IMPROVEMENTS IN ABC PEDAL SYSTEM IN AUTOMOBILE

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The design research in this paper is improvements of present ABC (Acceleration, Brake, and Clutch) pedal systems in automobiles for better driver comfort and safety. Principles of product design concepts are used to analyze the level of comforts and discomforts for the present ABC pedal system and to improve its performance. Customers survey has been done to gather the information from different customers to explore the real problems in using the ABC pedals. Customer needs are prioritized using Kano analysis and FAST analysis is applied to understand the functionalities of each component. To set the goals and targets (QFD) Quality function deployment is used.The research question addressed in this paper is to minimize the time and force required to operate the ABC pedals. Intuitive and logical methods are used to develope six different concepts and are evaluated by using the weighted decision matrix and infeasible concepts are eliminated. From weighted decision matrix it was observed that integration of brake pedal to the steering wheel leaving two pedals beneath the feet for clutch and accelerator satisfies the customer requirements in a better way when compared to other concepts.

Keywords: ABC-Acceleration Brake Clutch, FAST-Function Analysis and Statistical Technique, QFD-Quality Function Deployment, SAE-Society of Automotive Engineers.

1. INTRODUCTION

We have followed the basic product design procedure to understand the requirements, definition of the problem, analysis, synthesis, concept design and then optimization of concepts for ABC pedal systems of the car for better safety and comfort to the driver.

1.1. Problem Statement

- Most of the four wheelers use the conventional ABC (Acceleration, Brake, and Clutch) pedals, which needs more pedal force.
- At the time of accident there is every chance to misinterpret the position of pedals.
- There is no flexible mechanism for operating the ABC pedals.
- More leg force is required to apply ABC pedals, which leads to knee and ankle problems in long run to the drivers.

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Table 1.

Over Drive 2008	80% of accidents occur due to hyper tension
Auto Drive 2008	50% of accidents due to time lag at time of accident
Other Magazines	50% due to fatigue of driver

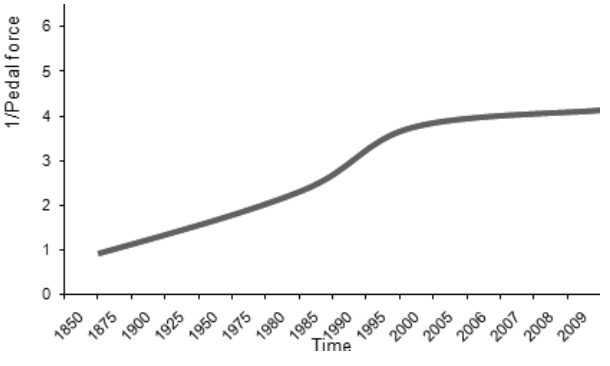


Figure 1.

See the reference Table 3.1. problem statement for the details collected from different automobile magazines to understand various reasons for accidents. The statistical report shows fatigue and tiredness of the driver are the main reasons for accidents.

1.2. Case Study of ABC Pedals in the Market with the "S-Curve"

S-Curve gives the technical developments that took place over a period of time for a product. It helps to identify the present technology that is available in the market and what strategies one should deploy to compete with the present technology. Based on the analysis of the present trends in ABC pedals with S-curve, it signifies that there is a need for technological improvement. See the reference Figure 1 S-curve. Pedal force is considered as the parameter to measure the S-Curve.

1.3. Questionnaire

24 LMV (Light Motor Vehicle like car) drivers and 17 HMV (Heavy Motor Vehicle like truck) drivers opinion was collected on present ABC system by questionnaire process. The statistical analysis of customer responses are shown in the reference Table 4.1.. For questionnaire, see the reference Figure 2 Questionnaire.

1.4. Affinity Analysis

Affinity analysis has been used to prioritize the needs of customer by grouping the similar customer requirements to the common requirement in order to focus on few requirements by considering the vital few from trivial many.

The customer needs are organized and prioritized depending upon their importance with respect to the customer's response. The rating of 0 to 5 is given to each need, depending on their importance. See the reference Table 3 for Affinity analysis

Table 2.

