

2017 IERE-TNB Putrajaya Workshop

Operation Big data based Failure Probability Assessment for RBM of Fossil Power Boiler Tube

Next Generation Operating Model for the Digital World

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1 **Background**

2 **Current Status of RBM for Boiler**

3 **Operation Data Based Approach**

4 **New RBM System for Boiler Tube**

5 **Conclusion**

Risk Based Maintenance

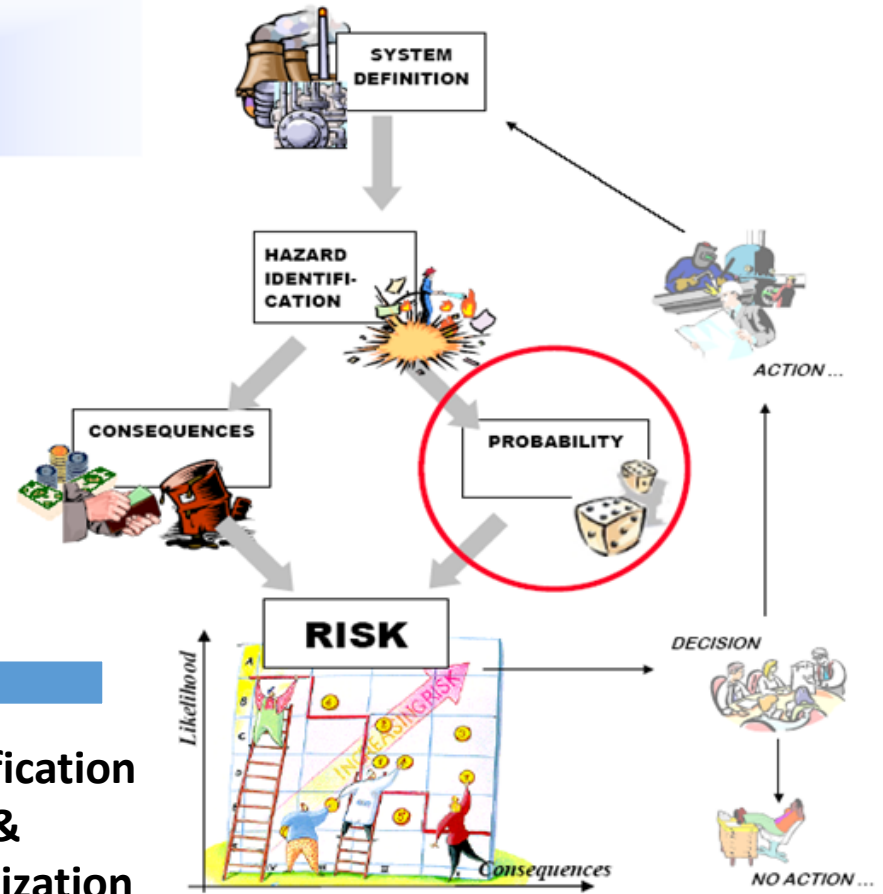
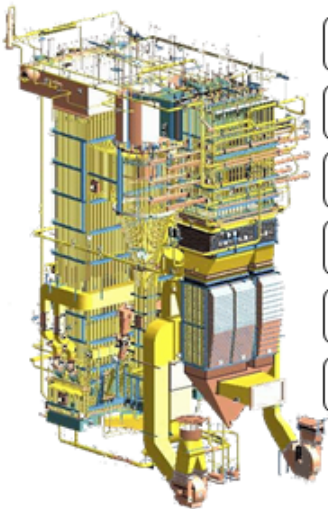
The Engineering Practice of Maintenance Optimization based on Identification and Prioritization of the Critical Failures Affecting on Productivity and Reliability

RISK

$$\text{RISK} = \text{probability} \times \text{consequences}$$

Boiler Damage Mechanism

- WW Weldment Crack
- SH Final Tube Creep Rupture
- Platen SH Spray Erosion
- Eco. Low Temp. Corrosion
- Final SH Out HDR TMF Crack
- ...





● RBM History in Korea

Introduction('04~'07)

- Government Leading
- Starting with TWI Riskwise
- Customization

Application('06~'09)

- Overhaul Optimization
- Integration with EAM
- KEWP applied RBM into all coal power plants

Extension('10~)

- Developed independent RBM Code for Coal Power Plant
- 5 GenCos applied RBM to optimize Overhaul

● Current Status of the Power Industry RBM application

- KEPIC(Korea Electric Power Industry Code) issued RBM Code in 2010
- ❖ RBM Basic Guideline, Detail Guideline for Boiler and Steam Turbine
- GenCos have operated the RBM based Asset Management System and a specialized team for risk engineering
- KEPRI has provided Overhaul Optimization Service(RBM) with GenCos, managed KEPIC and developed new risk assessment technology

