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PROPOSAL OF PROCEDURE FOR REMNANT LIFE-TIME EVALUATION OF BOILER COMPONENTS IN THERMAL POWER PLANTS

Damir Hodžić
Faculty of Mechanical Engineering
Vilsonovo šetalište 9, Sarajevo
Bosnia and Herzegovina

Ismar Hajro
Faculty of Mechanical Engineering
Vilsonovo šetalište 9, 71000 Sarajevo
Bosnia and Herzegovina

ABSTRACT
Evaluation of remnant life-time of thermal power plant boiler components gives us possibility for optimisation of plant maintenance and revitalization. Life time in service of particular components is highly dependant on material that is used for it. There are different methods for calculation of material exhaustion degree caused by creep and fatigue, same as methods for destructive and non-destructive material testing with aim to evaluate remnant life-time. Most of these methods are described by relevant technical standards and norms. At the same time, in relevant technical literature and norms there is no uniquely adopted form for making remnant life time evaluation procedure, i.e. when and how particular methods should be used in practice. Implementation of such procedure is usually decision of thermal power plant owners depending on plant characteristics and service conditions. In this paper is presented proposal of procedure for remnant life-time evaluation of boiler components exposed to creep. This proposal of procedure includes evaluation methods described in technical norms and it is presented in form of algorithm.
Keywords: Remnant life, creep, procedure

1. INTRODUCTION
Boilers and other types of steam power plant equipment are subjected to a wide variety of failures involving one or more of several mechanisms. Most prominent among these mechanisms are corrosion, including pitting and erosion; mechanical-environmental processes, including stress-corrosion cracking and hydrogen damage; fracture, including fatigue fracture, thermal fatigue fracture, and stress rupture; and distortion, especially distortion involving thermal-expansion effects of creep. Most steam-generator failures occur in pressurized components, that is, the tubing, piping, and pressure vessels that constitute the steam-generating portion of system, [1].
Thermal power plants around the world are aging and need to be assessed to ensure continued safe operation. Replacement is frequently not an option because of high capital costs, and the much lower cost of continuing the operation of the older plant, [2]. However, reliability and safety are issues that have become much more important in recent years, so the assessment of damage and of the risk associated with failure have become increasingly important.

There are different methods for calculation of material exhaustion degree caused by creep and fatigue, same as methods for destructive and non-destructive material testing with aim to evaluate remnant life-time. Most of these methods are described by relevant technical standards and norms. At the same time, in relevant technical literature and norms there is no uniquely adopted form for making remnant life time evaluation procedure, i.e. when and how particular methods should be used in practice. Implementation of such procedure is usually decision of thermal power plant owners depending on plant characteristics and service conditions.

2. BOILER AND PRESSURE VESSEL CODES

Boiler and pressure vessel codes and standards provide methods and rules that can be used to evaluate remaining life of boiler components. Annex I of the Pressure Equipment Directive 97/23/EC (PED) requires that the design must take appropriate account of all foreseeable degradation mechanism such as fatigue, [3]. For other degradation mechanism, such as creep interaction with fatigue there are very few methods available.

2.1. Fatigue evaluation

Many boiler and pressure vessel codes and standards provide provisions to exempt fatigue evaluations, [4]. Exemptions are based on the components meeting the code design rules and details. Fatigue exemption rules are also a function of construction details. If fatigue evaluations cannot be exempted, the next step would be to use simplified fatigue evaluation methods. Once again these methods are based on the components meeting the code design rules and details.

Table 1. Codes and standards for fatigue evaluation methods, [5]

1.	ASME Section VIII Division 2, (ASME VIII-2)
2.	British Standard, PD 5500
3.	German Technical Rules for Steam Boilers, TRD
4.	European Standards for Water-Tube Boilers, EN 12952
5.	European Standard for Unfired Pressure Vessels, EN 13345

2.2. Creep and fatigue interaction methods

The TRD 508 and EN 12952-4 method for creep life determination is simplified but an effective method for creep consideration and for creep-fatigue interaction, [4]. These rules are for in-service monitoring of creep and creep-fatigue life of water tube boilers, but are used for creep and creep-fatigue evaluations.

Table 2. Codes and standards for creep and fatigue interaction evaluation methods, [5]

1.	German Technical Rules for Steam Boilers, TRD
2.	European Standards for Water-Tube Boilers, EN 12952
3.	ASME Section III, Subsection NH

3. PROPOSAL OF PROCEDURE FOR REMNANT LIFE-TIME EVALUATION

Piping and tubing in steamlines, heaters, boilers, and superheaters are subjected to elevated temperatures that can cause degradation, deformation or cracking. Thus, it is possible for the life expectancy to be reduced. Therefore, it is often necessary that piping and tube life assessment be conducted. In history-based methods, plant records and the time-temperature history of the component is reviewed. The life-fraction procedure usually is inaccurate because of errors in assumed history, in material properties, and in the life-fraction rule itself, [6]. Direct postservice evaluation represents an improvement over history-based methods, because no assumptions regarding material properties and past history are made. Unfortunately, direct examinations are expensive and time consuming. The best strategy is to combine the two approaches. A history-based method is used to determine if more detailed evaluations are justified and to identify the critical locations and this is followed by judicious postservice evaluation. Considering this, in this paper is presented proposal of procedure for remnant life-time evaluation of boiler components exposed to creep. This proposal of procedure includes evaluation methods described in technical norms and it is presented in form of algorithm at Figure 1.

