

## **Ranking of maximum production strategies in gas processing plant of National Iranian Gas Company using AHP**

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### **Abstract**

This article uses Saaty's Analytical Hierarchy Process (AHP) to find out the most important bottlenecks of natural gas processing plant in order to solve them during annual overhaul as *the first* systematic decision making for operation managers. In the first step, some interviews has been implemented to find out criteria and attributes of this model and base on this in the second step, a questionnaire was designed to find the weight of every attributes using AHP technique. Criteria for questionnaire are carefully selected based on the principles of operation management attitudes. The main bottlenecks as the attributes which were highlighted during annual production are weighted and ranked to solve during overhaul. The data collected by AHP-structured pair wise comparisons were constructed into a web-based program. The result shows the weighed alternatives. Also regarding to the acceptance and implementation of the results by management team it was clear that this technique is considered as the most useful techniques in the filed of operation managements which can be used in the other gas processing plants in National Iranian Gas Company.

### **Keywords**

Multi Criteria Decision Making (MCDM), Analytic Hierarchy Process (AHP), Bottleneck, Risk Base Inspection (RBI)

### **Scope and purpose**

This case study is implemented in South Pars Gas Complex (SPGC) - Phases 2 & 3<sup>[7]</sup> as the typical natural gas processing plant of National Iranian Gas Company (NIGC); there were seven criteria and eight attributes (production bottlenecks) selected for weighting by this technique. This technique was used for the first time in operation management team to plan for production de-bottlenecking during annual overhaul and maximizing the natural gas production.

### **1. Introduction**

One of the vital concerns for the operation management team of gas processing plants of National Iranian Gas Company is keeping alive the production site specially in winter time when the natural gas demand reaches to maximum<sup>[6]</sup>; and because of this the annual overhaul is planned for solving the main bottlenecks which were known during production. It is obvious that during planning for this overhaul, the bottlenecks must be ranked (or weighted) based on their importance regarding the limitation of time and resources to solve the most important ones.

The researcher suggested the AHP technique which includes decisions that must considered large numbers of variables and objectives that cannot always be directly quantified.

## 2. Methodology

### 2.1 The AHP Approach

AHP was originally conceived by Thomas L. Saaty as a structured method for solving problems involving decision variables or decision attributes, at least some of which, are qualitative, and cannot be directly measured (Saaty, 1980) It met with almost immediate acceptance and was applied to a wide range of problems. Very soon it began to be applied to executive decisions involving conflicts in stakeholder requirements and strategic planning (Saaty, 1982; Arbel & Orgler, 1990; Uzoka, 2005) <sup>[1]</sup>.

The AHP is a comprehensive framework, which is de-signed to cope with the intuitive, the rational, and the irrational when we make multi-objective, multi-criterion and multifactor decisions with and without certainty for any number of alternatives. The AHP has been applied to many complex problems with various decision analyses, which enable decision-makers to derive ratio scale priorities or weights as opposed to arbitrarily as-signing them. Many others recognize a very important feature that AHP supports decision-makers by al-lowing them to structure complexity, to exercise judgment, and to incorporate both objective and subjective considerations in the decision process. The AHP is also a novel decision analyzing approach that structures a problem using a hierarchy. It enables us to make effective decision on complex issues by simplifying and expediting human natural decision-making processes. Some other sees the AHP is the theory of measurement for dealing with quantifiable or tangible criteria that has found rich applications in decision theory, conflict resolution and in models of the brain <sup>[2]</sup>.

### 2.2. Analytical Hierarchy Process (AHP)

The AHP method uses iterative pair-wise decision-making to output the alternatives in terms of a rank-ordered list. This method is particularly useful for problems such as the benchmark product decision because it can handle both discrete alternatives and qualitative and/ or subjective data.

The first step is to determine the priorities of the multiple objectives using pair-wise comparisons. Each compared objective ( $X_i, X_j$ ) is recorded with the more important of the two objectives ( $X_{i\max}$ ), and a rating indicating the degree of relative importance ( $\Delta R_{ij}$ ) (usually a 1-9 scale). For instance, if attribute  $X_1$  is much more important than  $X_2$ , it would be recorded as  $X_1=\max$  with a rating of 7/9. These comparisons are conducted for each possible combination of objectives, resulting in a scored list of combinations. The process may be done as a team consensus exercise, since this is a subjective evaluation. The resulting priorities of the multiple objectives are input into a pair-wise comparison matrix in which the important attributes are labeled on the y-axis, and the weak on the x axis (see Table 1) <sup>[3]</sup>.

Table 1: Matrix for Attribute Comparisons <sup>[3]</sup>.

