J. Mountain Res., Vol - 3 pp. 95-111, December, 2008

FUZZY FAILURE MODE EFFECTS IN A CARDIAC PACEMAKER

D. Pandey*, M.K. Sharma and Rajesh Dangwal*****

* Department of Mathematics, C.C.S. University, Meerut

**Deptt. of Mathematics, R.S.S. (P.G.) College Pilkhuwa, Ghaziabad

***Deptt. of Mathematics, H.N.B. Garhwal University Campus, Pauri Garhwal.

**Drmukeshsharma2k4@rediffmail.com

ABSTRACT

In past few years the demand of very sophisticated systems is growing up very fast resulting in the complexity of that system. Thus many times we arrive at the situation where it is either not possible or very tedious to consider all failure modes of the system during failure analysis. So we require some tools with the help of that we can avoid few of the failure modes that do not cause serious deterioration of the system. In the present paper we have developed an algorithm to screen out different failure modes. In this process of screening we first obtain the possibility of occurrence of that failure mode and then compare this possibility with the critical value (CV) taken in that problem. If the possibility of failure mode is larger than the critical value (CV), then this failure mode is taken for final expert system analysis otherwise it is dropped. Present Paper is devoted to the study of the functional behaviour of cardiac pacemaker. All failure-causing factors have been divided in four categories decisive factors, specific factors, momentous factors and related factors. There are five failure causing factors namely voltage of lithium-iodine cell, refractory index, impedance of the pacing circuit, Temperature, Distance of pacemaker from cellular phone.

Keywords: Failure mode, fuzzy ranking, Expert system, pacemaker, Fuzzification, Defuzzification.

INTRODUCTION

In reliability analysis of a system using classical set theoretic approach or some statistical methods, we require exact knowledge about the functioning of the system. But in most of the cases, it is not possible to acquire the information to a high degree of exactness. This brings the importance of fuzzy set theory in reliability analysis. Also with the help of approximate reasoning we can generate an algorithm to screen out any failure mode that consists of different failure causing factors having different weights. In this process of screening we first obtain the possibility of occurrence of that failure mode and then possibility of compare this possibility with the critical value (CV) taken in that problem. If the failure mode is larger than the critical value (CV), then this failure mode is taken for final expert system analysis otherwise it is dropped.

Present Paper is devoted to the study of the functional behaviour of cardiac pacemaker. All failure-causing factors have been divided in four categories decisive factors, specific factors, momentous factors and related factors. There are five failure causing factors namely voltage of lithium-iodine cell, refractory index, impedance of the pacing circuit, Temperature, Distance of pacemaker from cellular phone.

Pacemaker: The rhythmic beating of the heart is due to trigging pulses that originate in an area of specialised tissue in the right atrium of the heart. This area is known as sino-atrial node. In abnormal situations, if this natural pacemaker either ceases to function or becomes unreliable or the trigging pulse does not reach the heart muscle because of blocking, the natural and normal synchronizing of heart action gets disturbed. Under the circumstances, by giving external electrical simulation impulses to the heart muscle; it becomes possible to regulate the heart rate. These impulses are given by an electronic instrument called 'pacemaker'. A pacemaker basically consists of two parts: (i) an electronic unit, which, generates stimulating impulses of controlled rates and amplitude, known as pulse generator, and (ii) the lead, which carries the electrical pulses from the pulse generator to the heart.

Linguistic Variables:

The concept of a linguistic variable is very useful in dealing with situations which are too complex or too ill-defined to be reasonably described in conventional quantitative expressions. A linguistic variable is a variable whose values are words and sentences in a natural or artificial language. For example, 'low' is a linguistic variable. A linguistic value can be represented by the approximate reasoning of fuzzy number.

Classification and fuzzification of failure causing factors:

(a) Classification of factors causing system failure: The failure of a system may be caused by various factors. These factors may not play equal role in system failure. Rather they may have different importance. Thus these factors may be categorized as decisive, specific, momentous and related factors. Theses factors differ with each other in the sense that, their effects in the failure of the system are different. The factors that make the system immediately completely failed if they occur in their full strength, have been put in the decisive category. The specific factors however have key role in making system failed, but they are less significant in comparison to decisive factors. The momentous factors include that variety of factors that have very significant role but they cannot cause system failed even in their full strength. Related factors are the factors involved in system failure although they do not play a major role in system failure.

(b) Fuzzification of failure causing factors: These precipitating factors may be fuzzified by associating adequate fuzzy set to these factors. This facilitates us to quantify in four categories Decisive, Specific, Momentous, Related respectively and the crisp value obtained on defuzzzification of these factors is put in table

The weight of these factors is shown in fig. 16. Possibility of a particular failure mode in which the weight of Decisive, Specific, Momentous and Related factors is in accordance to table has been given as.

Pos (Failure mode)= $\left[w_d * (f_V(x) + f_{RI}(x)) + w_s * f_R(x) + w_m * f_T(x) + w_r * f_D(x)\right]$

$$= \begin{cases} \dfrac{x - 10.865}{4.59945} & for\ 10.86500 \le x < 15.46645 \\ 1 & for\ 15.46645 \le x < 16.77550 \\ \dfrac{21.364 - x}{4.5885} & for\ 16.77550 \le x < 21.36400 \end{cases} \quad \text{------------------} \quad 32$$

On comparing this fuzzy number thus obtained for Possibility of the failure mode using fuzzy ranking method we get that this fuzzy number is greater than the fuzzy number given for critical value (CV) in fig. 17. Thus this particular failure mode should be included in our final expert system analysis.

Conclusion:

This paper reports the method of failure mode screening based on fuzzy set theory. Which may be very useful for the assessment of different failure modes and then to rank these failure modes in order of their strength to precipitate the system. We have also used a technique for the measurement of the failure causing factors. The weight of different failure modes is taken as fuzzy numbers to incorporate the uncertainty involved in these data and these failure causing factors The functional behaviour of a pacemaker has been studied to apply the foresaid algorithm.

REFERENCES

Fonsecca J. Daniel and Knapp M. Gerald, "A fuzzy scheme for failure mode screening", *Fuzzy Sets and Systems* 121 (2001) 453-457.

Huang Z., Tong X., Zuo J Ming, "Posbist fault tree analysis of coherent systems", *Reliability Engineering and System Safety*, vol. 84, (2) 2004, pp 141-148.

Y. K. Gu, H. Z. Huang, "Fuzzy Mapping Between Physical Domain and Function Domain in Design Process", *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, vol. 12, (1) 2004, pp 7-20.

Zimmermann H.J., Fuzzy set theory and its application, second edition Amsterdam: Kluwer, 1991.