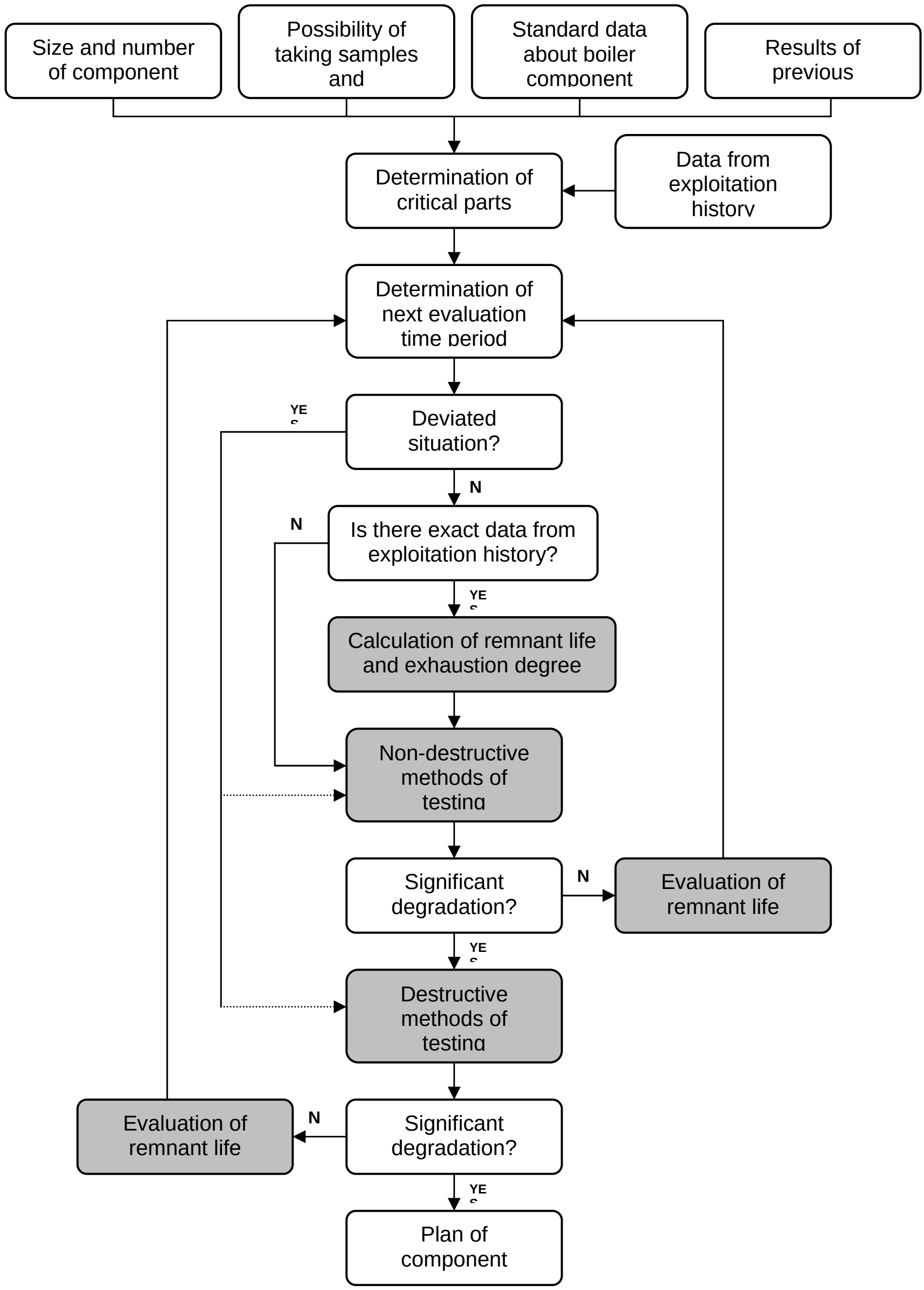

Figure 1. Proposal of procedure for remnant life-time evaluation, [7]

4. FINAL REMARKS

Most power-plant operators maintain relatively complete records. Records of operating conditions and preventive maintenance for a component that has failed, and for the system as a whole, are relatively good sources of background information. In the absence of documented plant history data the validity of accuracy of remnant life assessment must suffer. Plant data management plays a crucial role and involves the collection, storage and manipulation of data associated with operating and maintenance histories, inspection and monitoring, failure analysis, life assessment, resources, schedules, etc. Since damage is dependent upon factors specific to a given generating unit (design, operating modes) it is necessary to treat each unit and its components individually in order to obtain realistic life assessments. This process is made more manageable by a staged approach in which simple assessments are conducted until the need for more complicated procedures is indicated. For the initial evaluation, only design or overall service parameters need to be examined to ascertain if, on the basis of the most conservative considerations, the component has residual life greater than the anticipated extended-service period.

The two activities recommended prior the initial assessments are to assemble elementary service factors and to answer the following key questions for the component that is to be analyzed, [8]:

- Has operation exceeded the design parameters (temperature and/or pressure) for significant times or extents?
- Will the service during the extended life exceed the pertinent design parameters?
- Have the design philosophy or materials choices been shown to be non-conservative since the unit went into operation?
- Has the failure history been significant?
- Are steam-temperature records inadequate or not available for assessment of those components that function at elevated temperature?

A "yes" answer to any of these key questions suggests that the evaluation procedure should be entered with a combination of calculation and inspection, together. In any case, if the component fails the minimum-life criterion in initial evaluation (calculation), inspection method of assessment should be performed. Information for this evaluation is obtained from operating records and from measurements taken in an initial inspection. Calculation and inspection methods are intended to identify problem components that could reach end of life before the extended service is complete. These are the components that require more detailed analysis for confident life prediction.

If the remaining life determined in calculation and inspection is too short or has an unacceptable level or uncertainty in relation to operational targets, then the more precise evaluation should be implemented. In that case, information requirements include component surveillance and sampling followed by post-exposure tests.

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