Questionnaire	Opinion	No of car drivers (24) response (LMV)	No of truck drivers (17) response(HMV)
How comfort you are with the present ABC pedals system?	Good Average Poor	6 8 10	1 5 11
Have you faced health problems in using the ABC systems?	Yes No	7 17	11 6
Have you come across any difficulties in using ABC system while driving?	Yes Partial No	10 6 8	8 8 1
How frequently you come across with the above difficulties?	2-3 times a month Every 2-3 months 2-3 times a year	2 9 13	1 7 9
Please rate the pedal force required?	Very high High Medium Low	1 7 8 8	6 8 3 0
Please rate the time (sec)required to change the leg from one to another pedal	High(>1) Medium(.5) Low(<.5)	1 17 6	12 5 0
How comfort you are in using ABC pedal system in heavy traffic?	Very low Low Medium High	4 13 7 0	11 5 1 0

1.5. Kano Analysis

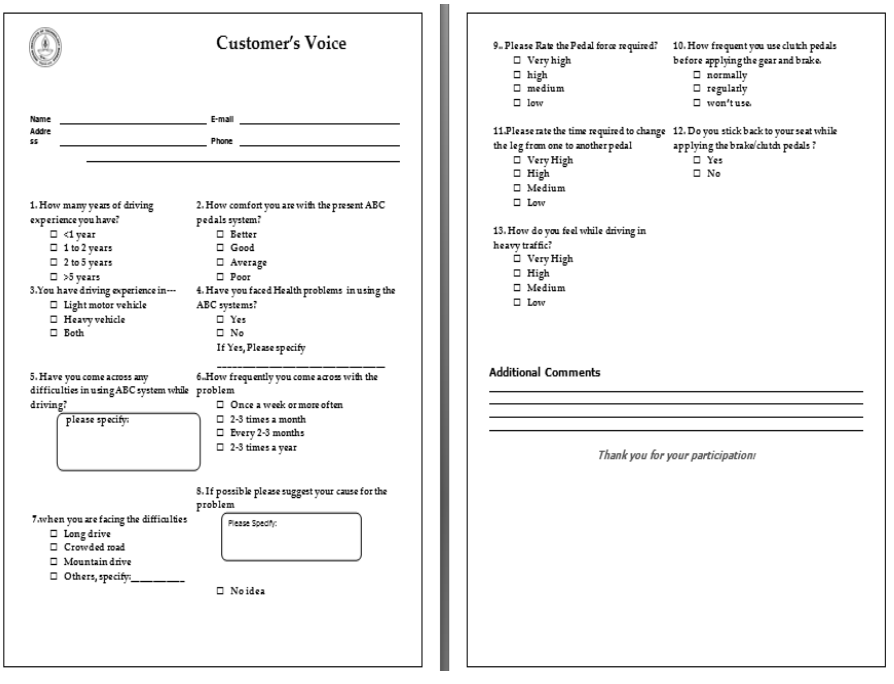
Our goal is to find a requirement that not only satisfies the customer but also make them to purchase the product and recommend it to others. Kano's model of customer satisfaction plots from distinguished to delight versus product function from absent to fully implement as shown in Figure 3. This plot shows three lines representing basic, expected and delighted performance features.

1.6. FAST Analysis

FAST analysis used for detail understanding of each component in the product. It was constructed by asking two type of questions 'HOW' from left and 'WHY' from right of it. It consists of objective of the product, basic function, critical function, secondary functions (which are essential for the performance of primary function), all- time and one-time functions (which are necessary for satisfactory functioning of the product). See the reference Figure 4 FAST analysis.

1.7. Function Structure of ABC System

Function structure gives the information about how the material, energy and information flow from input to output. It helps in understanding the critical components of product and its functionalities. See the reference Figure 5 for the Function structure for the Acceleration, Brake and Clutch pedal system.



