729. Diagnostic method of measuring hanger rods tension forces in the suspension of the power boilers combustion chamber

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Abstract. Combustion chambers of contemporary power boilers are suspended on hanger roads because of thermal strains. The hangers are placed along the side edges of a rectangular chamber. A tensile force of hanger road has a significant influence on stress state of combustion chambers. A method of tensile force measurements and determine the correct of are tensile force is therefore important. There are presented a novel method of a tensile force's measurements and methodology for determining the distribution of tensile forces.

Keywords: combustion chambers, natural frequencies measurements, FEM.

Introduction

The combustion chamber of the power boilers are suspended along their upper edges (Fig. 1, 2). The hanger rods tensile forces have a significant impact on stress state of combustion chambers walls and movement of entire chamber in an unidentified state during the start-up and stopping of power unit [3, 5]. In addition, the combustion chamber has bumpers installed at certain levels, restraining horizontal movements of the chamber. Incorrect distribution of the tension members forces can cause the contact with these bumpers, that is cause of the distortion or damage of the combustion chamber. During the inspection it was found that some of tension members are not carrying the loads. They are free of local, as shown in figure 3. In addition, it was found that the combustion chamber is supported on the bumpers. It might be a negative effect because of additional stresses on walls.

Fig. 1. View of combustion chamber's tension members

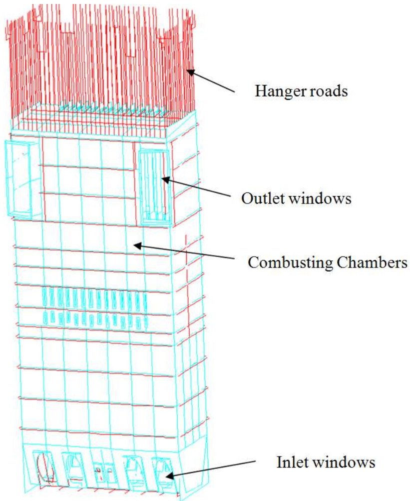

Fig. 2. View of combustion chamber with hanger roads

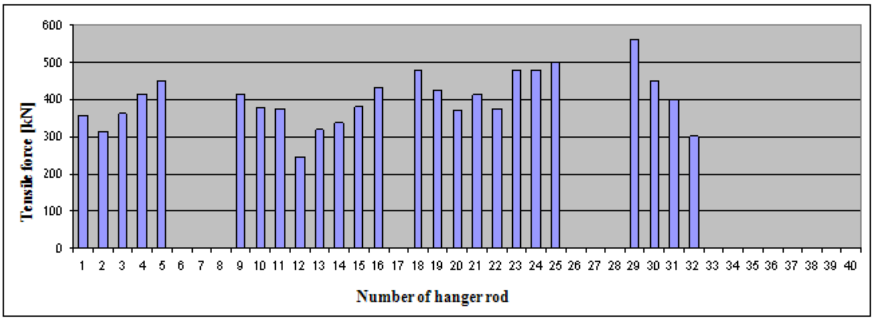

Fig. 3. The distribution of forces in the suspension of some tension members of combustion chamber

Therefore, there was a need to develop an effective diagnostic method of measuring the tensile forces of tension members of the combustion chamber suspension. The second important aspect was to determine the correct values of various tension forces of tension members. The combustion chamber is not a homogeneous structure, there are some different channels connected, as well as the windows in the walls of the inlet and outlet. Therefore, some specific criteria have to be adopted to determine the tensile forces. One of the criterions is the adoption of such the balance of power, which provides a constant level of effort in the combustion in both the cold and hot chamber [7].

FEM simulation of combustion chamber operations

The FEM model of combustion chamber with hanger roads was created in order to investigate influence of hanger roads strains on stress state of combustion chamber. Shell model of entire combustion chamber was used there. Material of combustion chamber walls was adopted as orthotropic [4, 6]. Combustion chambers walls are constructed of vertical pipes connected by flats. Complex structure of the walls was modeled by shell elements with constant thickness. The walls have different properties in a horizontal and vertical direction, so they are orthotropic models [2]. It is possible to create shell models of wall full structure, for water-tube boilers [1]. The replacement models are used in case of large power boilers with big heating surfaces.