	$X_{1\min}$	$X_{2\min}$	$X_{n\min}$
$X_{1\max}$	1	$\Delta R_{12}$	$1/\Delta R_{n1}$
$X_{2\max}$	$1/\Delta R_{12}$	1	$1/\Delta R_{n2}$
$X_{n\max}$	$\Delta R_{n1}$	$\Delta R_{n2}$	1

The opposite comparisons are given a rating equal to the reciprocal of the original comparison. For instance given  $X_1$  is much more important than  $X_2$ ,  $\Delta R_{12}$  would equal 7 at matrix position ( $X_{2\max}, X_{1\min}$ ). The opposite relation is at matrix position ( $X_{2\max}, X_{1\min}$ ) and has a value of  $1/\Delta R_{12}$ . Once the matrix is complete, the priorities of the objectives can be calculated using a process called synthesizing. The most accurate and robust synthesizing method, based on the research of Zahedi, is the mean transformation method. In this process, each column in the matrix is summed. Each value in the individual columns is then expressed as a fraction of that sum. Finally, the priority for each objective attribute is calculated as the average of the fractional values in their associated row. This provides a weighting factor for each objective showing its fractional contribution to the decision value.

The next step is to conduct pair-wise comparisons of the alternatives relative to each of the attribute objectives. This is done in the same manner as the objectives comparison, where a rating is provided for each pair to create a matrix for each objective. Finally, an overall priority rating is calculated by using the synthesizing process on each matrix, then multiplying the resulting alternative priority by the objective priority value found earlier and summing the values for each alternative. The result is a prioritized list of the alternatives <sup>[3]</sup>.

### 2.4. Using the Analytic Hierarchy Process

A typical device for entering judgments in an AHP group decision making session. As can be seen in the material that follows, using the AHP involves the mathematical synthesis of numerous judgments about the decision problem at hand. It is not uncommon for these judgments to number in the dozens or even the hundreds. While the math can be done by hand or with a calculator, it is far more common to use one of several computerized methods for entering

and synthesizing the judgments. The simplest of these involve standard spreadsheet software, while the most complex use custom software, often augmented by special devices for acquiring the judgments of decision makers gathered in a meeting room<sup>[4]</sup>.

The procedure for using the AHP can be summarized as:

- Model the problem as a hierarchy containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives.
- Establish priorities among the elements of the hierarchy by making a series of judgments based on pairwise comparisons of the elements. For example, when comparing potential real-estate purchases, the investors might say they prefer location over price and price over timing.
- Synthesize these judgments to yield a set of overall priorities for the hierarchy. This would combine the investors' judgments about location, price and timing for properties A, B, C, and D into overall priorities for each property.
- Check the consistency of the judgments.
- Come to a final decision based on the results of this process<sup>[4]</sup>.

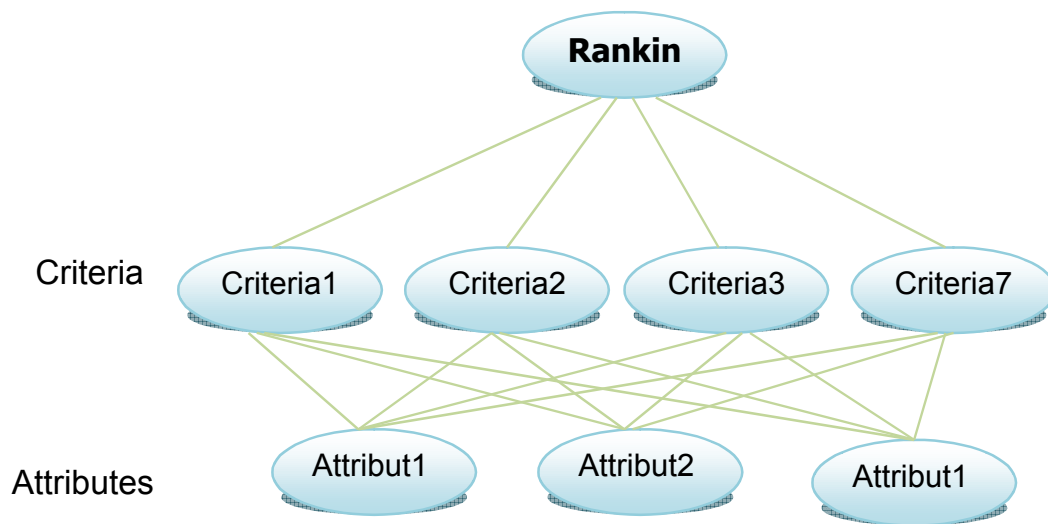


Figure 1: A schematic of AHP method

### 2.5. The web based application of AHP methodology

Base on the AHP methodology, and the following case study there are several tools were developed and used freely around the world for choosing the best choice, one of the web-based tools is used at the present paper.<sup>[5]</sup> Also for cross checking the results a MS-EXCEL tool was developed by researcher.

