CAR'S DASHBOARD IMPROVEMENT DESIGN CONCEPTS THROUGH INTEGRATION OF AHP AND TRIZ

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ABSTRACT

In this study, the Multi Criteria Decision Method (MDCM) of Analytical Hierarchy Process (AHP) was established as a support tool for TRIZ practitioners to specify the problem statement in TRIZ methodology framework which previously done by Functions Analysis, Cause And Effect Analysis and 5 Whys. The proposed framework was analyzed and evaluated by a case study of a sedan car dashboard. From a survey, the problems were evaluated based on customer's preferences of selecting a car through AHP method and identified that only 3 major problems that should be furthered for the next steps. The application of AHP method into TRIZ methodologies resulted effectively solved the core problems and beneficially lead to several advantages such as cost waste might be avoided and the design efficiency would be increased during the product design and development processes.

Keywords: Analytical Hierarchy Process, TRIZ, integration

1. Introduction

Innovative design of products has become a bottleneck in the intensely competitive manufacturing atmosphere of development of many companies. In the early design stages, decision of design plays an essential role in deciding the product development time, it is enormously vital to make the approach effectively achievable for engineering optimization which commonly achieved when trade-off parameters meet in balanced condition. The practice of TRIZ (Theory of Inventive Problem Solving) emerged from the idea of utilizing the trade-off parameters as a focus for systematic innovation in the product design. In TRIZ approach, before the development of contradiction and solution, identifying and selecting the "right problem statement" before "defining it as right" is a crucial prerequisite for success in any system and process improvement with TRIZ. The effectiveness of TRIZ method is depending to the problem definition. Prior to that, several techniques in TRIZ only covers the problem identification such as Function analysis, Cause and Effect Chain analysis and 5 Whys analysis. If the problem statement is incorrect or imprecise, then the contradiction would be not effectively done and would lead to ineffective solution. During product analysis process, a list of problems might be identified. Instead of trying to solve all listed problems, it works best if only selected problems were solved as well as achieving the multi-criteria needs and preferences. The Analytic Hierarchy Process (AHP) method was chosen to do the task of selecting the 'right' problems which based on multi criteria. As illustrated in Figure 1, instead of solving all problems in the lists, solving only the selected problems will efficiently which are under customer preferences and customer complaints. Once the problem statement was clear, the complex problem would be breaking up into a contradiction matrix and incentive principles, TRIZ might provide the way for solution.

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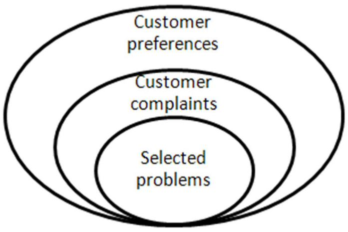

Figure 1. Integration AHP and TRIZ.

2. TRIZ and AHP

In 1946, a series of methods, tools and strategies named TRIZ was developed in the former Soviet Union by G. Altshuller [13]. It was developed through over millions of research and the world's most successful patents and primarily based on the concept of resolving contradictions. In TRIZ solution stage, there are a few tools including 40 inventive principles, the contradiction matrix, scientific effects and Algorithm of inventive solving (ARIZ), substance-field analysis modeling and laws of evolution. The most frequent applied tool is the matrix, which is consisting contradictions and 40 principles. There are 39 engineering parameters which generally under five main categories namely as physical, performance, manufacturing, measurement and efficiency. The 39×39 matrix contains the maximum four most probable principles for solving design problems as shown partially in Figure 2. The TRIZ approach have been applied to various design problem-solving such as improvement of hydraulic cylinder (Zhang et.al, 2009), development of friendly and energy efficient notebook computer (C. H. Yeh et.al, 2011), new innovative design method of energy-saving products (Hui Zheng et.al, 2010), hemp fiber production lines (Jinke Xu et.al, 2012) and eco-innovation of domestic dishwashing (Jones et.al, 2001).

