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The Results of a Site Repair after a High Vibration Trip of a Secondary Cooling Fan in HANARO

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1. Introduction

HANARO, an open-tank-in-pool type research reactor of 30 MWth power in Korea, which is different from a power plant reactor, exhausts a heat generated from the reactor core into the atmosphere through a secondary cooling tower instead of an electric power production from the heat. After a cooling tower overhaul[1], No. 2 cooling fan of the cooling tower was stopped by a high vibration trip while HANARO was operating normally. This paper describes the development of a high vibration trip of the cooling fan and the results of a site repair of the cooling fan.

2. Supervision for high vibration of cooling fan

The secondary cooling tower is composed of four cells including a motor, a driving shaft, a gear reducer, a cooling fan, a cooling water distributor, a fill and an eliminator respectively, and a basin accumulating cooled water through each cell. The motor supplies rotating forces with high and low speeds, half of the high speed, to run the gear reducer connected to each cooling fan for cooling the secondary cooling water.

A vibration switch is installed in each gear reducer to detect a high vibration of fifteen point two five millimeter per second (15.24 mm/s) of the running fan[2]. When the vibration value exceeds the limit, the switch sounds an alarm and stops the running fan to protect it from any damage. But, in this time, the reactor's normal operation is maintained until the temperature of the cooling water exceeds 33 ^{o}C[3]. The real time vibration values of each running fan are only recorded in a control panel of HANARO control room, but the vibration trends are not directly shown on the panel.

3. A high vibration development of cooling fan

3.1 No.2 cooling fan

During a normal operation of HANARO, two high vibration trips have occurred in No. 2 cooling fan as shown in fig. 1. This figure is drawn by using the accumulated vibration values during a normal operation to analysis a high vibration development before a trip.

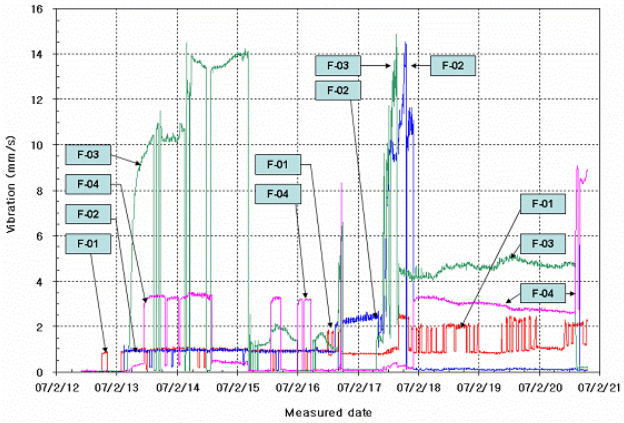

Figure 1 High vibration development of cooling fan

The first trip occurred at about four o'clock PM of Feb. 16. It is estimated that this trip was a false alarm because the vibration values did not exceed the limit and an abnormal condition was not found at the site. The fan was restarted after re-tightening the fixing bolts of the vibration switch and the vibration values were maintained at around 2 mm/s. But, after then vibration values were gradually increased as shown in the figure.

The second trip occurred at about seven o'clock PM of Feb. 17. A high vibration was recorded in about fourteen point two five millimeter per second (14.25 mm/s). Before the vibration reached the limit, the vibration rose up to four times that of the initial value of one point nine millimeter per second (1.9 mm/s) and came to a state of a lull for about five hours. After about 20 minutes the fan was restarted and run for about two and half hours.

3.2 No. 3 cooling fan

As shown in fig. 1, No. 3 cooling fan has been operated at a low speed at the beginning. For about three days from the thirteenth to the fifteenth of February, the fan was operated five times with a high speed start without a sufficient low speed operation. During this operation period, the vibration of the fan nearly reached the limit, but a high vibration trip did not occur.

On the morning of the seventeenth in February, the vibration of the fan nearly reached the limit for three hours without a high vibration trip. After this, the fan was operated at a low speed.

3.3 No1 and No. 4 cooling fans

During a high speed operation, the vibration value of No. 1 cooling fan was gradually increased to one and half times that of the initial value without a high vibration trip because these vibration values are low. No. 4 cooling fan is operated at a low speed during a normal operation. Its vibration value is higher than that of the other fans because a pinion gear surface was a litter worn down.

4. Results of Site Repair

4.1 No. 2 and 3 cooling fans

When we checked the installation status of each gear reducer, we found that each gear reducer was distorted by an angle of about five degree in the same direction as the fan rotation and the reducer of No.3 fan was more distorted than that of No.2 fan. Each shaft coupling was misaligned and the rubber bushings for the shaft coupling were damaged. The wall of the No. 3 coupling connection bolt holes was worn.

When a cooling fan is started at a high speed without a sufficient low speed operation, a high speed rotary force works on the fixing bolts of the gear reducer more than a low speed start. Hence the gear reducer of No. 3 fan is more distorted than that of No. 2 fan. And it is estimated that the shaft coupling of No. 3 fan is damaged during five high speed starts, because the vibration is varied in a large range of about two times of the initial value during a low speed operation.

Fig. 2 shows the vibration trends of each cooling fan after replacing the stainless steel bolts with a high tension bolt for fixing each gear reducer and re-aligning the shaft connected to the motor and the gear reducer[4]. Each fan runs to a high speed after a measured time of 1000 for No.2 cooling fan and 2400 for No. 3. Each vibration value of a high speed operation is indicated below 4.2 mm/s for No. 2 cooling fan and below 3.3 mm/s for No. 3 cooling fan and stabilized below the vibration limit. Before each fan starts, the indicated unstable vibration values are due to a noise.

4.2 No. 1 and No. 4 cooling fans

After the repair, the vibration values of No. 1 cooling fan are shown after a measured time of 3500. The vibration values are indicated below 2 mm/s with stability and this is reduced to about 70 % of the values before the site repair.

And the vibration values of No. 4 cooling fan are indicated after a measured time of 2900. At a the beginning the vibration values are indicated at about 9 mm/s and gradually increased to about 10 mm/s. This value is higher than that before the repair but it is maintained stability below the vibration limits.

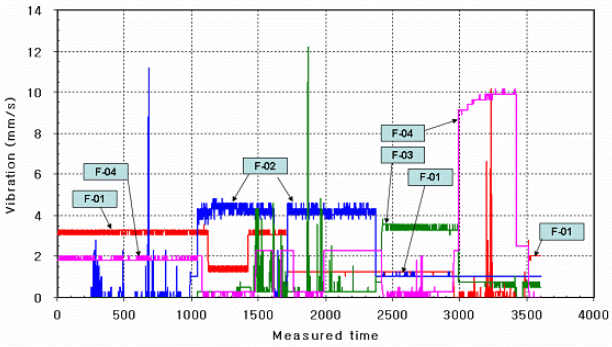

Fig. 2 Cooling fan vibrations after field repair

5. Conclusions

A high vibration trip was developed because a gear reducer was distorted by an angle of about five degree in the same direction as the cooling fan rotation by a rotating force, and a shaft alignment mismatched. And the vibration is gradually increased to above the limit of a high vibration trip.

The major reason for the high vibration trip of the cooling fan is that the bolt tightening forces for fixing the gear reducer are not as strong as the rotating force of the cooling fan for many high speed starts. And it is easier to distort a gear reducer that an impulsive force of many times high speed start without a sufficient low speed operation works strongly for fixing the bolts of the gear reducer.

After replacing the stainless steel bolts with high tension steel bolts for fixing the gear reduce, the vibration values were stabilized and maintained below the limit of a high vibration trip.

References

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