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Evaluation of Performance Parameters of End of Line (EOL) Testing Machine in Automotive Industry using AHP Technique

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Abstract—*Automobile industry is one of the most competitive and dynamic industry. Increased demand and ever increasing customer expectation has become a challenge for this industry to meet with. This catered significant need for deployment of advanced machineries, leading to increase in complexity in efficient working of the machines. Present work is an attempt towards the indicated problem with implementation of Analytic Hierarchy Process (AHP) technique to evaluate performance parameters of End of Line (EOL) testing machine in one of the automotive industry, to analyse and prioritize the most significant parameter that can be considered for enhancement of the performance of the EOL machine.*

Keywords: *AHP, Performance parameters, automotive industry.*

1. INTRODUCTION

The Analytic Hierarchy Process (AHP) is a multi-criteria decision making method and was introduced by Thomas L. Saaty in 1970s [1, 2, 3]. The AHP is a decision making tool which can be used to solve complex decision problems [4]. Due to its simple mathematical modelling, AHP has been widely used by the decision maker and the researchers in variety of areas like in construction industry for the selection of the best contractors, selection of the cranes; in manufacturing industry for selection of suppliers, selection of computer systems; in educational institutions for selection of best student, selection of university faculty; in food industry for quality management system, etc. [5, 6, 7, 8, 9]. It measures relative priorities for a given set of criteria on a ratio scale, based on the judgment of the decision-maker. In addition, the AHP also check the consistency of the decision maker's evaluations [3].

2. METHODOLOGY

The AHP can be implemented in the following steps [10]:

2.1 Establishment of structural hierarchy

The very first step of AHP is to structure the problem in to a hierarchy in which the goal of the problem is labelled at the top level and the criteria are represented at the low level.

2.2 Determine the intensity value of the relative alternatives

With the reference to the yardstick shown in table 1 [10], the pairwise comparison is formed by assigning the intensity value to them.

Table 1: The intensity chart for pairwise comparison

Intensity of Importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance

2.3 Determine the relative priority vector matrix.

In this step, firstly we need to create a pairwise comparison matrix P (say), of order r x r, where r is the number of criteria of the decision. Each element p_{mn} of the matrix P denotes the priority of the m^{th} criterion relative to the n^{th} criterion. If the value is more than, less than and equal to 1, it represents that the m^{th} criterion is more important, less important and equal important to the n^{th} criterion respectively.

The elements p_{mn} and p_{nm} of the matrix P satisfies the equation:

$$p_{mn} \cdot p_{nm} = 1 \quad (1)$$

The next step is to find the normalized pairwise comparison matrix P_{norm} by computing each element $\bar{p}_{mn}$ of the matrix P_{norm} as:

$$\acute{p}_{mn} = \frac{p_{mn}}{\sum_{c=1}^{r} p_{cn}} \quad (2)$$

The relative priority vector matrix z is computed by averaging the sum of elements of each row of normalized matrix P_{norm}, this is shown in the equation 3,

$$z_m = \frac{\sum_{c=1}^{r} \acute{p}_{mc}}{r} \quad (3)$$

2.4 Rank the alternatives.

After computing the relative priority vector matrix z and the pairwise comparison matrix P, an another vector g is calculated by multiplying the matrix z and P, this is shown in the equation 4,

$$g = P.z \quad (4)$$

We get the ranking of the alternatives by ordering the elements of vector matrix g in descending order.

2.5 Check the consistency

During the evaluation of pairwise comparison matrix, there might be chance of inconsistencies.

The AHP can also be very useful tool to check the consistency of the input made by the decision maker. This can be verified by the evaluating the consistency index and consistency ratio.

Consistency Index (CI) is calculated by the formula shown in equation 5, where σ_{max} is the average of the elements of the vector computed by dividing the elements of matrix g and z.

$$CI = \frac{\sigma_{\max} - r}{r-1} \quad (5)$$

In the AHP, the pairwise comparisons made by the decision maker are considered to be consistent if the consistency ratio (CR) is less than 10% [10].

The CR is computed by the formula shown in equation 6.

$$CR = \frac{CI}{RI} \quad (6)$$

3. APPLICATION AND ANALYSIS

In this paper, an AHP concept is applied on the EOL Testing machine which is used for the final inspection of the window regulator in an automotive industry, to calculate the importance priority of their parameters viz. current, noise, opening speed, closing speed and stroke length.

In total there are 5 test results or parameters of EOL TEST RIG (r=5), which need to be compare each one to each of the others.

Step 1: Establishment of structural hierarchy

Here, the parameters of EOL Test Rig. is structured in hierarchy with goal i.e. to rank the parameters of EOL Test Rig. as shown in Fig. 1.

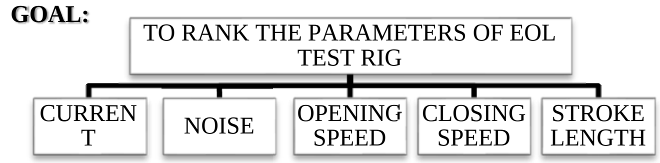

Fig. 1: A Simple Hierarchy of the Parameters of EOL Test Rig.

Step 2: Determine the intensity value of the relative alternatives

With reference to table 1 [10], the pairwise comparison table is prepared as shown in the table 2.