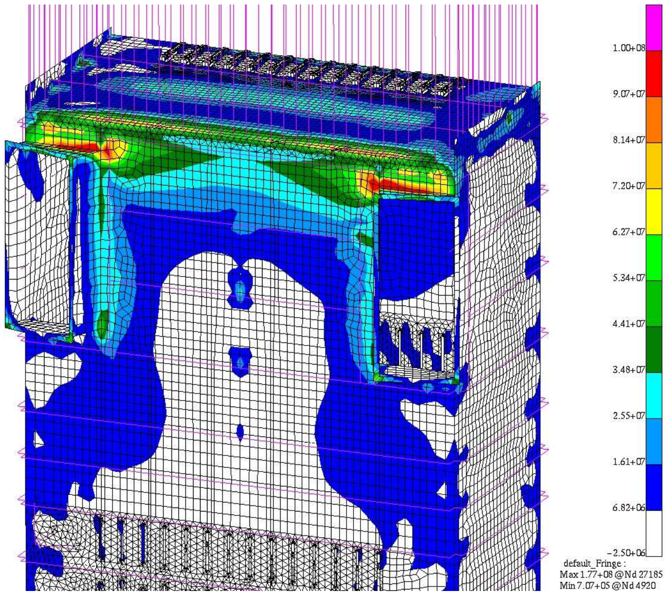

Fig. 4. Distribution of stresses in the top part of combustion chamber from side of inlet channels to cyclone

Calculations of combustion chamber with the hangers roads were made for heat and cold states. The stresses distributions were analyzed in top part of the combustion chamber for each of the state (Fig. 4). It was obtained the optimum stresses distribution by the criterion of constant displacements of combustion chamber upper edge. Fig. 5 presents an optimum stress distribution of tensile forces in the hanger roads for the cold state. We will be able to perform a procedure of hanger roads stretching. If we use these graph. The simulation is showing us how important is correct hanger roads stretching. We had to assume that hanger roads were fitted according to the criterion of nominal length with the tolerance ±1mm. Dispersion of length in the small band of the tolerance, causes changes of tensile force in neighboring tension members for the length of tension member about 12m. It might be the reason of huge local stresses in top edges of combustion chamber.

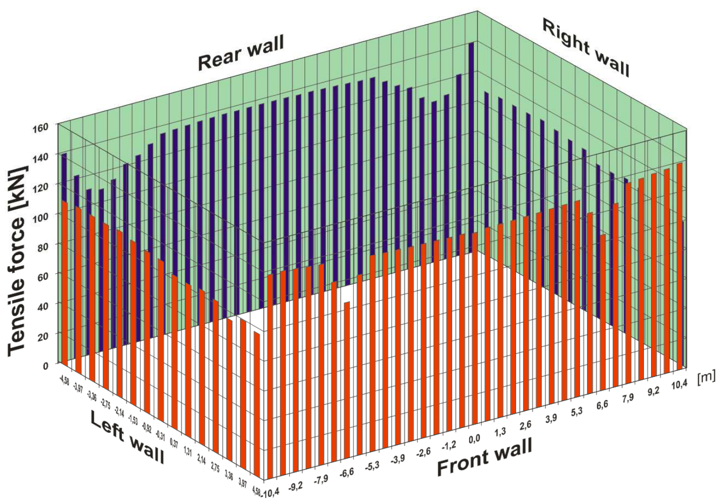

Fig. 5. Distribution of tensile forces for cold state

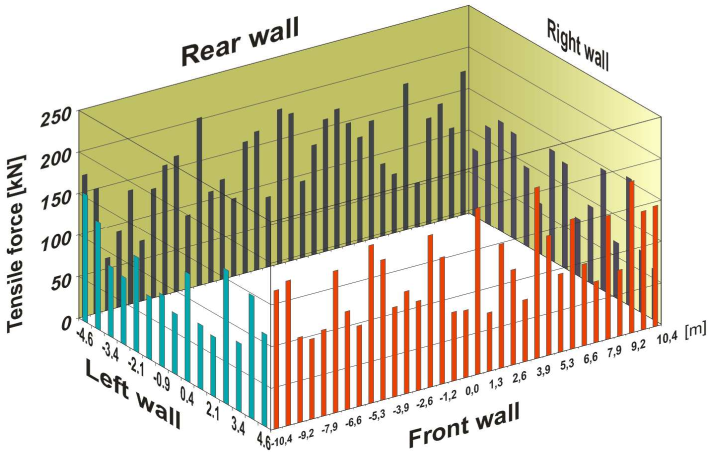

Fig. 6. Distribution of tension member tensile forces during the installation of tension members with nominal length and her tolerance ± 1mm , without adjustment of stretching of tension member

Method of tension members tensile forces measurements

In addition, in this project an innovative method for measuring the tensile forces on the object was put forward. It has been developed own proprietary method of tensile forces measurements of tension members. The phenomenon of the oscillation frequency changes was used here, depending on the hangers rods tensile force. Consequently, a series of tension force measurements by various methods such as measurement of strain using strain. In the first method, the strains were measured by electric resistance strain gauge, glued to the tension members. The second method was the measurement of torque for tightening the bolts in the system with simultaneous measurement of tension member frequency. Tension members are not a homogeneous structure with constant distribution of weight. Each of tension member has a double nutted bolt. Some tension members are connected to other using a rudder bar in order to bypass an girder of grate. Fem models were therefore built to identify correlation between frequency and tensile force. It was done for each type of string and then calculations were proceeded. The method has been prepared to identify tensile forces of tension members using measurements of their frequencies. Figure 7 presents the dependence of the oscillation frequency as a function of strings tension for three different lengths of hanger rods that have occurred in the examined boiler. The figure presents how to read tensile force for the frequency of tension member vibration.