- Risk Matrix classifies Severity of Failures using POF and COF Level
- POF and COF are assessed by Equipment condition and Failure Records
- The Type of Maintenance Activity and Schedule are decided by Risk Level

Simplified Risk Evaluation Equations

$$POF = POF_g + POF_c$$

$$COF = COF_1 + COF_2 + COF_3$$

POF_g : Generic Probability of Failure

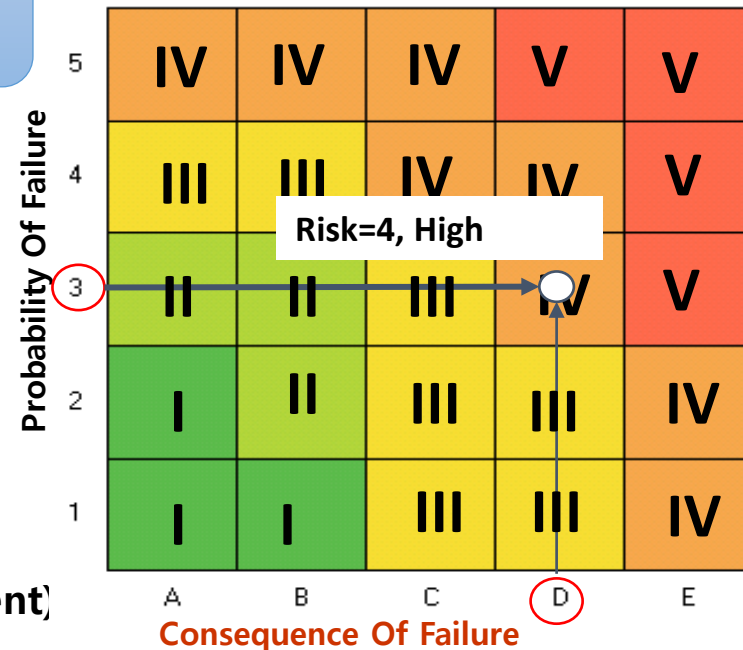
POF_c : Compensation of Probability of Failure

Based on Field Inspection and Measurement

CF₁ : Production(Power Generation) Loss

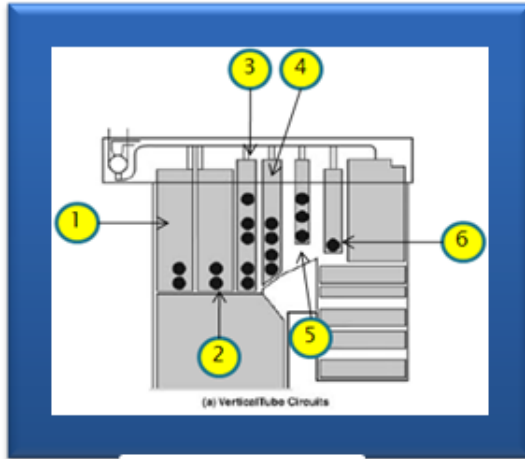
CF₂ : Direct Maintenance Cost(Equipment, Labor, Etc)

CF₃ : Indirect Maintenance Cost(Operation & Management)

