Evaluation of Time Study for YGN 1 and 2 Fuel Handling Equipment Modifications

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1. Introduction

KHNP plans to upgrade/modify the fuel handling equipment in order to reduce the overhaul period. The existing fuel handling equipment for Yonggwang Nuclear Power Plant Units 1 and 2(YGN 1 and 2) is handling less than three(3) fuel assemblies per hour. However, the fuel movement rate will increase to about six(6) fuel assemblies in case of the modification and upgrade of the fuel handling equipment. During fuel off-loading and reloading, data for each fuel handling equipment were collected and evaluated. The purpose of this evaluation is to determine the specific steps that can be taken at the YGN 1 and 2 to shorten the fuel movement time and then recommend the items to be modified and upgraded.

2. Data Collection and Review of Data

Data were measured on three(3) equipment, such as Refueling Machine(RM), Fuel Transfer System(FTS), and Spent Fuel Handling Machine(SFHM), during the fuel off-loading and reloading. The method used for data collection is as follows:

- Multiple cycles were recorded.
- RM, FTS, and SFHM were recorded separately.
- Any irregularities were ignored, such as
  - Trouble inserting bowed fuel assembly
  - Equipment problems

Data were averaged for multiple cycles per equipment. The time study results are shown on Table 1.

Table 1. Time study results for each machine

No.	Name of Machine	Average Time for Cycle
1	RM	23 Min./FA
2	FTS	22 Min./FA
3	SFHM	21.5 Min./FA
4	Total average cycle	23 Min./FA* (= 2.7 FA/hr.)

* Equal to slowest machine's cycle

Several points observed from the measured results are as follows:

- RM took the longest machine cycle.
- FTS usually waited for RM about two(2) to five(5) minutes.
- More than eighty percent(80%) fuel assemblies were reloaded by the off indexing function using the loading assistance tool(LAT).
- There is no Gripper Camera in the mast.
- The fuel withdrawn from the Upender on the fuel building side was visually inspected using the inspection device, which is installed on the back side of the refueling canal. The inspection time usually takes six(6) to eight(8) minutes.

3. Recommendations for Modification

Based on reviewing the time study results, the following sets of recommended modifications were developed to increase the fuel movement rate up to six(6) fuel assemblies per hour for the plant.

3.1. Modifications to the Refueling Machine

- Increase the Bridge, Trolley and Hoist speed
- Operate the Trolley and Bridge simultaneously
- Apply automatic positioning function to reduce hunting for core positions.
- Provide automatic "Off-Index" function.
- Install the Gripper Camera for verifying proper gripper-to-fuel engagement.

3.2. Modifications to the Fuel Transfer System

- Interlock the FTS with the RM for automatic initiation from the RM
- Interlock the FTS with the SFHM for automatic initiation from the SFHM.
- Increase the Upender winch and Carriage Drive speed

3.3. Modifications to the Spent Fuel Handling Machine

- Increase the Bridge, Trolley and Hoist speed
- Operate the Bridge and Trolley simultaneously.
- Improve manual positioning to reduce hunting for pool locations.

It is important to note that the performance of the refueling machine, the fuel transfer machine, and the spent fuel handling machine is all interrelated. As the performance of any one of these three systems is improved, it has a positive impact on the performance of the other two.

4. Detailed Descriptions for Modifications

4.1. Modifications to the Refueling Machine

• Bridge and Trolley Speeds – The bridge and trolley speed of the Refueling Machine is increased to 18 m/min. and 12 m/min., respectively. This upgrade is usually accomplished by changing out the motors and gearboxes. In addition, separate motor drives are put in for the trolley and the bridge, so the two(2) motors can operate simultaneously and traverse to the upender diagonally.

• Automatic Positioning – Based on observations and experience in other plants, there is always some amount of jogging of the bridge and trolley to get properly aligned in the core during manual operations. With the application of the automatic positioning function, jogging of the system is a thing of the past. Once the system has properly aligned at installation, the Refueling Machine will stop on the precise position every time.

• Hoist Speed – The hoist speed is increased to 12 m/min. All of the original slow speed areas are still observed for protection of the fuel.

• Automatic Off-Index Function – The operator can select an off-index mode of operation and then the Refueling Machine will automatically move to the off-index locations. Off-index is the location near the final core location for the fuel assembly, but in "open water" and not directly adjacent to another fuel assembly. When the refueling machine is positioned at the off-index location, the hoist can operate at high speed the entire distance while lowering or raising the fuel assembly.

• Gripper Camera – A removable gripper camera is installed inside of the mast and looks past the gripper at the fuel assembly top nozzle and serial numbers. The operator can then visually verify perfect alignment and watch the latching of the fuel with 100% assurance.

4.2. Modifications to the Fuel Transfer System

• Interlock with Refueling Machine and Spent Fuel Handling System – The Refueling Machine and the Fuel Transfer System will be linked so that automatic transfer initiation can take place from the Refueling Machine. In addition to automatic initiation, the PLC will allow the Refueling Machine to go directly to the upender position without waiting. This will allow the upender to raise immediately upon arrival to the Containment Building if the fuel assembly are out of the way. This will also allow the transfer cart to depart for the fuel building as soon as the upender is down.

The Spent Fuel Handling Machine and the Fuel Transfer System will be also linked so that automatic transfer initiation can take place. The upender operator position is eliminated(reduced man-ram exposure and labor cost). In addition to automatic initiation, the PLC will allow the SFHM to go directly to the upender position without waiting.

• Upender winch and Carriage Drive Speeds – The upender winch and the carriage drive speeds are increased to 12.2 m/min. and 15 m/min., respectively.

4.3. Modifications to the Spent Fuel Handling Machine

• Improve Manual Positioning – This feature will reduce the hunting and constant jogging that is now present on the machine. This feature is very beneficial to plants that are reracking to higher density racks with smaller fuel rack lead-ins.

• Bridge and Trolley Speeds – The bridge and trolley speed is creased to nine(9) m/min. This upgrade is usually accomplished by changing out the motors and gearboxes. In addition, separate motor drives are put in for the trolley and the bridge, so two(2) motors can operate simultaneously.

• Hoist Speed – The hoist speed is increased to twelve(12) m/min., instead of the approximately six(6) m/min. that is allowed now. All of the original slow speed areas are still observed for protection of the fuel.

5. Concluding Remarks

By implementing modifications and enhancements to all three equipment, the RM, FTS, and SFHM, the fuel movement rate can be reached up to six(6) fuel assemblies per hour, which would be two(2) times faster than that of the existing.

In addition to the above hard time savings, there are a number of "soft" time savings that are more difficult to calculate. These include:

• Higher reliability with new equipment.

• No obsolete or hard-to-get parts.

• Data collection abilities for fuel placement, overrides, abnormal conditions, etc.

• Core verification can be done while the fuel assembly is moved with the gripper camera.

• Reduced radiation exposure to refueling personnel since they are not on the bridge for as long.

• Elimination the chance of a fuel assembly being placed in the wrong pool or core position.

• Pre-planned reload/off-loading sequences are loaded into machine controls, thus eliminating human operator error potential.

REFERENCES

[1] Feasibility Study for Yonggwang Units 1,2 Fuel Handling Equipment Modifications, KHNP, 2004. 10.