Fuzzy analytic hierarchy process (Fuzzy AHP) application for inspection mechanisms selection towards automated inspection system development: a case study

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ABSTRACT: This paper presents the application of fuzzy analytic hierarchy process (Fuzzy AHP) method for inspection mechanisms selection towards automated inspection system development. A case study from adhesive tape-based manufacturing industry was used to show the applicability of the method. The Fuzzy AHP method applied in this paper consists of four steps; hierarchy structure development, criteria weighting, alternative weighting and final score of the alternative. The four criteria (Cost, Reliability, Durability and Minimal Lagging) and three alternatives (Pressure Strips, Profiling Pressure and Image) are firstly defined in the development of hierarchy structure. Based on the evaluation process of criteria and alternative weighting, the final score of each alternative are obtained. The final result shows that the alternative of Image give the highest score at 0.706, follows by Profiling Pressure and Pressure Strips at 0.645 and 0.081, respectively. Therefore, the alternative of Image is highly recommended to be used as the inspection mechanisms towards automated inspection system development.

Keywords: *Fuzzy AHP, Inspection mechanism; Case study.*

1. INTRODUCTION

In a project management, selection of the best option with multiple criteria consideration is a crucial decision making process to optimize the benefits of the project. Scientifically, this decision making process can be classified as a multi-criteria decision-making (MCDM) structure.

In the literature, numbers of methods are introduced and applied to solve varieties of MCDM problems [1]. One of them is fuzzy analytic hierarchy process (Fuzzy AHP) method. The Fuzzy AHP is an expansion version of a classical AHP method [2] by taking into account the fuzzy environments. Under this method, the evaluation process of criteria and alternative weighting are carried out based on fuzzy linguistic values [3].

Some recent studies related to the application of Fuzzy AHP in manufacturing industry is as follows. Jain et al. [4] applied Fuzzy AHP to solve a supplier selection problem in an Indian automotive industry. Mondragon et al. [5] compared the results between AHP and Fuzzy AHP applications to solve a problem of technology and supplier selection in textile industry. Averill [6] discussed the usefulness of the Fuzzy AHP application in material finishing industry. The study intend to select the best solvent for cleaning equipment to be used in oxygen service and for cleaning metal parts prior to further finishing treatment. Banadkouki and Lotfi [7] combined the application of Fuzzy AHP and Fuzzy TOPSIS to solve a selection problem of computer-integrated manufacturing (CIM) technologies. Their study found that the computer-aided process planning is the best CIM technology.

This paper presents another research project related to the application of Fuzzy AHP method. A problem of inspection mechanisms selection is the focused of the presented paper.

2. CASE STUDY OVERVIEW

The case study presented in this research project is carried out at a manufacturing company produces various types of adhesive tapes for domestic and industrial applications.

The case study is focused on the lamination process due to high defects occurred at this process. The initial defects analysis reveals that the bubble trap, poor bonding and adhesive picking are the three major types of defects. The root cause analysis found that this three defects have shared the same root cause, which it is due to the misalignment of the nip rollers of the lamination machine.

Since this problem is continued to occurred for few years without an effective and sustainable solution, the top management of the company looking for a better solution. The company aim to adopt an automated inspection system to the lamination machine.

One of the important process towards AIS development is to select the inspection mechanism. Thus, it will ensure the final AIS will work in optimal effectiveness and efficiency levels. The project team have finalized the four key criteria for the selection of inspection mechanism, there are cost, reliability, durability and minimal lagging.

In this paper, these four criteria are further used as the evaluation criteria towards AIS mechanism selection process. The development of the AIS is continued with the application of Fuzzy AHP to systematically identify

the optimal mechanism of the AIS.

3. FUZZY AHP PROCEDURE

In this study, the Fuzzy AHP was applied based on the steps presented in Musman and Ahmad [8].

The summary of the Fuzzy AHP procedure is as follows. The first step is the development of hierarchy structure of the problem. The second step is criteria weighting, which is carried out based on pairwise comparison matrix. The generic version of pairwise comparison matrix is given in equation 1. The $(\tilde{d}_{ij}^{k})$, indicates the k_{th} evaluator's preference of i_{th} criteria over j_{th} criteria, via fuzzy triangular numbers. If there is more than one evaluator, the preferences of each Evaluator $(\tilde{d}_{ij}^{k})$ are averaged [8].

$$\tilde{A}^{k} = \begin{bmatrix} \tilde{d}_{11}^{k} & \dots & \tilde{d}_{1n}^{k} \\ \dots & \dots & \dots \\ \tilde{d}_{n1}^{k} & \dots & \tilde{d}_{nm}^{k} \end{bmatrix} \quad (1)$$

In this study, the weighting of criteria used linguistic terms that corresponding to triangular fuzzy numbers as given in [9]. Under this step (Step 2), four specific evaluations of criteria is carried out. The geometric fuzzy comparison values $(\widetilde{r_i})$ is firstly determined [9]. Next the fuzzy weight of a single criterion $(\widetilde{w_i})$ is found as given in [3]. Finally, by using non fuzzy weight of criterion, the normalized weights of each criterion are calculated [10].

In the third step (alternative weighting), the same evaluation process as presented in Step 2 is applied. Normalized of non-fuzzy relative weights (N_i) of each alternative for each criterion is averaged and individual score of each alternative is obtained. Finally (Step 4), the final score of all alternatives is summarized. The alternative with highest score is highly recommended as the optimal selection.

4. RESULTS AND DISCUSSION

The overall summary of the normalized (N_i) values of each alternative according to criteria is as follows. The normalized (N_i) values for alternative image (*I*), profiling pressure (*PP*) and pressure strips (*PS*) are calculated as 0.706, 0.645 and 0.081, respectively. Therefore, this result highly recommended that the alternative image (*I*) is the optimal inspection mechanism that can be used for AIS development.

5. CONCLUSION

The application of Fuzzy AHP method to solve inspection mechanism selection problem is presented. This selection problem is structured of four predefined criteria and three alternatives. The method is applied based on four steps; hierarchy structure development, criteria weighting, alternative weighting and final score of the alternative. Final evaluation result revealed that the alternative of Image give the highest score at 0.706, thus recommends to the project team to select this alternative

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