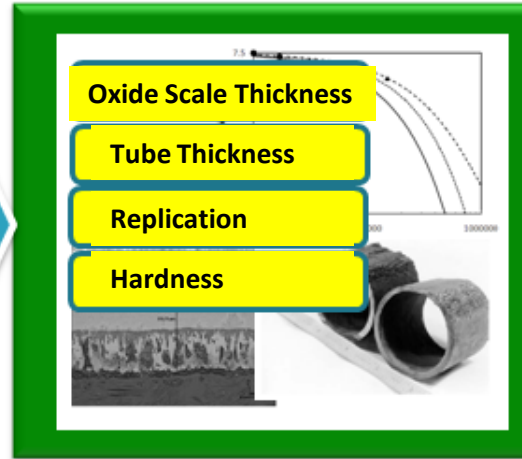


KEPRI RBM Process for Power Boiler

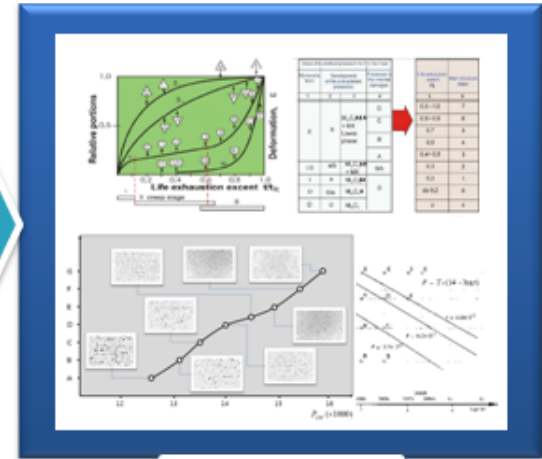
Definition of Assessment Location



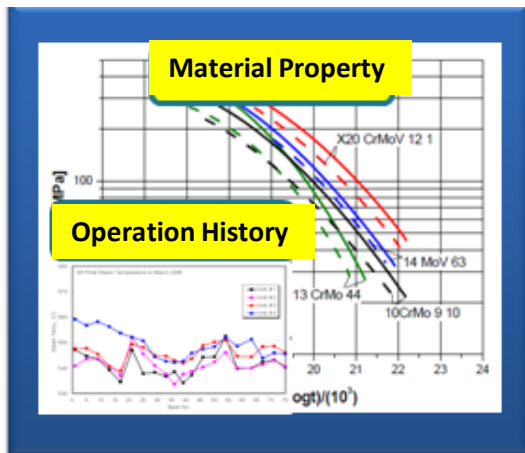
Field Inspection



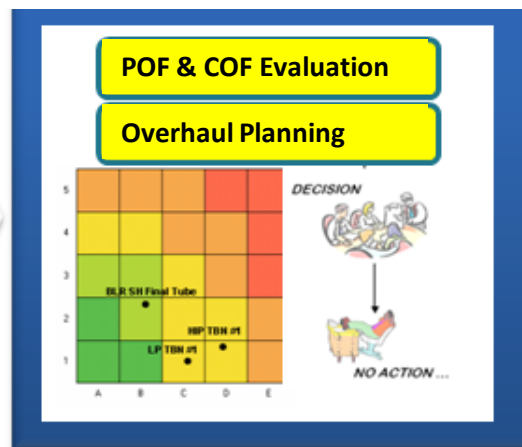
Inspection Result Assessment



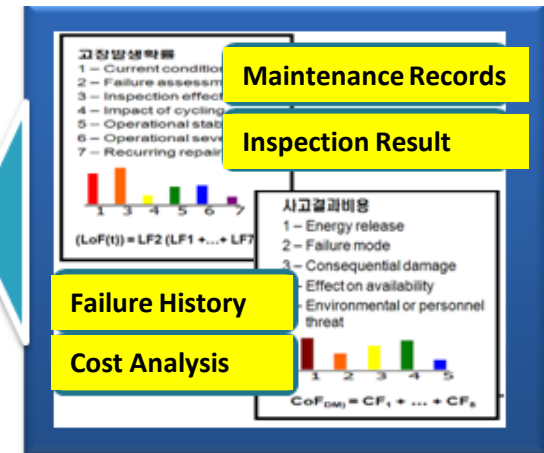
Generic POF Analysis



Risk Assessment & Maintenance Planning

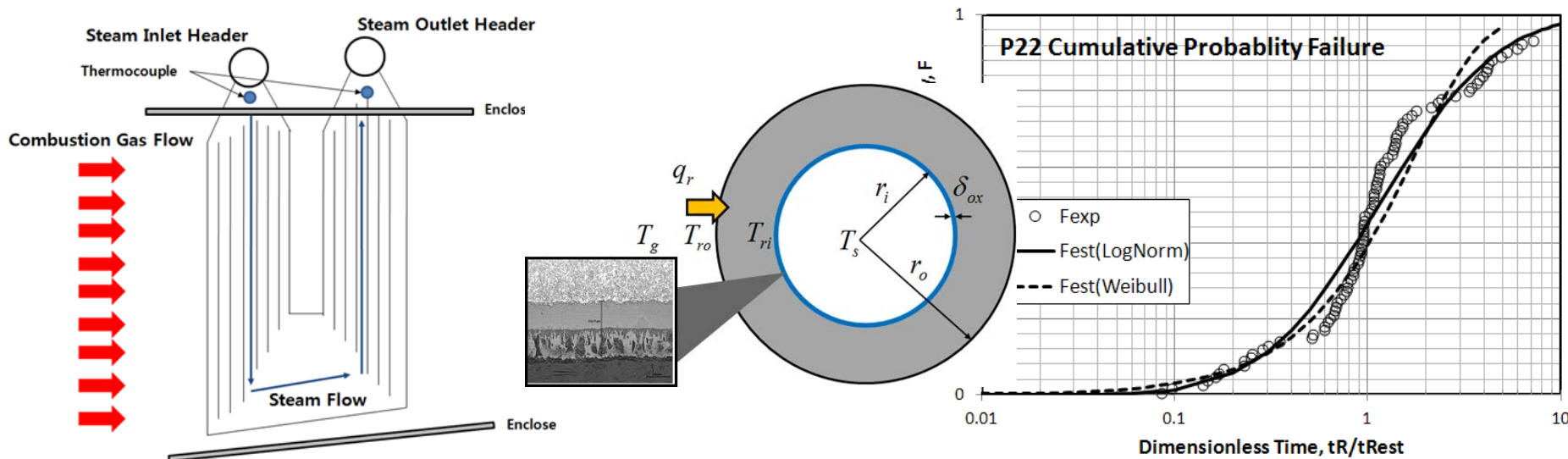


POF Compensation & COF Evaluation



● Obstacles of RBM application for Boiler

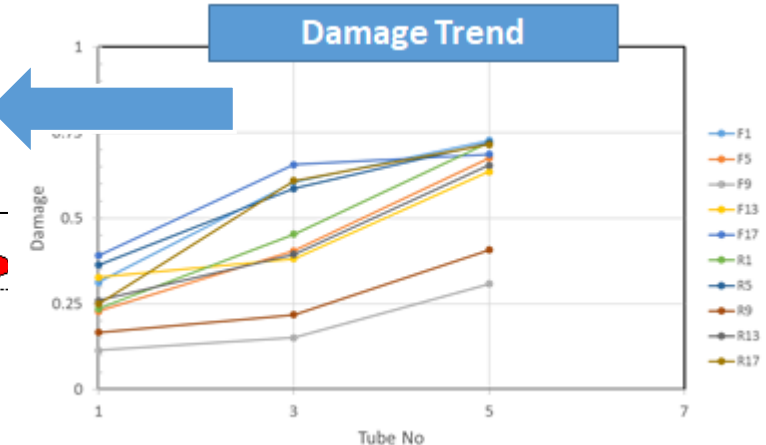
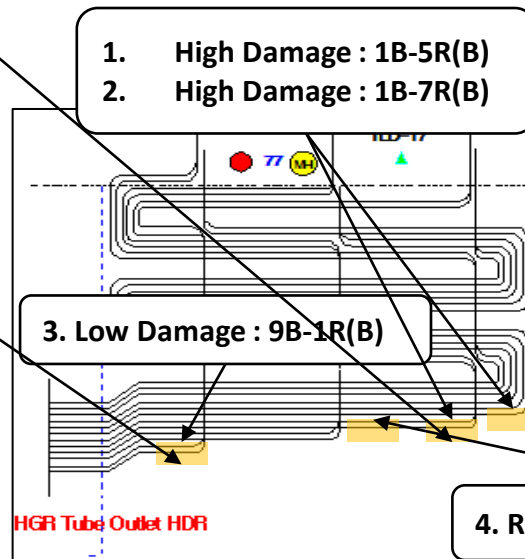
- Too many assessment points(more than 400 points) are accompanied by large budget and long downtime for field inspection and Measurement
- Complicated and Specialized POF assessment
- ❖ To assess POF for tube creep, it is required to carry out heat transfer, stress, probabilistic damage analysis and metallurgical analysis
- Few RBM engineers who have specialty in Risk Assessment and Maintenance Planning of Boiler(Only 2 GenCos have a RBM engineer)



- Long term operation data is a key of easy RBM application
 - Most of the power plant have the on-line monitoring system which accumulates long term operation data more than 1TB/Yr
 - Such big data makes long term damage assessment possible, which performs key rolls in RBM application replacing with expert's job
- ❖ Generic Creep POF Assessment and Field Inspection Planning