Table 2: Pairwise comparison of the parameters

S. No.	COMPARISON		INTENSITY VALUE
1.	Current	Opening Speed	9
2.	Current	Closing Speed	9
3.	Current	Noise	5
4.	Current	Stroke Length	3
5.	Opening Speed	Closing Speed	1
6.	Opening Speed	Noise	1/5
7.	Opening Speed	Stroke Length	1
8.	Closing Speed	Noise	1/5
9.	Closing Speed	Stroke Length	1
10.	Noise	Stroke Length	1/5

Step 3: Determine the relative priority vector matrix

Pair wise comparison matrix (P)

When, we have all the relative intensity values of the parameters, then a pairwise comparison matrix is form shown in table 3.

Table 3: Pairwise comparisons matrix

	Current	**Opening Speed**	**Closing Speed**	**Noise**	**Stroke Length**
Current	1	9	9	5	3
Opening Speed	1/9	1	1	1/5	1
Closing Speed	1/9	1	1	1/5	1
Noise	1/5	5	5	1	5
Stroke Length	1/3	1	1	1/5	1

Normalization matrix (P_{norm})

Each element of the P_{norm} is calculated by using equation 2, and relative priority vector using equation 3. The resultant matrix is shown in table 4.

Table 4: Normalized pairwise comparison matrix and Relative priority matrix z.

	Current	**Opening Speed**	**Closing Speed**	**Noise**	**Stroke Length**	**Sum Of Rows**	**Relative priority vector (z)**
Current	0.569620	0.52941	0.52941	0.757	0.27272	2.658	0.531749
Opening Speed	0.063291	0.05882	0.05882	0.030	0.0909	0.302	0.06043
Closing Speed	0.063291	0.05882	0.05882	0.030	0.09090	0.302	0.06043
Noise	0.113924	0.29411	0.29411	0.151	0.45454	1.308	0.261644
Stroke Length	0.189873	0.05882	0.05882	0.030	0.09090	0.428	0.085747
Sum Of Columns	1	1	1	1	1	5	1

Step 4: Ranking

To find the ranking of the parameters of the EOL testing machine, a vector matrix g (shown in Table 5) of order (1 x 5) is calculated by multiplying the matrix P and z (see Eqn. 4). Then, the elements of the matrix g are arranged in the descending order to rank the parameters.

Table 5: Vector matrix (g) of the parameters of EOL Test Rig.

PARAMETERS	VECTOR MATRIX (g)
Current	3.18495
Opening Speed	0.318019
Closing Speed	0.318019
Noise	1.401027
Stroke Length	0.436185
Sum	5.6582

Step 5: Check for consistency

After ranking the parameters, AHP can also be useful to check the consistency by evaluating consistency index (CI) and Consistency ratio (CR).

CI is evaluated by using Eqn. 5.

In this case, σ_{max} = 5.39

So,

Consistency Index CI = (5.39-5)/(5-1) (r=5)

CI= 0.097

As, r=5

Random index (RI) = 1.12

Therefore, Consistency Ratio (CR) = CI/RI = (0.097/1.12)

CR= 0.087

4. RESULTS AND DISCUSSION

The resulting ranking of the parameters based on the above pairwise comparisons are shown in table 7.

Table 6: Priority ranking of EOL TEST RIG parameter.

S. No.	Parameters	Priority (%)	Rank
1.	Current	56.3	1
2.	Noise	24.4	2
3.	Stroke Length	8.0	3
4.	Opening Speed	5.6	4
5.	Closing Speed	5.6	4

With reference to the result, the current has achieved top priority, which is to be considered in future for the inspection of window regulator with extreme care so that product quality can be enhanced.

5. CONCLUSION

With increase in technical complexity in manufacturing of automotive parts, close and continuous assessment of the performance as well as testing parameters is significant to retain efficient working and enhance productivity. Present work demonstrates application of AHP technique for evaluation of testing parameters like current, opening speed, closing speed, stroke length and noise of the EOL test rig. in automotive industry and the most significant parameter i.e. current is identified. This concludes effective implementation of multi criteria decision making approach like AHP for future study and investigation in this area.

REFERENCES

[1] Saaty, T.L., "Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process", *RWS Publications*, Pittsburgh, PA, 1994.

[2]. Saaty, T.L., "Multicriteria Decision Making: The Analytic Hierarchy Process", *RWS Publications*, Pittsburgh, PA, 1988.

[3] Saaty, T.L., "*The Analytic Hierarchy Process*." McGraw-Hill, New York, 1980.

[4] Triantaphyllou E., Mann S., "Using the analytic hierarchy process for decision making in engineering applications: some challenges", *International Journal of Industrial Engineering: Applications and Practice*, Vol. 2, No. 1, pp. 35-44, 1995.

[5] Dalalah D., AL-Oqla F., Hayajneh M., "Application of the Analytic Hierarchy Process (AHP) in MultiCriteria Analysis of the Selection of Cranes", *Jordan Journal of Mechanical and Industrial Engineering*, Vol. 4, No. 5, 2010, pp. 567 – 578.

[6] Tahriri F., Rasid Osman M., Ali A., Mohd Yusuff R., Esfandiary E., "AHP approach for supplier evaluation and selection in a steel manufacturing company", *Journal of Industrial Engineering and Management*, 2008, pp. 54-76.

[7] Anagnostopoulos K., Vavatsikos A., "An AHP Model for Construction Contractor Prequalification", *Operational Research - An International Journal (ORIJ)*, Vol.6, No 3 (2006), pp.333-346.

[8] Greda A., "*Application of the ahp/anp in food quality management*", ISAHP, 2009.

[9] Grandzol J., *"Improving the Faculty Selection Process in Higher Education: A Case for the Analytic Hierarchy Process"*, Association for Institutional Research, Vol. 6, 2005.

[10] Saaty, T.L., "*Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World"*, Pittsburgh, Pennsylvania: RWS Publications, (2008).