	Worsening Feature → / Improving Feature ↓	Weight of moving object	Weight of stationary object	Length of moving object	Length of stationary object	Area of moving object	Area of stationary object	Volume of moving object	Volume of stationary object	Speed
		1	2	3	4	5	6	7	8	9
1	Weight of moving object	+	-	15, 8, 29.34	-	29, 17, 38, 34	-	29, 2, 40, 28	-	2, 8, 15, 38
2	Weight of stationary object	-	+	-	10, 1, 29, 35	-	35, 30, 13, 2	-	5, 35, 14, 2	-
3	Length of moving object	8, 15, 29, 34	-	+	-	15, 17, 4	-	7, 17, 4, 35	-	13, 4, 8
4	Length of stationary object		35, 28, 40, 29	-	+	-	17, 7, 10, 40	-	35, 8, 2.14	-
5	Area of moving object	2, 17, 29, 4	-	14, 15, 18, 4	-	+	-	7, 14, 17, 4		29, 30, 4, 34
6	Area of stationary object	-	30, 2, 14, 18	-	26, 7, 9, 39	-	+	-		-

Figure 2. Part of 39 contradiction matrix.

Analytic hierarchy process (AHP) which originally developed by Saaty, is now known as one of the most popular methods used to aid in alternatives selection (Saaty, 1980). The obvious strength of AHP is instead of just using traditional approaches of weight's assigning, AHP utilized the pairwise comparisons to derive accurate ratio scale priorities instead. Briefly, this process compares the performance, relative importance or likelihood of two elements with respect to another element in the level above of the hierarchy. A nine-point scale is used to assist the pair-wise comparisons for each level with respect to the goal of the best alternative selection. The scale represents the practitioner's judgments or preferences among the alternatives namely equally important, moderately more preferred, strongly more preferred, very strongly more preferred, and extremely more preferred to the others as shown in Table 1. Generally, basic steps of AHP namely decomposition, comparative judgment and systhesis (Saaty et.al, 2001).

Table 1: Relative scale of pair wise comparison

Intensity of relative importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

4. The proposed approach

With an intention to utilize the strengths of TRIZ and AHP, this study desires to establish a systematic product design model by adopting major tools from TRIZ and AHP such as contradiction matrix, inventive principles, pair wise comparison and consistency analysis. The integrated approach is displayed in Figure 4 comprises of the following steps.

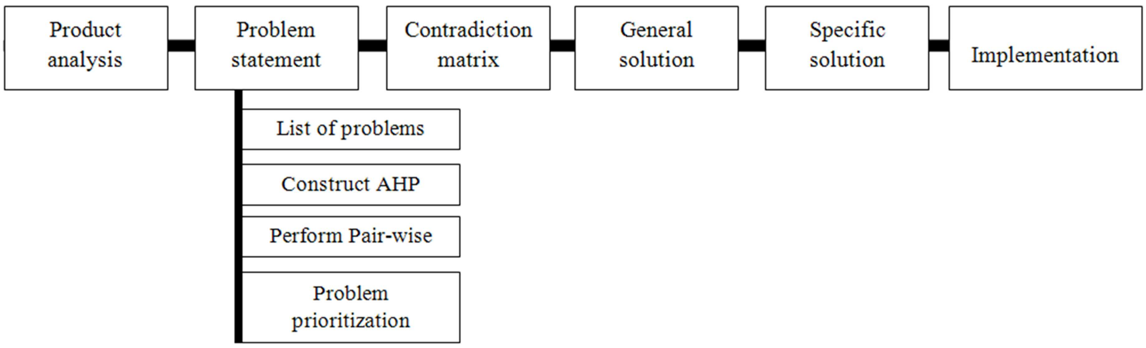

Figure 3. Proposed approach framework

Step 1: Product analysis (Design criteria identification)

Since that the proposed approach incorporates engineer and customer perspective to analyze the existing product, several questionnaires surveys need to be distributing in order to identify the criteria importance and the problems faced. This rate of importance will determine the weight of evaluation in the next step.