## 3. The case study

Based on above statements and in previous section the problem for these managers is to rank between the several alternatives (production bottlenecks) and find the most important one to focus on them accordingly, in order to have a sustainable gas production after the annual overhaul. There were several interviews has been organized for finding the criteria and the alternatives. The criteria and the alternatives which were selected are as follow:

### 3.1. The Criteria:

- Quality and the quantity of production (w=25%)
- Shut down numbers and durations (w=10%)
- Efficiency (w=10%)

- iv. Productivity (w=10%)
- v. Easy Usage (w=10%)
- vi. Environmental Aspects (w=10%)
- vii. Financial Aspects and the outcomes (w=25%)

### 3.2. The Alternatives:

- A. Maintaining the troubles for feed gas of refining plant
- B. Optimizing Internal Consumption and gas flaring
- C. PM (Preventive Maintenance) for avoiding the unscheduled shut downs
- D. Attending to the meeting of production de-bottle necking based on PDCA cycle
- E. Preparation of scheduled production failures reports for the top-management and solution follow-up.
- F. Following the Best-Practice organizations between the gas plants.
- G. Planning for the new feed gas and the related reservoirs due to extra capacity existence in some cases.
- H. Using RBI (Risk Base Inspection) method and consequently shortening the number and the period of annual overhaul.

After that the questionnaire has been designed based on AHP alternatives-criteria and send it back to the study group of operational managers which are selected from the second gas plant of SPGC-Phases 2&3.

Table 2: The scale for pair wise 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
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation.

The results were as below:

Table 3: The Matrix Results of Alternatives

	1st DM	2nd DM	3rd DM	4th DM	5 <sup>th</sup> DM	6th DM	7th DM	8th DM
	30%	10%	10%	10%	10%	10%	10%	10%
A	22%	30%	31%	28%	27%	28%	19%	27%
B	10%	20%	17%	16%	21%	21%	13%	21%
C	24%	26%	17%	19%	23%	23%	26%	23%
D	12%	13%	15%	13%	14%	14%	16%	14%
E	8%	5%	7%	10%	7%	7%	5%	7%
F	10%	4%	6%	7%	4%	4%	7%	4%
G	4%	2%	3%	4%	2%	2%	6%	2%
H	10%	1%	3%	4%	1%	1%	8%	1%

So the final AHP group decision table is as below:

Table 4: AHP Group Results

Alternatives	A	B	C	D	E	F	G	H
Weight	26%	16%	23%	13%	7%	6%	3%	5%

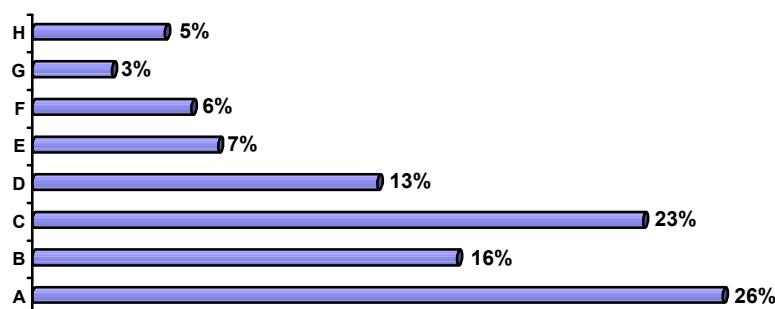


Figure 2: The weighted alternatives based on AHP technique

## 4. Discussion and Conclusions

### 4.1. Results

As it could be seen in figure 2 the first alternative (Maintaining the troubles for feed gas of refining plant) is the most important one based on AHP methods and accordingly the organization must follow up the bottle-neck in this matter.

Simultaneously the other alternatives the alternative C. (Preventive Maintenance for avoiding the unscheduled shut downs) and the other one B. (Optimizing Internal Consumption and gas flaring) and D. (Attending to the meeting of production de-bottle necking based on PDCA cycle) should be considered and must be observed in the other sensitive ranks.

And the last alternatives are less important base on their weights.

The results of three sources (expert choice software and web base application and the excel tools) were similar (+/- 5%).

### 4.2. Conclusions

The results are reported to the management team of SPGC –Phases 2 &3 and the meeting was organized to confirm the results and took their acceptance of the model. So in the annual overhaul they knew the most important week points and tried to solve the main concerns. Also the system analyzers which attended to the meeting found this method very useful and wanted to develop this tool in their organization in the other fields.

### 4.3. Suggestions

The suggestion of the author for the operational mangers:

- Following up the 4<sup>th</sup> top ranked operational problem and try to solve them in near future base on below table:

Table 5: Top ranked operational concerns

Alternatives	Weight	Description
A	26%	Maintaining the troubles for feed gas of refining plant
C	23%	PM for avoiding the unscheduled shut downs
B	16%	Optimizing Internal Consumption and gas flaring
D	13%	Attending to the meeting of production de-bottle necking based on PDCA cycle

- The use of AHP method in the other field of decision making
- Feed back for future decision making to improve the method.

## 5. Acknowledgement

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