Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Assessment of Core Damage Status using Core Exit Thermocouple

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1. Introduction

To manage severe accident efficiently we need to diagnose the plant status with confidence. But the harsh environment of the containment during the severe accident might render much of the implemented instruments unreliable or even unavailable. This roused a lot of research in the past[1] or even at present[2]. To be of help for national radiological emergency preparedness, KINS is also developing a diagnosing technique of severe accident progression. The first step to diagnose the accident is to assess core damage status with confidence and the main philosophy is to use instrument information as less as possible except the most reliable one to diagnose. In this paper we present some evaluation results of assessing the core damage status using the core exit thermocouple. The target plant was KSNP.

2. Methods and Results

The well known method of assessing the core damage is that of Westinghouse CDAG[1] (core damage assessment guideline). The concept of Westinghouse CDAG will be summarized in section 2.1. Our method is also based on CDAG, but after analyzing the behaviour of the instruments and of the core exit thermocouples during the accident, we found that the previous Westinghouse CDAG cannot be applied as it is to KSNP. One main reason is the code system with which we analyse the behaviour of our plants during the accident. This makes us to look at the previous Westinghouse CDAG from the beginning and also to establish our own assessment guideline. These are described in sections 2.2 to 2.4.

2.1 Westinghouse CDAG [1]

One of the regulatory requirements following the TMI-2 was to estimate the amount of core damage during accident. Thus WOG developed a core damage assessment guidance to provide timely recommendations with respect to offsite radiological protective measures. The use of samples of plant fluids were found not adequate to provide timely information regarding the condition of the core during the accident progression. The CDAG relies on two primary indicators for assessing the degree of core damage: the core exit thermocouples and the containment high range radiation monitor. The RTD temperature and the pressure of RCS are used as confirmatory information in assessing the core damage.

2.2 Evaluation of Installed Instruments

We have investigated the behaviour of installed plant instrumentations to select instruments which are reliable and vital for the assessment. Core exit thermocouples (CET), resistance thermal detector (RTD) in hot leg, reactor vessel level instrumentation system(RVLIS), power range excore detector, containment radiation monitors are normally said to be useful in detecting the accident. Among these we found that CET is the only instrument which gives direct information about the status of core and which is in conformance with our system. For example, we don't have a reliable code system to relate the degree of core damage with that of the containment radiation level. Also our MELCOR analysis showed that the RTD temperature is not quite in line with the degree of core damage because there can be a reverse flow of water in hot leg depending on the accident assumed. Fig.1 shows that even when the clad temperature is over 2,750 K, the hot leg RTD remains at the saturated temperature for SBLOCA case analysed. This result is contrary to the WOG CDAG which uses RTD as a complementary tool to assess the core damage and it definitely says that it is more prudent not to use RTD in assessment.

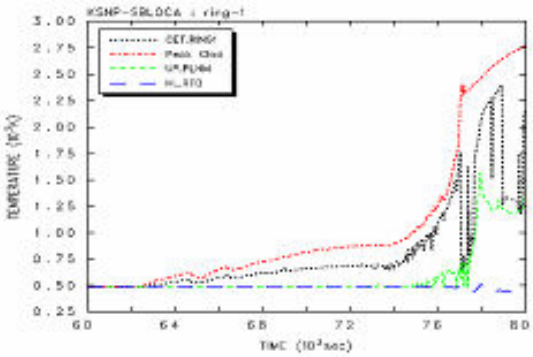

Fig.1 Temperature development of reactor core and of hot leg. Red line is clad temperature and the blue line is hot-leg temperature.

Also RVLIS can tell us that the core uncovering has occurred only. Thus, we conclude that CETs alone can give some information, though limited, about the core status with some confidence. Thus it it necessary to relate the core damage status to the behaviour of CETs alone.

2.3 Behaviour of Core Exit Thermocouples

In KSNP reactor, we have 45 CETs just 4~6 inch above the active fuel. The availability of CETs during severe accident has been intensively studied by INEEL[4]. The study concludes that CET value is reliable until it is 1600°F while the measured value becomes very doubtful one when it is over 2,200°F. In WOG SAMG(severe accident management guideline) it is credited until 1800°F. We have analysed the behaviour of CETs during severe accident using MELCOR code. The core input was made of 4 radial rings as is shown in fig.3. Fig.2 shows the temperature development of CETs for radial rings 1,2,3 and 4. The accident scenario simulated is large break LOCA. The fig.3 shows that even the core exit temperatures for rings 1~3 are higher than 1,250K , that of ring 4 can be still less than 1,100K. In case the CET temperature of ring-4 is 1,250K, the temperature of fuel cladding is around 1,360K. The melting temperature of cladding is around 1,173K, thus the CETs of ring-4 can still give correct temperature while the other CETs are already doubtful at the time when some claddings are melting.

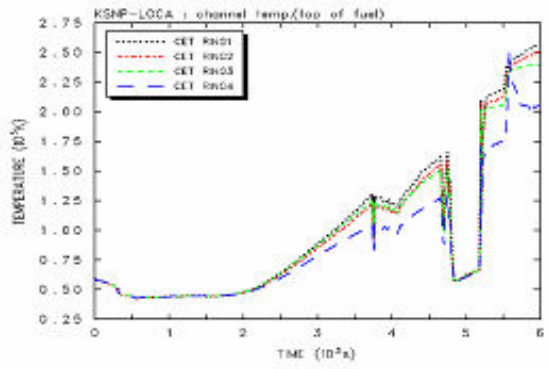

Fig.2. Temperature development of CETs for 4 radial rings. The accident scenario considered is LBLOCA..

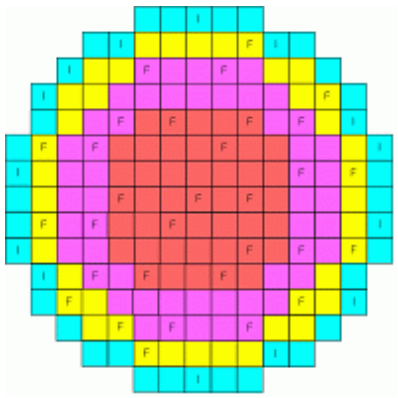

Fig.3 Radial distribution of CET temperature
(I<=1,250K, F>1,250K : LBLOCA, at 3,500 ec.)

3. Conclusion

The temperature measured by CETs can be used in assessing the core damage status. The analysis with MELCOR code shows that even when the CETs for ring 1, 2 and 3 are over its availability limit, the CET for ring 4 could remain still within its' availability range.. This means that the CETs for outer ring are still giving reliable information when the fuel cladding is melting in the core. On the other hand the RTD temperature in hot leg does not provide reliable information concerning the core damage because the temperature history of RTD varies highly depending on the local flow condition of hot leg sometimes irrelevant of the core damage status. Our analyses results are different from that of WOG CDAG in many aspects, thus justifying our efforts to develop a plant specific method for assessing core damage.

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