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Application of Pugh Selection Matrix for Fuel Level Sensing Technology Selection

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***Abstract*— *Technology selection is one of the most important step in Design Process. Choosing the right technology alternative, there is not always a single definite criterion of selection, and decision makers have to take into account a large number of criteria including technological, economic, ethical, political, legal, and social factors. The proper technology selection for Fuel Level Sensor using Pugh Selection Matrix for its application in Heavy Commercial Vehicles is discussed in this paper. In this paper, factors affecting sensor technology selection are identified. Various level sensing technologies are compared across these criteria using Pugh Selection Matrix. The entire procedure is illustrated and finally the best technology is selected for fuel level sensing for Heavy Commercial Vehicles*.**

Keywords—FuelLevelsensor, Pugh Selection Matrix, Heavy Commercial Vehicles, Criteria.

I. Introduction

Fuel level sensor is a device to indicate the level of the fuel in fuel tank fitted in an automobile. This will have features to communicate the fuel level to the dashboard of the vehicle and is of significant attention to the driver during vehicle usage.

The proper technology selection Pugh Selection Matrix, will be discussed and exemplified in this paper. Heavy Commercial vehicles have a very particular requirement when it comes to fuel tanks configuration, depending on usage, road conditions, weight distribution and application. After the selection of the fuel tank layout, the challenge is to correctly select the level sensor system, which provides useful information to the vehicle driver. If this measurement is not correctly performed, a significant logistic issue is raised, as usually, a commercial vehicle with full load carries up to 400-600 litres of diesel. Even though the selection of the sensor technology is sometimes neglected during the product development, in this particular case its wrong choice can lead to errors and, as mentioned before, logistics issues.

The objective of any selection procedure is to identify appropriate selection criteria, and obtain the most appropriate combination of criteria in conjunction with the real requirement. Thus, efforts need to be extended to identify those criteria that influence an alternative selection for a given problem, using simple and logical methods, to eliminate unsuitable alternatives, and to select the most appropriate alternative to strengthen existing selection procedures.

Burge, D. S. (2011) describe the basic concept of Pugh Matrix and its application. Hubka V (1981) studied that Pugh Matrix is a matrix to evaluate multiple concepts to select an appropriate concept. However, some researchers applied Pugh matrices slightly different, e.g. for component selection. Some researchers applied alternative ways of selecting concepts. Muller G et al. (2011) applied Pugh concept selection in the sub sea oil and gas industry. One of Muller's research showed that Pugh Matrix is appreciated amongst engineers. In this paper, various criteria affecting the Fuel level sensor output are identified. Pugh concept selection matrix is used to find the best technology alternative.

II. Methodology

A Pugh Matrix can be used whenever there is the need to decide amongst a number of alternatives. Although specifically developed by Stuart Pugh to help in selecting between a numbers of design alternatives, the tools has in recent years be used a general purpose decision making aid because of its ease of use.The Pugh Matrix is easy to use and relies upon a series of pairwise comparisons between design candidates against a number of criteria or requirements. One of its key advantages over other decision-making tools such as the Decision Matrix is its ability to handle a large number of decision criteria

Smith E. (2002) studied the potential failure modes of early wire wound versions of fuel level sensor and proposed design changes. Mazzorana, R et al. (2014) describe the Fuel tank system characteristics and the analysis of the fuel level sensor technology selection applied to the Latin America environment. Anandaraj N (2015) studied design and development of capacitive sensor for automobile applications.

In this paper, the alternative candidate design options have been determined and studied. They are as follows: RF Capacitance, RADAR, Ultrasonic/Sonic, Displacers, Differential Pressure, Air Bubblers, Magnetostrictive, Anisotropic Magneto resistive, Hall Effect and LVDT. The process for constructing a Pugh Matrix for sensor selection technology comprises five steps.

Step 1: Criteria for selection are identified and clearly defined. The robustness and validity of the outcome is fundamentally dependent on an appropriate set of criteria/requirements. Rushing this step usually results in a non-robust outcome that is challenged and overturned.