Customer's Voice

Name _____ E-mail _____
Address _____ Phone _____
_____

1. How many years of driving experience you have?
- ☐ <1 year
- ☐ 1 to 2 years
- ☐ 2 to 5 years
- ☐ >5 years

2. How comfort you are with the present ABC pedals system?
- ☐ Better
- ☐ Good
- ☐ Average
- ☐ Poor

3. You have driving experience in---
- ☐ Light motor vehicle
- ☐ Heavy vehicle
- ☐ Both

4. Have you faced Health problems in using the ABC systems?
- ☐ Yes
- ☐ No

If Yes, Please specify
_____

5. Have you come across any difficulties in using ABC system while driving?

please specify:

6. How frequently you come across with the problem
- ☐ Once a week or more often
- ☐ 2-3 times a month
- ☐ Every 2-3 months
- ☐ 2-3 times a year

7. when you are facing the difficulties
- ☐ Long drive
- ☐ Crowded road
- ☐ Mountain drive
- ☐ Others, specify:_____

8. If possible please suggest your cause for the problem

Please Specify:

- ☐ No idea

9. Please Rate the Pedal force required?
- ☐ Very high
- ☐ high
- ☐ medium
- ☐ low

10. How frequent you use clutch pedals before applying the gear and brake.
- ☐ normally
- ☐ regularly
- ☐ won't use.

11. Please rate the time required to change the leg from one to another pedal
- ☐ Very High
- ☐ High
- ☐ Medium
- ☐ Low

12. Do you stick back to your seat while applying the brake/clutch pedals ?
- ☐ Yes
- ☐ No

13. How do you feel while driving in heavy traffic?
- ☐ Very High
- ☐ High
- ☐ Medium
- ☐ Low

Additional Comments
_____
_____
_____
_____

Thank you for your participation!

Figure 2.

Table 3.

Customer data : Improvement ABC pedal system		
Customer statement	Interpreted need	Importance
✓It is very hard to operate ABC	✓Pedal force	5
✓Flexibility is not there in applying the ABC	✓Flexibility	4
✓Leg and knee problems in using the ABC pedals	✓Health problem	4
✓Emergency system should be there	✓Safety	3
✓It Should be more comfort	✓Comfort	2
✓Not easy to operate on a ghat road	✓Critical conditions	3
✓Pedals distance is more	✓Distance between the pedals	3

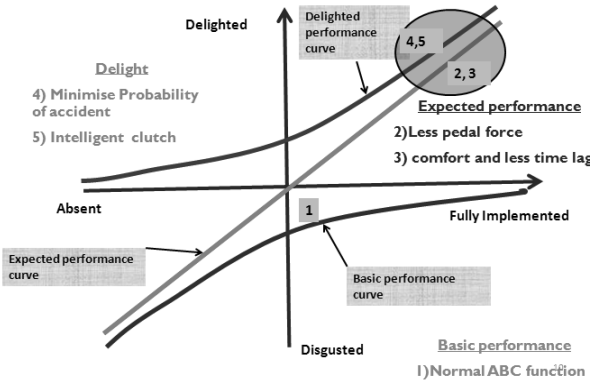


Figure 3.

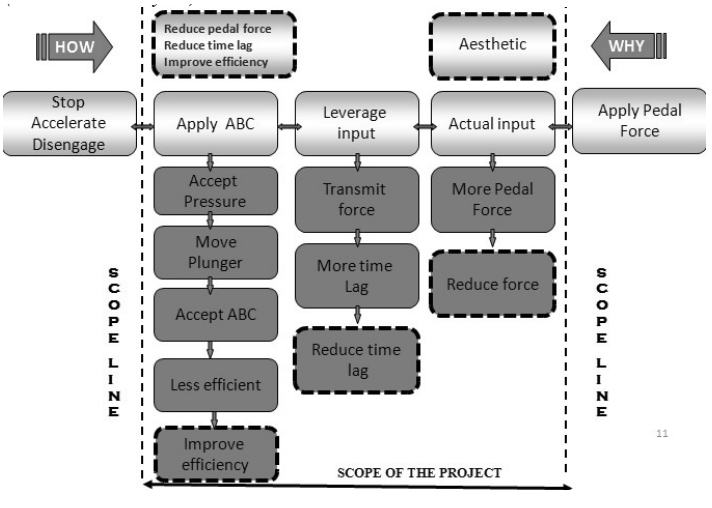


Figure 4.

