3. All the locations must have fulfill basic requirement like water, electricity, manpower etc.
4. All the locations must have skilled and unskilled labor.
5. All the locations must have all the government permissions.

Pairwise Comparisons

Six pairs formed are Price/Distance, Price /Labor, Price/Wages, Distance /Labor, Distance / Wages, Labor / Wages.

Table. 5: Pair wise Comparison Scale

The Fundamental Scale for Pairwise Comparisons		
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 1.1, 1.2, 1.3, etc. can be used for elements that are very close in importance.		

With the help of above scale, we have assigned intensity factors to different pair and then these intensity values are converted into priorities. Following steps are follower:

1. Prepare problem matrix.
2. Adding of all the column elements'.
3. Divide Column total to each element of the same column
4. Finding out row average

The row average values are the priorities of criteria w.r.t goal obtained i.e., for distance, price, labour, wages are 0.654, 0.198, 0.086, 0.062 respectively.

Comparing Alternatives

Choose the order of decreasing priority of the covering criteria. That means price first.

Price

For the sake of comparison of price of location some technical questionnaire were held to the managerial team of the firm. Technical questionnaire were of 25 marks. Summary of results obtained are

Locations	Technical Questionnier	Total Marks
A	15	15
B	17	17
C	21	21

As a result of calculations from matrix obtained led to following priority values:

Candidates	Priorities Values	Priorities Number
A	0.501	1
B	0.118	3
C	0.381	2

Distance

For distance following results were obtained.

Candidates	Priorities Values	Priorities Number
A	0.282	2
B	0.060	3
C	0.658	1

Labour

Availability of labour was taken into consideration. As a result of calculations from above matrix we will get following priority values

Candidates	Priorities Values	Priorities Number
A	0.179	2
B	0.685	1
C	0.136	3

Wages

Now we will compare all the locations on the criteria of Wages. For this comparison we will focus on the wages to be pay to Labor. On analyzing wages and with the help of pair wise comparison scale we can assign the intensity values the details of which is as follows :

From A = 1/3 = To B
From A = 1/2 =To C
From B = 4 = To C

On the basis of these values we will make priority matrix which is as follows:

From priority matrix following values of priority values were found out

Candidates	Priorities Values	Priorities Number
A	0.156	3
B	0.620	1
C	0.224	2

Comparison of Locations

For comparison of all locations, a comparative analysis chart was made and different priorities obtained against each location were entered. The location, with maximum priority is selected.

Criteria	Price	Distance	Labor	Wages	Row Avg.
Price	.1519	.1375	.2222	.2857	.1933
Distance	.7595	.6878	.6667	.5000	.6535
Labor	.0506	.0764	.0741	.1429	.0860
Wage	.0380	.0983	.0370	0.0714	0.0612
ΣRow Avg.	1.000				

The row average values are the priorities of criteria with respect to goal.

Final Calculations

Location A score = 1993(.0512) + .6535(.2819) + .0860(.1790) +.0621(.1561) = .3091

Location B scores = .1993(.1185) + .6535(.0598) + .0860(.6850) + .0612(.6196) = .1595

Location C scores = .1993(.3803) + .6535(.6583) + .0860(.1360) + .0612(.2243) = .5314

Based on the above analysis, Location *C* should be chosen for KAKDA ROLLING MILLS to establish a new mill.

RESULT

Result For Case Study-1

On the basis of above comparative chart we can find that as for the candidate A the total sum of priorities is 0.378952 and it is Maximum, therefore we can recommend the candidate A for selection.

Result For Case Study-2

On the basis of above comparative chart we can find that as for the Location C the total sum of priorities is 0.5314 and it is Maximum, therefore we can recommend the Location C for the firm.

CONCLUSION

On the basis of above analytical discussion we can conclude that Analytical hierarchy Process can be successfully used in selecting right candidate for the job and the right location for set up a new plant. We can also implement the same process in case of employee evaluation, vendor selection, business forecasting, and etc. successfully. Industries should take necessary steps in this field and try to reduce their fuzziness in decision making to a minimum level.

REFERENCES

1. Thomas L. Saaty "Response to Holder's Comments on the Analytic Hierarchy Process" *The Journal of the Operational Research Society,* **42**(10), pp. 909-914 (1991)
2. Saaty T.L. The analytical hierarchy process, McGraw-hill, New York, **32**(09) , pp126-128 (1980).
3. Hwang, C.-L., and K. Yoon. 1981. Multiple Attribute Decision Making, Springer-Verlag, N.Y.
4. R. D. Holder "Response to Holder's Comments on the Analytic Hierarchy Process: Response to the Response" *The Journal of the Operational Research Society,* **42**(10) , pp. 914-918 (1991)
5. Smith, Bush and Schmidt. The Selection of Bridge Materials Utilizing the Analytical Hierarchy Process, **29**, pp238-239 (2003).
6. www.ieeexplore.com/publication/at pdf_org analytical hierarchy process html. Retrieved on 28/11/09
7. books.google.co.in/books *retrieved on 02/*12/09
8. www.amazon.com/AHP Technology retrieved on 30/12/09
9. www.acceleam.com/publications/atPDF_08_ org. Retrieved on 04/1/10.
10. Kirkwood, C. "Strategic Decision Making – Multi objective Decision Analysis with Spreadsheets", Duxbury Press, 1997, Belmont CA,
11. Russell, Roberta S. and Taylor III, Bernard W. Operations Management 4th edition. Upper Saddle River, New Jersey: Prentice Hall, 2003.
12. J.w.Ra. Chain wise paired comparison decision science, **30**, pp 581-582(1999).
13. M. Mahajan, Industrial Engineering and Production Management,
14. D.S Kumar, GATE for Mechanical Engineers
15. www.careerplanner.com, retrieved on 27/02/2010, 03/03/10.