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RMS DEFUZZIFICATION ALGORITHMS APPLIED TO FMEA

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ABSTRACT

FMEA is a systematic process for indentifying potential design or process failure before they occur. The aim is to eliminate them or minimize the risk associated with them.

The method is a procedure to analize failure modes and clasified them by severity. It is a systematic process for identifying potential failures before they occur with the intent to eliminate them or minimize the risk associated with them. A group of experts make this quantification gathering information from memory and experience of the plant personel. The most known way to implement this analysis is in an ordinary tabular form which is difficult to trace. An FMEA worksheet is often arranged in a lot of columns with inconvenient horizontal scrolling. In order to eliminate this trouble a matrix method was developed [1]. The idea has already been explored for different authors [2].
The matrix FMEA is a pictorial representation of relationships between several FMEA elements. Traditionally, the numbers in the matrix are a prioritization of failures based on ranked numbers evaluating concepts as severity, frequency of occurrence and detectability of failure. Vague or ambiguous information and subjectivity in the ranking scales adds inherent inconsistrency. Some authors eliminate this deficiency by introducing fuzzy logic by using linguistic variables to describe the severity, frequency of occurrence and detectability of failure. Finally some defuzzyfication process [3] is applied to obtain a crisp number. The most common methods are Maximum, Mean of maximum, Centroid and Height. Actually, a lot of methods exist but no one gives a right effective defuzzified output because each method gives different results. Chandramohan et al. [4] introduce RMS defuzzification algorithms based on RMS (Root Mean Square) value and in this paper it is presented this new approach applied to Fuzzy FMEA methods. Traditionally the prioritization of failures in FMEA is performed based on the Risk Priority Number (RPN). RPN is a mathematical product of the seriousness of a group of
effects (severity), the likelihood that a cause will create the failure associated with those effects (occurrence), and an ability to detect the failure before it gets to the customer (detection). In equation form RPN = S . O . D
The overall procedure for making a fuzzy criticality assessment is similar to that used in fuzzy control systems [1]. The analysis uses linguistic variables to describe severity, frequency of occurrence and detectability of failure. These inputs are then 'fuzzified' using membership functions supplied by an application area expert to determine the

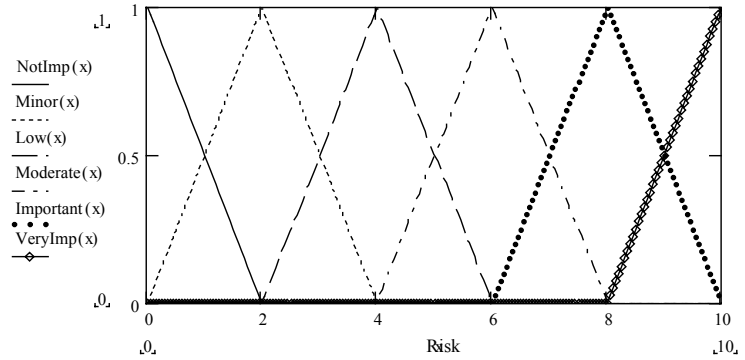
degree of membership in each input class. The resulting 'fuzzy inputs' are evaluated using a linguistic rule base and fuzzy logic operations to yield a classification of the 'riskness' of the failure and an associated degree of membership in the risk class. This fuzzy output is then 'defuzzified' to give the Criticality Rank for the each failure.
The linguistic variables S, O and D are fuzzified by trapezoidal membership functions. To calculate risk results min-max inferencing is used. The defuzzification process creates a crisp ranking from the fuzzy conclusion set to express the riskness of the failure so that the corrective actions can be prioritized. The RMS algorithms are used. The Root Mean Square 1 (RMS_1) [2]:

$$RMS_1 = \sqrt{\frac{\int_A^B f(\mu(x))^2\,dx}{B-A}}$$; A and B are the lower and upper limits of the function

The Root Mean Square 1 (RMS_2) [2]: $$RMS_2 = \sqrt{\frac{\int f(\mu(x))x^2\,dx}{\int f(\mu(x))\,dx}}$$

f represents the aggregated membership function and $\mu(x)$ is the degree of membership.

This function calculates the RMS value based on the area under the membership function $f(x)$. The risk membership function just taken for illustration purpose is shown in the following figure and it is defuzzified using RMS algorithms.



The results clearly indicate a difference and are meaningful. Each result is presented and discussed. RMS_2 can be used for this type of application but divided by the risk with the maximum value of the membership function considered. The algorithm is useful but with some modification that was verified in each case can be easily implemented.

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