PWR FUEL PERFORMANCE ISSUES and FRETTING WEAR RESISTANT FUEL DESIGN

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1. Introduction

To maximize efficiency of Nuclear Power Plants the utilities increase the cycle length, fuel burn-up, enrichments of uranium and stretch out the power up-rate. Because of these severe nuclear fuel operating conditions various of fuel performance issues such as Grid to Rod Fretting(GTRF) failure and fuel assembly bow and Incomplete Rod Insertion(IRI) problem, and Fuel assembly handling problem because of excessive grid growth at high burn-up. This paper presents various issue and status worldwide fuel performance including fretting wear performance of PLUS7 TM fuel design.

2. DESIGN VERIFICATION AND FUEL PERFORMANCE

KEPCO NF had developed PLUS7 TM fuel from 1999 to 2002 to improve the fuel performance against the existing fuel. To improve grid-to-rod fretting wear resistance, PLUS7 TM uses the contour springs and dimples which make grid-to-rod area contacts rather than the point contacts in existing fuel. The springs and dimples are also designed in the horizontal direction to minimize the grid-induced pressure drop.

The mixing vanes of the PLUS7 TM grids were arranged in the grid assembly to have the hydraulic balance to prevent the fluid-induced fuel assembly vibration. The PLUS7 fuel assembly vibration is very small over the range of flow rates of the plants was shown via fluid-induced fuel assembly vibration test. And the fluid-induced high frequency vibration characteristics were evaluated over the range of flow rates of the plant. The 500 hours long-term wear-resistance test results showed that the PLUS7 TM fuel did not generate the fretting wear-induced fuel failure for the fuel lifetime.

Four PLUS7 TM Lead Test Assemblies (LTAs) were loaded to an OPR1000 (Ulchin Unit 3) and irradiated for three cycles from 2002 to 2007. At the end of Cycles 5, 6 and 7 of UCN-3, pool-side examinations of the LTAs were conducted. We checked visual inspection of fuel rods and measured fretting wear depth at grids contact points. After 3rd cycle operation we transport LTA skeleton to Hot Cell Test facility and measure and investigate grid cell size, grid cell stiffness and wear characteristics.

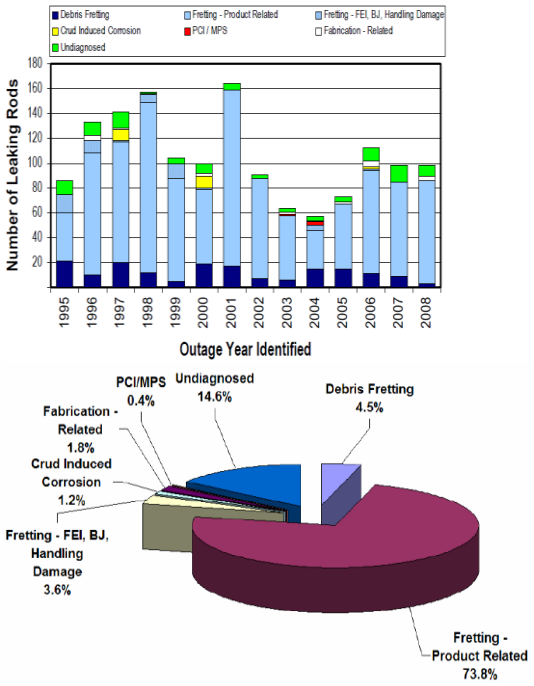
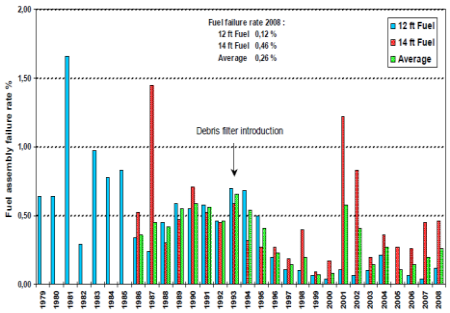


Fig. 1 Fuel Performance A



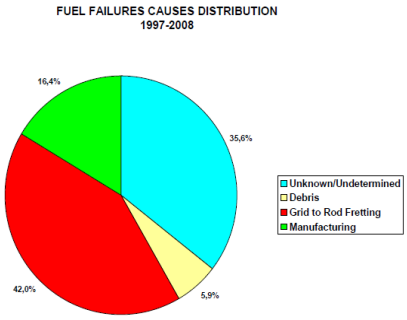


Fig. 2 Fuel Performance B

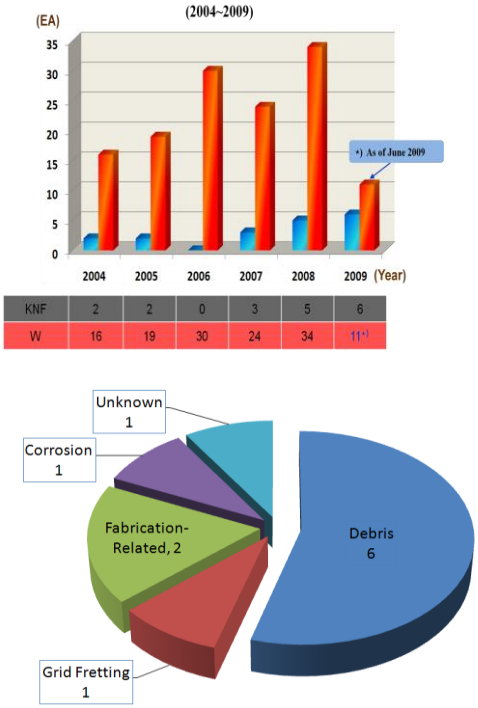


Fig. 3 Fuel Performance C

3. Conclusions

Based upon the successful in-reactor performance of the LTAs, and more than 1,500 PLUS7 TM fuel assemblies commercial operation experiences on OPR1000 nuclear power plants since 2006 PLUS7 ^{TM} fuel show very good fretting wear resistance performance.

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