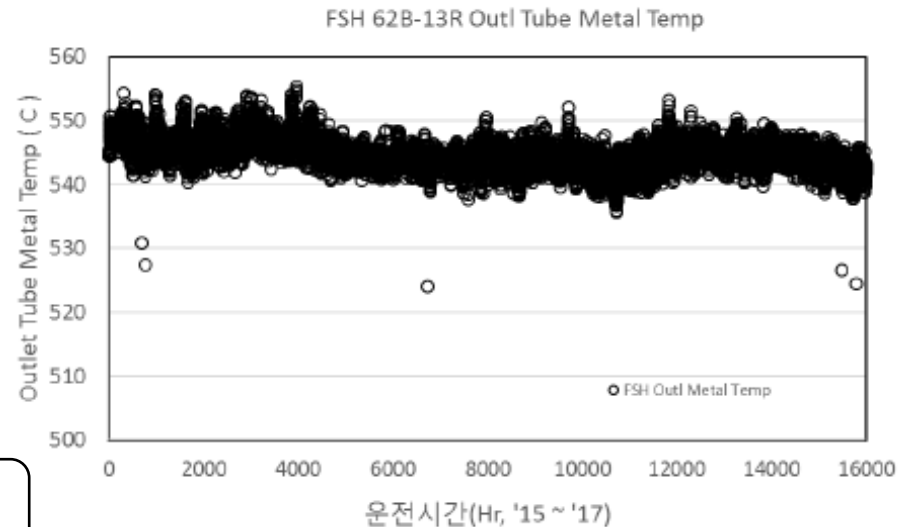
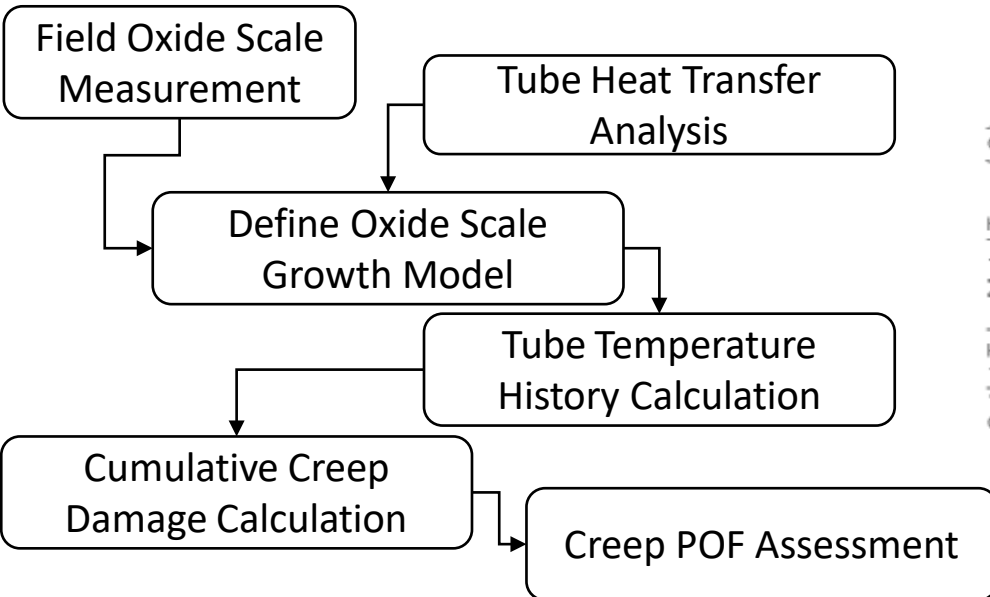
Cumulative Tube Damage

Bundle	1R	3R	5R
F1	0.313	0.606	0.727
F5	0.228	0.404	0.676
F9	0.114	0.150	0.308
F13	0.327	0.381	0.636
F17	0.391	0.656	0.687