1.8. Quality Function Deployment

Quality function deployment is the methodology that is most popularly used to convert the customer needs into engineering specifications and establish the targets to meet these needs. It also compares the requirement with the present competitors in the market. See the reference Figure 6 QFD.

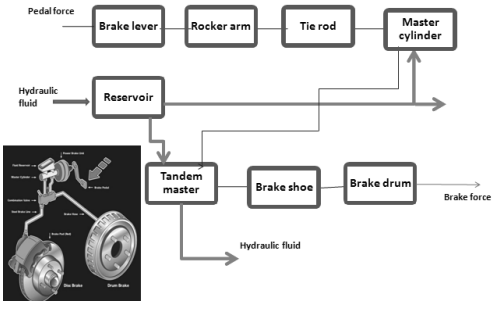
1.9. Concept Generation

Concepts are generated by considering six critical customer requirements. i.e. (1) Easy to apply ABC pedals, (2) Minimum time required to shift leg from one pedal to another, (3) Less leg pain, (4) Flexible to operate, (5) Comfort to use and (6) Distance between pedals. Concepts are generated by Intuitive methods (Morphological analysis and brain storming) and Logical (TRIZ) of idea generation.

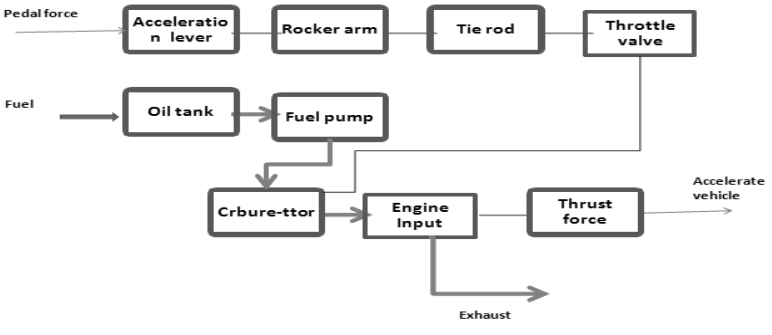
Concept generation by TRIZ method

TRIZ aims to create an algorithmic approach to the invention of new systems, and the refinement of old systems. In this paper the TRIZ principles are applied for the present problem by considering the

Brake system



Acceleration system



Clutch System

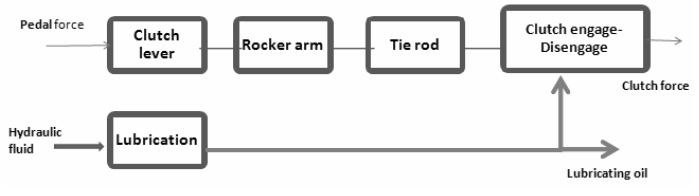


Figure 5.

minimum leg pedal force and minimum time required to operate pedals as the design parameters. See the reference Table 4 for the TRIZ analysis. 6 concepts are generated with the TRIZ Analysis. See the reference Figure 7 for all the concepts.

1. Split pedal system (Design proposal 1)
It address the minimizing of the reaction time (i.e. Time required to shift leg from one pedal to other pedal)

2. Electronic replacement of the conventional ABC (Design proposal 2)
It address the minimizing of the pedal force (i.e. force required to operate the pedal)