Step 2: Problem statement

The problems identified in previous steps are constructed in the form of hierarchy. Pairwise comparison construction and judgment are performed by utilizing Expert Choice software. The software was developed by (Forman et.al, 2000) a multi-attribute decision support software tool based on the AHP methodology. The highest level in the hierarchy is the objective to prioritize the problems. Meanwhile, the second and third levels are with the set of criteria and sub-criteria and the last level comprises the lists of problem stated in the first step. The judgments are decided based on the author's experience and knowledge by using the relative scale of pairwise comparison as depicted in table 6. The priority vector of the judgment represents how important of each attributes. After the calculation of consistency analysis for all levels is completed, the overall priority vector calculation in order to select the best design concept must be performed. After the prioritize ranking is developed, the listed problem forms in a rank and the top rank problem will be taken for further step. This specified and clear problem statement will be the basis for TRIZ processes.

Step 3 & 4: Construct the Contradiction Matrix and propose the related inventive principles

Map the problems into the terms of TRIZ's 39 parameters of contradiction matrix in order to acquire pairs of improving-worsening features. Then, find the related solution principles, according to the pair. The suggested inventive principles are then may be adopted to stimulate redesign ideas.

Step 5: Develop specific solution

The selected inventive principles will stimulate ideas for solution. The idea may come from either a single principle or combination of principles. However, it does not stimulate free associative thinking. Experience and knowledge will determine the effectiveness of TRIZ method.

Step 6: Idea implementation

Once the solution has been decided, it will take for further processes of product development.

4. Result and discussion

A questionnaire survey has been conducted to identify problems from user's perspective. From the survey, a list of problems has been identified as shown in Table 3. With the major aim for this study case of car's dashboard is to optimize the value in term of the ergonomics, quality and functionality. The sub-criteria under these three main criteria are based on the literature review from books, internet articles and journal.

Table 2. List of customer complaints about the dashboard

1	No hanging a stuff function
2	Material and color should be improved
3	Panel meter should be more interesting
4	Utility storage should be covered/ too visible
5	Valuable items (laptop) should be keep in safe place
6	Compartment should be convenience to store small items (coins, cards)
7	Vibration when at high speed
8	Case for bottle should be bigger
9	Glove compartment should have the light
10	Glove compartment should have organizer

A four level hierarchy of AHP model has been constructed in this study case. The top of hierarchy representing the objective of 'To prioritize the problems', the middle levels representing criteria and sub-criteria and list of problems at the lowest level as depicted in Figure 6.