R1	0.235	0.453	0.721
R5	0.363	0.586	0.720
R9	0.167	0.218	0.407
R13	0.260	0.394	0.655
R17	0.249	0.610	0.715

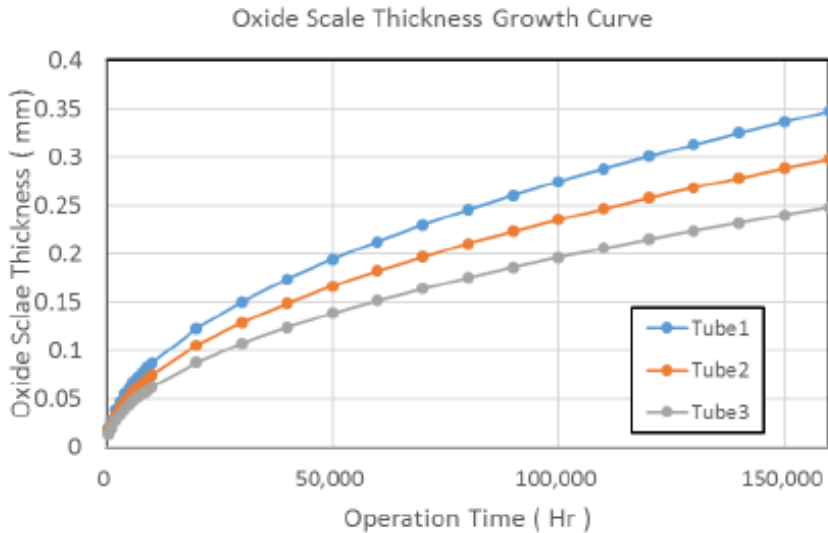
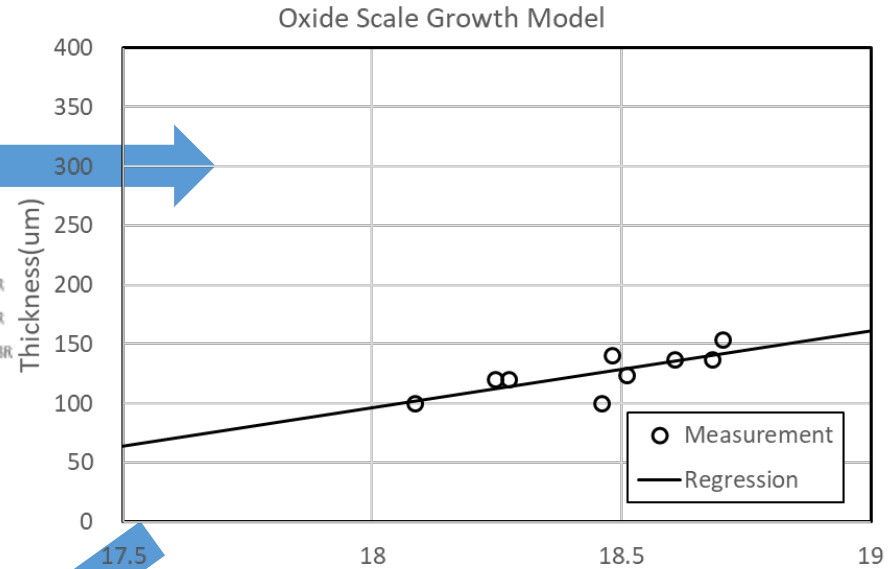
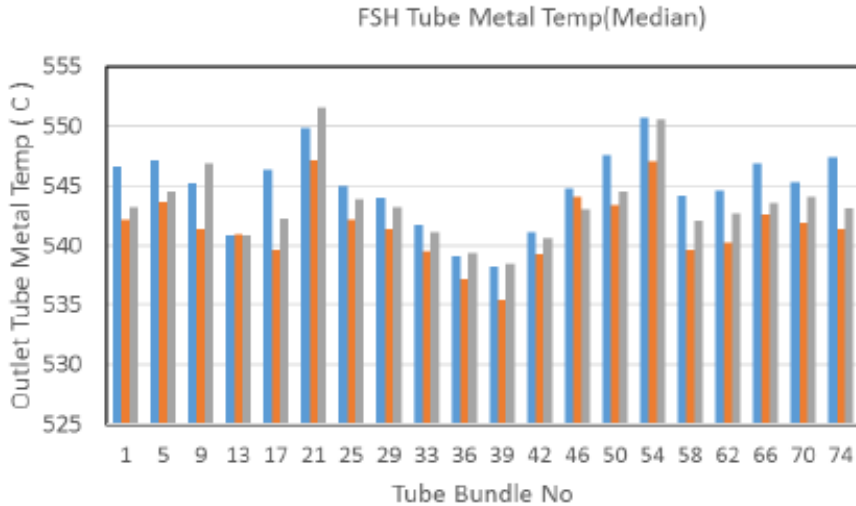