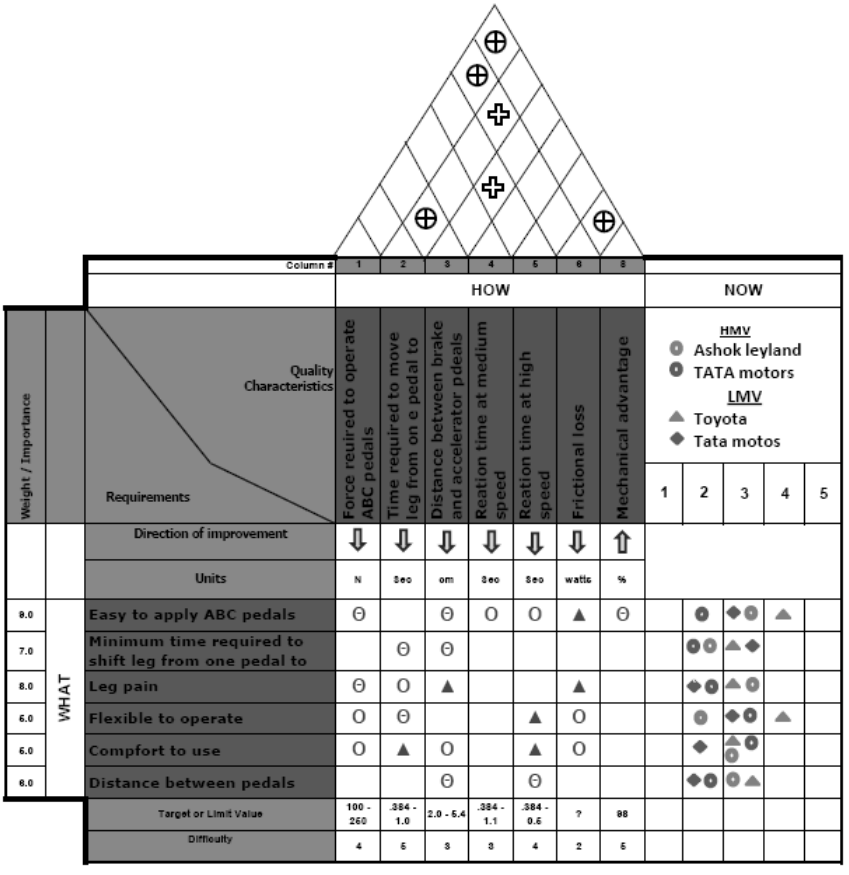


Figure 6.

3. Electrical replacement of the conventional ABC (Design proposal 3)
It address the minimizing of the pedal force (i.e. force required to operate the pedal)

4. Integration of clutch with the brake pedal (Design proposal 4)
It address the minimizing of the reaction time (i.e. time required to shift leg from one pedal to other pedal)

5. Integration of clutch with the gear shift lever (Design proposal 5)
It address the minimizing of the reaction time (i.e. time required to shift leg from one pedal to other pedal)

6. Integration of brake pedal with the steering wheel (Design proposal 6)
It addresses both the reaction time and pedal force.

1.10. Evaluation of Concepts

Weighted decision matrix method has been used to evaluate the concepts by giving relative rating with respect to the customer requirements. See the reference Table 5 for the decision matrix analysis.

Reasons considered for the Concept 6 as best

- No need to shift leg from one pedal to other since we have only two pedals beneath our foot.
- Pedal force is minimized due to introducing the piezoelectric concept.

Table 4.

S.No.	Degraded parameter	Parameter no	Inventive principles
1	Speed	9	13,**28**,15,19
2	Temperature	17	**28**,30,36, **17**
3	Tension and pressure	11	18,21,11
4	Durability	15	8,3,**17**,14

28→"Replacement of the mechanical system"
17→"Moving to a new Dimension"