Criteria for selection are Effect of Operating Temperature Range, Effect of Fuel slosh, Effect of Presence of Impurity in Fuel, Mechanical Shock and Vibration, Cost, Accuracy, Suitability for automobile, Resolution and Linearity.

Step 2: Thick Film Resistor (TFR) based sensor design option is the baseline and core all criteria/requirements as '0' for this baseline. As TFR sensor is the existing design its performance is reasonably well known.

Step 3: Each candidate design option is compared against the baseline design, criteria by criteria and a pair-wise score is decided with:

0= same

1 = better

- 1= worse

The Pugh Selection Matrix is shown in Table 1.

Step 4: Assign Weightages to the criteria. Typically the weighting is on a 1 to 10 scale with 1 the lowest and 10 the highest weighting. Table 2 shows the weightages of the criteria.

Step 5: For each candidate design option the total score can be calculated by summing the number of +1 and –1. The highest ranked score is the "winner" but use common sense – DON'T just select "highest" ranked concept.

Table 1- Pugh Selection Matrix

	Alternative Design options										
Criteria	**Baseline-TFR Based**	**RF Capacitance**	**RADAR**	**Ultrasonic/Sonic**	**Displacers**	**Differential Pressure**	**Air Bubblers**	**Magnetostrictive**	**Anisotropic Magneto resistive**	**Hall Effect**	**LVDT**
Effect of Operating Temperature Range	0	1	1	-1	-1	-1	-1	1	1	1	1
Fuel slosh	0	1	-1	-1	-1	-1	-1	-1	0	1	1
Presence of Impurity in Fuel	0	-1	1	-1	-1	1	1	1	0	-1	1
Mechanical Shock and Vibration	0	1	1	1	-1	-1	-1	-1	0	0	1
Cost	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Accuracy	0	1	1	1	-1	-1	-1	1	0	1	1
Suitability for automobile	0	1	1	1	0	0	0	-1	0	1	0
Resolution	0	1	1	1	0	0	0	1	0	1	1
Linearity	0	1	0	0	0	0	0	0	0	0	0

Table 2 Weightages of the criteria

Criteria	Weightages (1-10)
Effect of Operating Temperature Range	**7**
Effect of Fuel slosh	**6**
Presence of Impurity in Fuel	**7**
Mechanical Shock and Vibration	**6**
Cost	**10**
Accuracy	**9**
Suitability for automobile	**8**
Resolution	**10**
Linearity	**7**

III. Results and Tables

In this Section, Sum of Positives, Negatives and Same for each of the design alternatives are calculated to identify best alternative.

Table 3 Sum of Positives, Negatives and Same.

Alternative Design options	RF Capacitance	RADAR	Ultrasonic/Sonic	Displacers	Differential Pressure	Air Bubblers	Magnetostrictive	Anisotropic Magneto resistive	Hall Effect	LVDT
Sum of Positives	7	6	4	0	1	1	4	1	5	6
Sum of Negatives	2	2	4	6	5	5	4	1	2	1
Sum of Sames	0	1	1	3	3	3	1	7	2	2

With a Pugh Matrix there is no clear "winner" but there is often a clear "loser" in such cases perform a sanity check (does the decision make sense) and remove the losing option. At this point the Weightages give to the criteria/requirements can give better differentiation.
So Weighted Sum of Positive, Negatives are calculated as follows by considering example of RADAR technology.

Weighted Sum of Positives (P) = Sum of Weightages of (Effect of Operating Temperature Range, Presence of Impurity in Fuel, Mechanical Shock and Vibration, Accuracy, Suitable for automobile, Resolution) = (7+7+6+9+8+10) =47

Weighted Sum of Negatives =Sum of Weightages of (Fuel slosh, Cost) (N) = (6+10) =16

Hence score obtained is =(P-N)= 47-16=36

Similarly Table 4 shows the scores of alternative design options.