● Operation Data based Tube POF Creep Assessment

- Most of the boiler failures occur in tube bundles and one of the hard detection damage mechanisms is creep
- When creep damage evaluation, oxide scale thickness should be dealt with input parameter of temperature calculation but damage evaluation
- ❖ In case of constant steam temperature operation condition, oxide scale thickness gives reliable damage prediction



3-3 Operation Data Based Approach



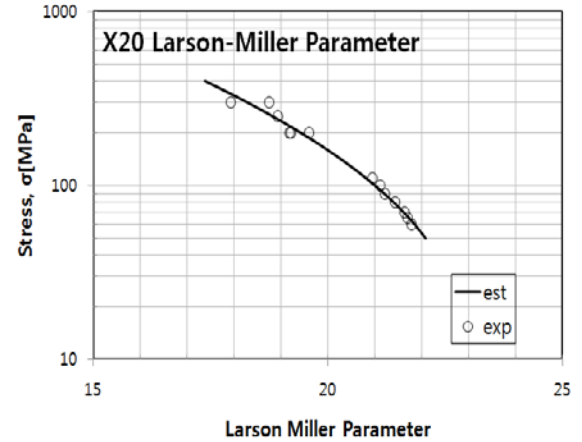
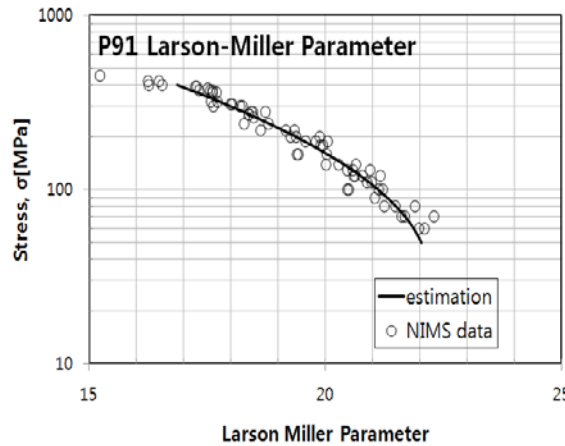
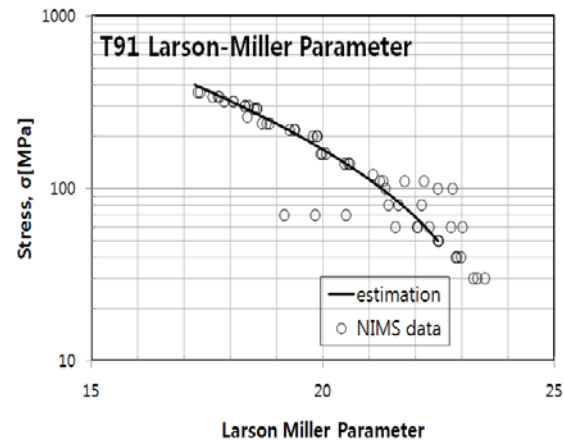
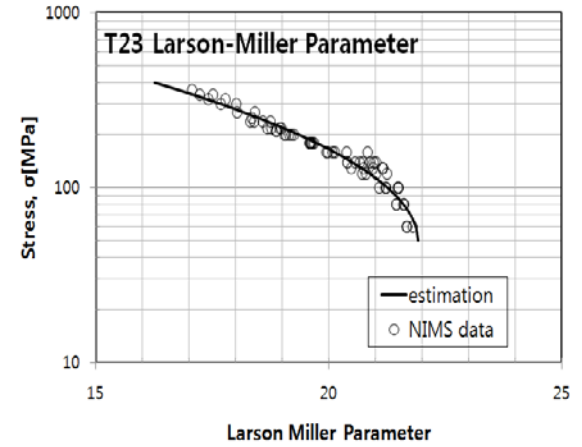
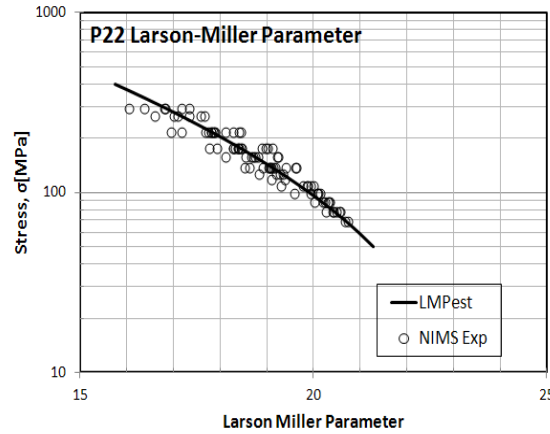
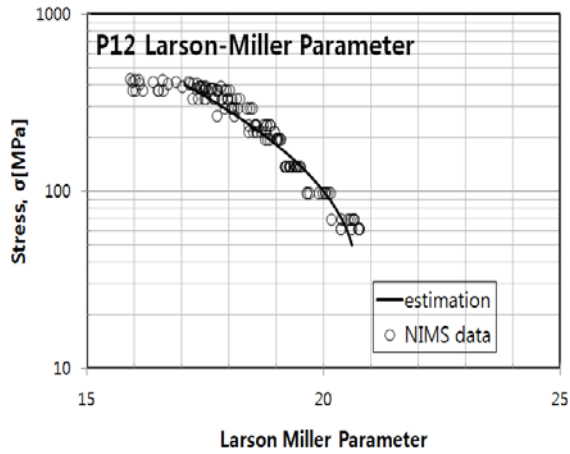
Cumulative Tube Damage

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3-4 Operation Data Based Approach