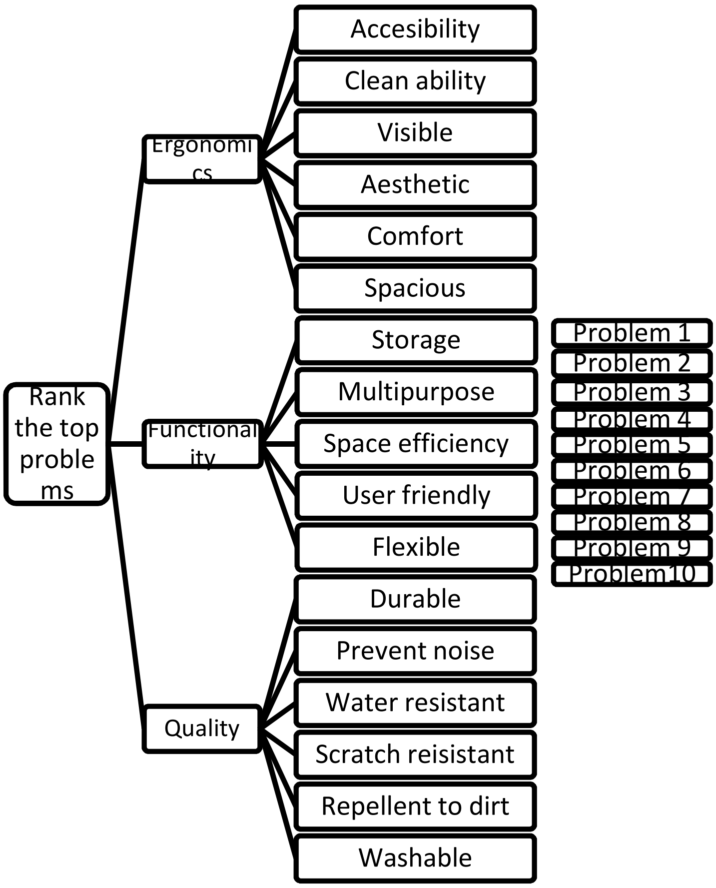

Figure 4. The hierarchy model for problems ranking.

By utilizing the Expert Choice software, the result in Figure 5 showed that problem 10 (glove box should be better with organizer) scored the highest and problem 3 (panel meter should more interesting) scored the lowest. Before that, a general screening task of each problem has been conducted to study each problem's compatibility relationship to each criteria and reviewed each problem as 'closely related', 'partially related', 'non-related' and the data will be used as a foundation data for pairwise activity.

Figure 5. Expert Choice software ranking result

Based on the result of AHP processes with overall inconsistency of 0.02 which is under recommended 0.1, the author decided to focus on the top three complaints. However, the problem 2 will not be covered since that the material aspect is totally out of the scope. The problems are listed as:

1. The glove box should have organizer
2. Compartment should be convenience to store small items (coins, cards)
3. Valuable items (laptop) should be keep in safe place

As shown in Table 3, the problem statements have been converted to the technical term of TRIZ's 39 parameters in order to construct the contradiction matrix. From the matrix, the suggested solution principles have been evaluated and several principles are chosen regarding to the potential and relevance of solution offered. The possible solution ideas are triggered based on principles.

Table 3. Principle evaluation and possible solution

Prob.	**Improved**	**Degraded**	**Principle**	**Relevance**		**Possible solution**
				Yes	**No**	
1	Organize the glove box, convenience of use *Parameter : 33- Ease of operation*	Design will be complex *Parameter :36- Complexity*	12- Equipotentiality		√	Not applicable
			17- Another dimension	√		Make a partition in the glove box
			26- Copying		√	Not applicable
			32- Change color	√		Different color scheme to organize items in glove box
2	Add function to store small items *Parameter : 39- Productivity*	Space consuming *Parameter: 6- Area of stationary object*	7- Nested doll	√		Utilized the unused area 'inside' the dashboard
			10- Preliminary action		√	Not applicable
			17- Another dimension	√		Utilized the unused area 'inside' the dashboard
			35- Change parameter		√	Not applicable
3	Add function for secret compartment *Parameter : 39- Productivity*	Space consuming *Parameter: 6- Area of stationary object*	7- Nested doll	√		Utilized the unused area 'inside' the dashboard
			10- Preliminary action		√	Not applicable
			17- Another dimension	√		Utilized the unused area 'inside' the dashboard
			35- Change parameter		√	Not applicable

5. Conclusion

The decision making and problem solving process has become critical in the industry. TRIZ has broadly used in problem solving process due to its structured and organized methodology and become a tool that triggered creative idea to innovation. The key of TRIZ's effectiveness is identifying the problem clearly and precisely. Besides the current TRIZ's tools identifying the core problem such as function analysis and cause and effect analysis, the AHP approach had been applied in this framework. With ability to rank and prioritize a list of alternative, AHP has been employed to integrate with TRIZ methodology in order to refine a list of problems to solve and only the selected problems have to solve instead of solving all problems. From result, only 4 out of 10 listed problems needed to solve in order to meet the customer requirements and preferences. Area of glove box, compartment, cup holder were improvised based on TRIZ method. This study illustrated how effective the AHP method as a support tool for TRIZ methodology. For future work, the integration between TRIZ and AHP may be can be apply in other part of TRIZ method such as principles selection and generated idea selection. Other product development tools can be tried to integrate with TRIZ such as Quality Function Deployment (QFD) and Failure mode and Effect Analysis (FMEA).

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