Conceptual Design on Slurry Pouring Mechanism using Analytical Hierarchy Process (AHP) and Sensitivity Analysis (SA)

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ABSTRACT – Pouring slurry into the mold is one of the main activities in part making in the ceramic process. Inappropriate design of slurry pouring mechanism will increase cost and development time. This paper aims to determine the best conceptual design of the slurry pouring mechanism using Analytical Hierarchy Process [AHP] and Sensitivity Analysis (SA). At the early design stage, various solutions for the specific design characters were determined using the morphology chart. Five (5) innovative design concepts were proposed and AHP was utilized to determine the best conceptual design. SA then was conducted by utilizing expert choice software to validate the selection process in determining the best design concept. The results reveal that the DC4 was the best design as it has the highest value of 0.319 (31.9%) compared with other conceptual design concepts. The study showed by considering morphological chart and AHP able to assist designers to evaluate and determine the best conceptual design at the early stage of the product development process.

1. INTRODUCTION

Determining the best conceptual design is one of the main design stages in the product development process. Cost and development time of making products will increase if the wrong selection was made at the early stage of the design process [1]. In this study, a conceptual design of slurry pouring mechanism was developed and a selection process was conducted based on an Analytical Hierarch Process (AHP) and Sensitivity Analysis. The conceptual design of slurry pouring mechanism was initiated to reduce human fatigue, increase safety in the pouring process and enhance the performance and allowed the different sizes of mold to be handled. AHP [2] method was applied in the development of the conceptual design of slurry pouring mechanism.

In this study, Morphological Chart is a method to generate early sketching design and it involves multiple design solutions for components serving the same functions out of breaking down of sub problem to allow innovation of product solution and best practical combination to be implemented [3]. AHP is one of the decision-making techniques which has been widely used for more than 20 years recently and it has also been used in product development activities. The use of AHP is not only limited to the AHP itself but can be integrated with other design tools [4]. This paper explores an integrated approach for the decision-making problem that combines the AHP and Sensitivity Analysis.

There are few papers presented the integration of both methods in the literature review. Fahrul et al. [5] presented an integrated approach by combining the MC and the AHP for evaluating product sustainability at the early stage of the product development process. Hsiao and Chang [6] employed MC, AHP and PUGH methods to generate and evaluate design alternatives of electric scooter. The integration of Theory of Inventive Problem Solving (TRIZ), MC and AHP method also was applied by Mansor et al. [7] in the development of conceptual design for composites automotive parking brake lever using the integration of Theory of Inventive Problem Solving (TRIZ), MC and AHP methods.

Despite some works have been carried out in terms of integration AHP in the product development process, there is still very limited study for determining the best conceptual design of slurry pouring mechanism using integrated AHP in the literature review. Thus, this paper illustrates the use of AHP and Sensitivity Analysis in determining the most suitable conceptual design of slurry pouring mechanisms at the conceptual design stage.

2. METHODOLOGY

Figure 1 shows the process flow in generating and evaluating the best conceptual design of slurry pouring mechanism at the early stage of the product development process.

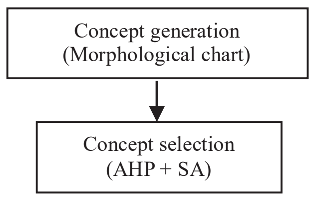

Figure 1. Flow of research methodology

Figure 1 shows the flow of the design process to carry out several conceptual designs at the early stage of the design process. The Morphological Chart (MC) method was implemented to generate various alternatives of the overall structure of slurry pouring mechanism. More than 50 conceptual designs (CD) can be carried out from the process however, there are five main conceptual designs of slurry pouring mechanism have been selected in this study as depicted in Figure 2. The best conceptual design was determined based on the AHP method. In AHP steps, the selection of the best conceptual design depends upon a variety of factors which include performance (P), weight (W), material cost (MtC) and manufacturing cost (MfgC).

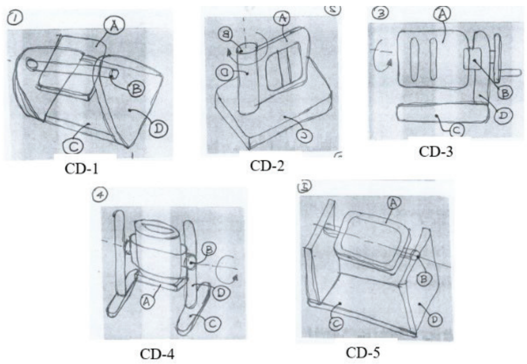

Figure 2. Five conceptual design.

Table 1 shows the main criteria pairwise comparison with respect to the main goal. Then the sensitivity analysis was conducted by using Expert Choice 11 software.

Table 1. Pairwise comparison of the main criteria with respect to the goal

Goal	P	W	MtC	MfgC
Performance (P)	1	7	5	3
Weight (W)	1/7	1	1/3	1/5
Material Cost (MtC)	1/5	3	1	1/3
Manufacturing Cost (MfgC)	1/3	5	3	1

3. RESULTS AND DISCUSSION

AHP analysis result shown in Table 2 indicates conceptual design 4 (CD4) has the highest ranking and it is the most appropriate conceptual design for further development.

Table 2: AHP results

Goal	Priority vector	Ranks
CD1	0.243	2
CD2	0.075	5
CD3	0.182	3
CD4	0.319	1
CD5	0.180	4

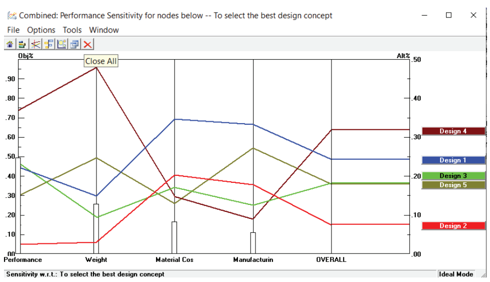

Figure 3: Sensitivity analysis

Results showed that CD4 was the first choice. The second choice was conceptual design 1 (CD1) and the last choice was conceptual design 5 (CD5). In general, the judgements for all levels are acceptable because the consistency ratio (CR) is less than 0.1. Figure 3 shows how important the criteria for instance, performance (P) shows the highest to the goal with number 1. It is meant that performance (P) is the most important consideration with respect to the goal criterion compared to the other criteria. By using Sensitivity Analysis, CD4 was retained as the best conceptual design of slurry pouring mechanism as depicted in Figure 3.

4. CONCLUSIONS

Five (5) conceptual designs were generated and evaluated using Morphological Chart and AHP method. SA using expert choice software was conducted to validate the selection process and it reveals the best selection of all the five (5) conceptual designs is still the same as DC4 as the best conceptual design. AHP and Sensitivity Analysis have demonstrated the ability to be practiced in achieving idea generation concept and design selection processes that provide a systematic approach to assist designers in generating and determining the best solution of conceptual design at the early stage of the product development process.

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