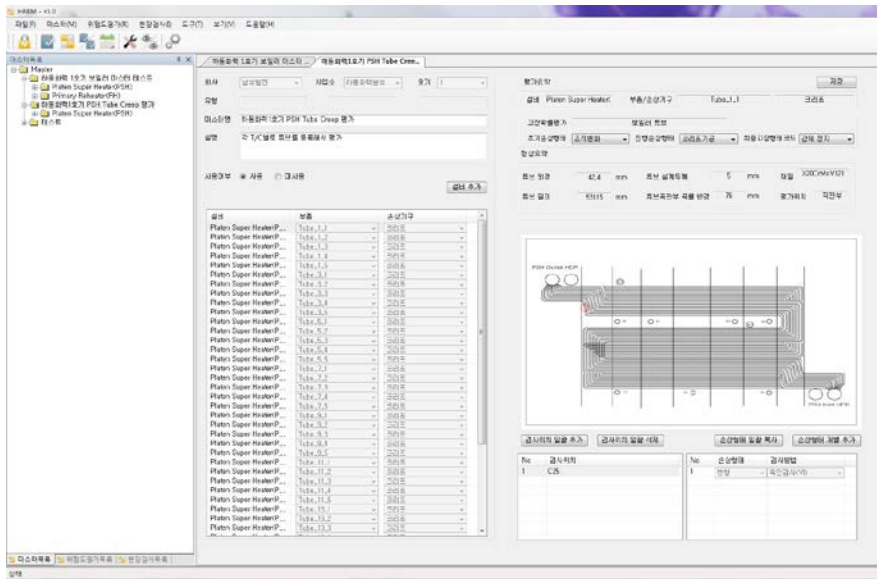


Creep Curves of Boiler Tube Materials



● System Configuration & Data Model

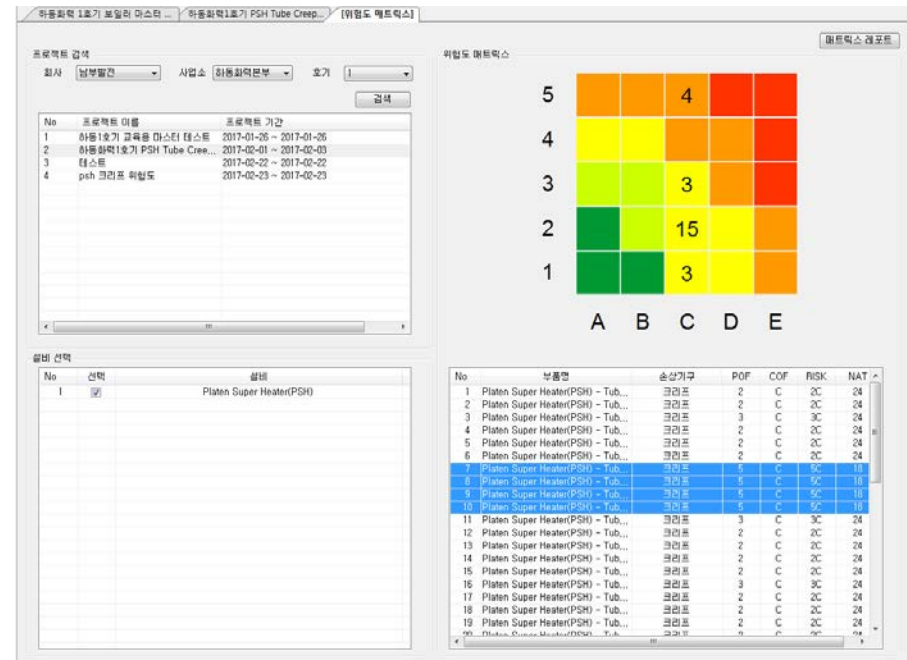
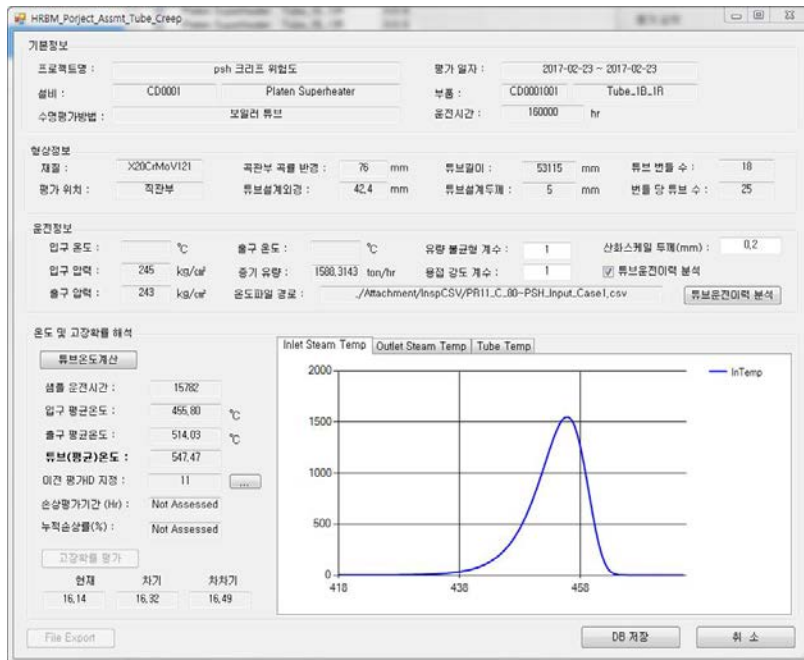
- Data interface with Real-Time DB automatically or manually
- Using parallel calculation module for the long term creep damage evaluation based on real operation data(8,760events/Yr, Tube)
- Each Assessment point has design (geometry, material properties, drawings) and inspection information(inspection location, method)
- According to long term damage assessment, inspection is carried out for some points identified as highly damaged





● Tube Risk Assessment and Maintenance Planning

- The risk of the assessed tubes are showed on risk matrix, which let user do proper action for high risk tubes
- The POF of tubes is evaluated for each boiler overhaul interval(every 2years) to find optimized overhaul time
- What-If function provides for risk prediction after performing some actions such as replacement, repair, or changing inspection method



- RBM is one of the best practices of power plant contributing to maintenance optimization which prevents from critical failures and over maintenance.
- But there are some obstacles. That is, risk assessment is quite complicated and there are so many assessment points in a boiler, which requires many specialized engineers for RBM application
- Operation big data based damage assessment is easily implemented system and performs key rolls such as the POF assessment of the long term creep damage and making optimized inspection plan to focus on highly damaged points
- KEPRI developed tube RBM system based on operation big data, which revealed high performance long term damage calculation and classified damage level of inspection points for optimization of the inspection planning