Table 4- Scores of Alternative Design

Alternative Design options	**Weighted Sum of Positives (P)**	**Weighted Sum of Negatives (N)**	**Score =(P-N)**
RF Capacitance	53	17	36
RADAR	47	16	31
Ultrasonic/Sonic	33	30	3
Displacers	0	45	-45
Differential Pressure	7	38	-31
Air Bubblers	7	38	-31
Magnetostrictive	33	30	3
Anisotropic Magneto resistive	7	10	-3
Hall Effect	40	17	23
LVDT	45	10	35

IV.Conclusion

Based on scores, it can be concluded that Air Bubblers, Displacers, Differential Pressure are clear losers whereas LVDT, RF Capacitance, RADAR, Hall Effect type fuel sensors are high scorers. LVDT level sensors are effectively used for measuring liquid height up to 100 mm. But fuel tank height of Heavy commercial vehicles is more than 100 mm so LVDT level sensors cannot be used for this application. RF Capacitance type fuel level sensor is the best technology for the given application by Pugh Selection.

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References

i. *Anandaraj N., "Design and Development of Capacitance Type Level Sensor for Automotive Vehicle Application," SAE Technical Paper 2015-26-0015, 2015.*

ii. *Burge, D. S. "The Systems Engineering Tool Box", http://www.burgehugheswalsh.co.uk/uploaded/1/documents/pugh-matrix-v1.1.pdf (2011)*

iii. *Fleming, W. J. "New automotive sensors—A review", IEEE Sensors Journal, 2008, vol. 8, no. 11, pp. 1900-1921*

iv. *Frey, D. D., Herder, P. M., Wijnia, Y., Subrahmanian, E., Katsikopoulos, K., &Clausing, D. P. (2009). The Pugh Controlled Convergence method: model-based evaluation and implications for design theory. Research in Engineering Design, 20(1), 41-58.*

v. *Geslot, F., "Capacitive Fuel Level Sensor: Performance and System Approach," SAE Technical Paper 910492, 1991, doi: 10.4271/910492.*

vi. *Mazzorana, R., da Silva Junior, O., and de Oliveira, R., "Fuel Tank - Level Sensor Technology Selection Based on Engineering Criteria and Application Environment," SAE Technical Paper 2014-36-0128, 2014,*

vii. *Cervone, HF 2009, 'Applied Digtial Library Project Management', OCLC Systems & Services: International Digital Library Perspectives, vol. 25, no. 4, pp. 228-32*

viii. *Muller G., Application and Validation of Systems Engineering Methods and Techniques in Practice.http://www.gaudisite.nl/NOVA_Muller_AdvancesInSystemsEngineering Research.pdf*

ix. *SandeepChakravorty ,SmarajitGhosh, " Power Distribution Planning using Multi–Criteria Decision Making Method", International Journal of Computer and Electrical Engineering, December 2009, Vol. 1, No.5, pp.622–627,*

x. *Smith, E. and Ireland, H., "Design Guidelines for Automotive Fuel Level Sensors," SAE Technical Paper 2002-01-1074, 2002*

xi. *Pugh, S. Concept selection: a method that works. In: Hubka, V. (ed.), Review of design methodology. Proceedings international conference on engineering design, Rome, March 1981, 497 – 506*

xii. *Adela Tušanová, JánParalič ,"A comprehensive framework for software as a service adoption " , ICTM 2012 proceeding of the International Conference on ICT Management for Global Competitiveness and Economic Growth in Emerging Economies : Wroclaw, Poland, September 17-18, 2012. pp. 347-356.*

xiii. *Muller G., Klever D.G., Bjørnsen H.H., and Pennotti, M., "Researching the application of Pugh Matrix in the sub-sea equipment industry", CSER , Los Angeles (2011)*

xiv. *G. Muller, "Systems Engineering Research Validation," 2011. [Online]. http://www.gaudisite.nl/ SEresearchValidationPaper.pdf*