§49. Monitoring System of Superconducting Magnet Using Fuzzy Theorem

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In a large superconducting magnet system like a fusion reactor, continuous monitoring and evaluation of the state of superconducting magnet is necessary. For the monitoring of these magnet system, we have proposed a new method using Fuzzy theorem[1]. This time, we have investigated the optimal selection of membership functions to express the state of the magnet exactly. As a result, it becomes clear that increase of the number of membership functions can improve the monitoring of superconducting magnet even if the actual data have large noises.

An experiment was carried out using NIFS's superconducting coil called "TOKI-MC" module coil[2]. Many kinds of sensors are placed into it. These sensors can be divided into two groups. One is for "global" signals like terminal voltage, balance voltage and transport current, and the other is for "local" signals like tap voltage, strain, AE, and temperature, etc.. We consider that the best selection of the membership functions would be the combination of the global one and the local one. The reason why is that a quench arises from a local point and extends to all area. So, this time, we selected two membership functions (balance voltage, current) as global one, and four membership functions(strains) as local one.

The experiment was carried out at a constant excitation rate of 2kA/min. Figure 1 shows the analyzed results for the case of two, four, and six membership functions. Where, the dotted line shows the expected dangerous rate which is obtained assuming that the strain will be proportional to the square of the current. Figure 1(c) shows the dangerous rate composed by six membership functions. Analytical results of these characteristics are summarized below;

(1) The dangerous rate obtained by 2 membership functions has large noise because of the high sensitivity voltage membership function.

(2)The dangerous rate obtained by more than 4 membership functions is appropriate for the judgement of the state of magnet. And the time at which it reaches the dangerous level is about 50 sec before the actual quench.

(3)Furthermore, the case of 6 membership functions, its dangerous rate increases almost linearly in the range higher than the dangerous level. And a small burst signal is recognized clearly for about 20 sec before quench as shown in figure 1(c). This burst signal can be considered to be the preceding sign of quench.

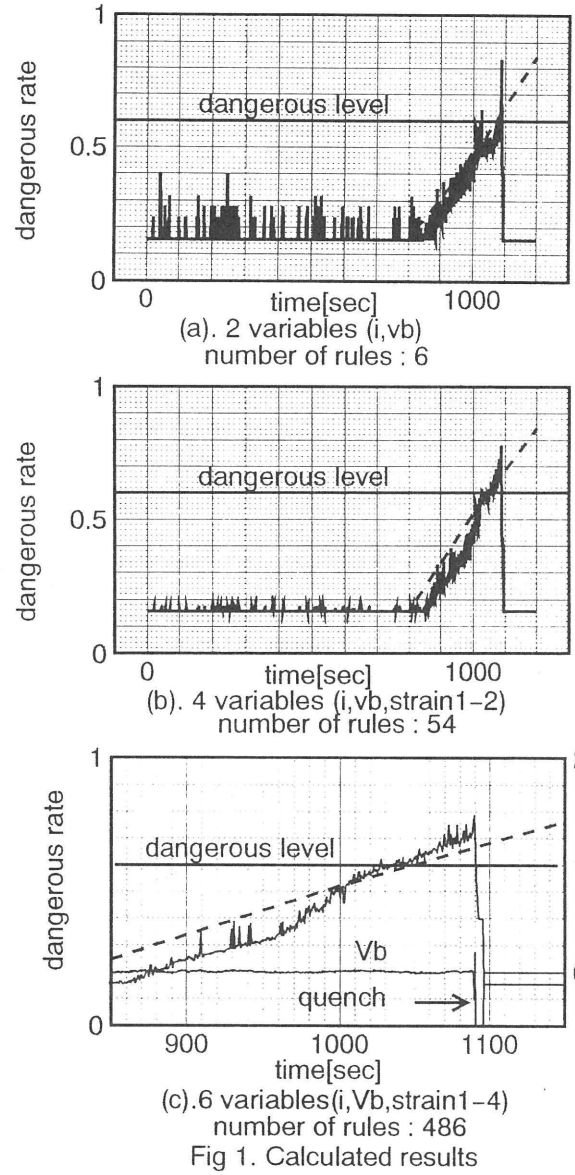

Fig 1. Calculated results

References

1)Ninomiya,A. et al.:IEEE Trans. on Appl. Super. Vol.3, No.1, march, pp 301-304,1993

2)Sakamoto,M. et al.:IEEE Trans. on Appl. Super. Vol.3, NO.1, march, pp 543-546,1993