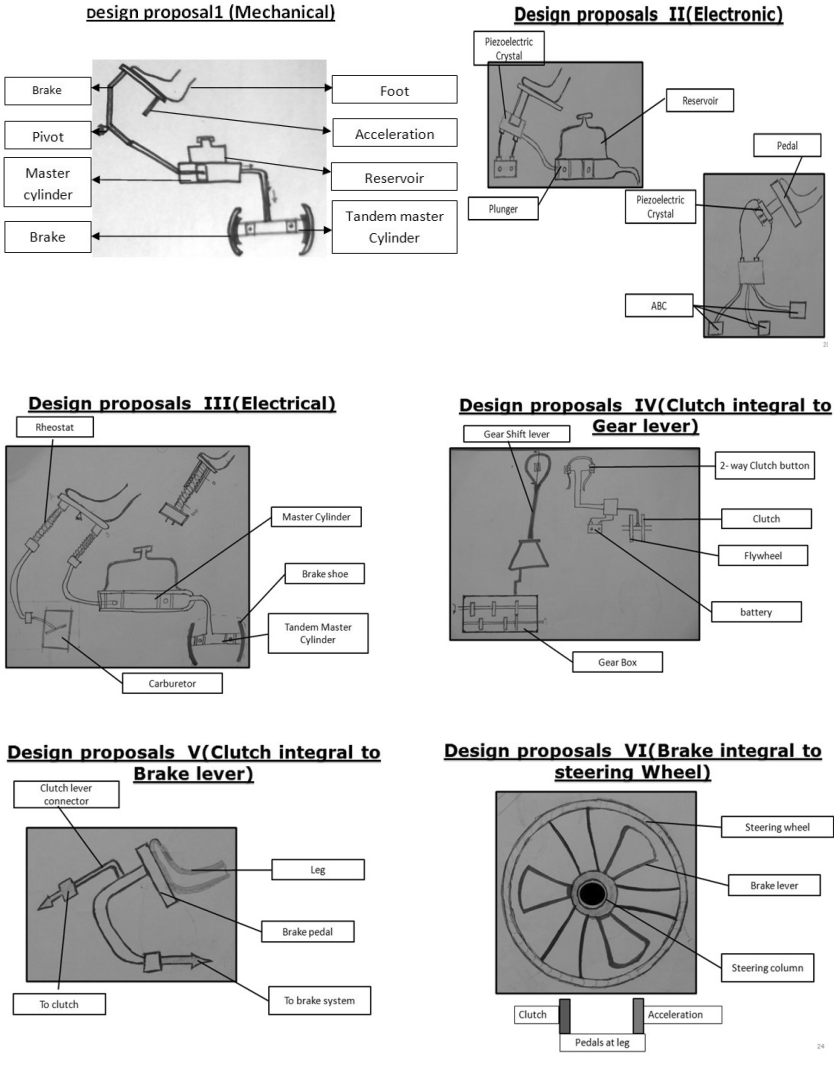


Figure 7.

Table 5.

		Concept 1		Concept 2		Concept 3		Concept 4		Concept 5		Concept 6	
Criteria	**Wt.**	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating
Easy to apply ABC pedals	9	4	36	9	81	4	36	2	18	6	54	9	81
Minimum time required to shift leg from one pedal to another	7	6	42	8	56	7	49	4	28	8	56	8	56
Leg pain	8	6	48	8	64	8	64	2	16	8	64	10	80
Flexible to operate	5	8	40	6	30	6	30	3	15	6	30	6	35
Comfort to use	5	2	10	6	30	4	20	4	20	4	20	8	40
Distance between pedals	6	5	30	5	30	4	24	4	24	4	24	9	54
Total			206		281		223		121		248		346

1.11. Conclusion

From weighted decision matrix it was observed that concept 6, i.e., integration of brake pedal to the steering wheel leaving two pedals beneath the feet for clutch and accelerator satisfies the customer requirements in a better way when compared to other concepts. This integration uses the piezoelectric crystal concept for operating the brake at the steering wheel. In the present market there are automobiles with "Automatic transmission system" with two pedals is one such system with disadvantages like more costly, fuel efficiency is 25% less than the normal transmission system and gives less acceleration.

The electronic integration of brake pedal to the steering wheel has advantages which overcome the problems of automatic transmission system by continuing with manual transmission system as well as customer requirements from the questionnaire. It has the advantages like, no need to shift legs from one pedal to other since we have only two pedals and pedal force can be minimized due to usage of piezoelectric crystals.

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