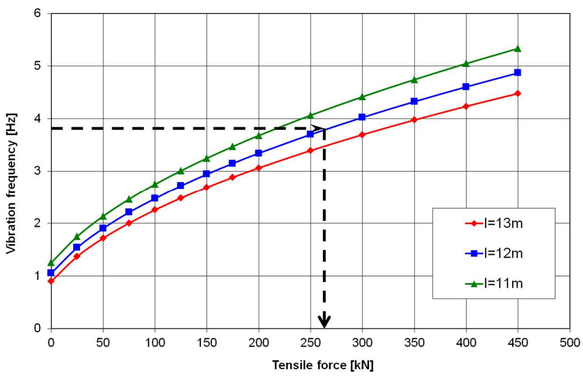

Fig. 7. Hangers rods vibration frequencies as a function of tension for the three lengths of hanger rod

The measurements of tensile forces in tension members

Tensile forces in rods were determined by the measurements of natural frequencies. There were therefore used accelerations sensors in connected to recorder. The vibration were excited by a hummer impact thereupon was received course of vibrations presented in Fig. 8. The Fig. 9 is presented a spectrum of vibrations after Fourier analysis. We could read a basic frequency of stretched tension member vibration on these graphs. Then we have read a real tensile force of tension member for its fixed length from the graph (Fig. 7). Measurements of tension member tensile forces verifies methodology using electric resistance wire strain gauge. There was used a hole method to identify inside stresses (Fig. 10). The method involves the measurements of relaxation strains. They were caused by local lightening of elements around a spot drilling hole. The strains measurements are indicated to stress state in the elements before spot drilling a hole. A system of two strain gauges parallel to direction of force and two compensation sensors in the same temperature as the active sensors were used in the measurements due to well - know direction of stresses. System of four foil strain gauges connected to Wheastone's bridge enables the measurements of strains around spot drilling hole. The measurements were made with twice larger than a single active sensor. Values of stresses (result of tension member static load by mass of power boiler) and value of tensile forces were estimated, assuming Young modulus of hanger rod material E = 205 000 MPa and constant of strain gauges k = 2.15.

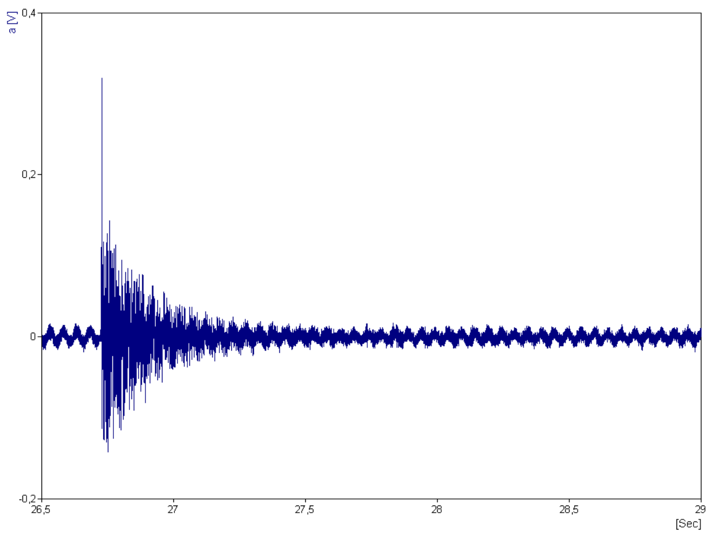

Fig. 8. Course of an acceleration after excitation of tension member vibration

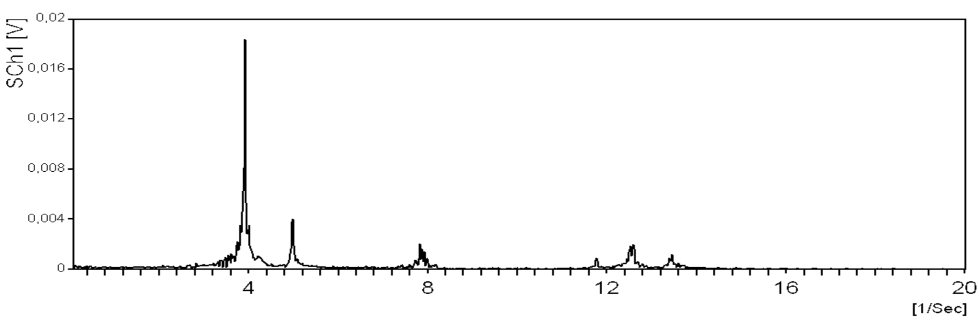

Fig. 9. Amplitude spectrum of tension members vibration

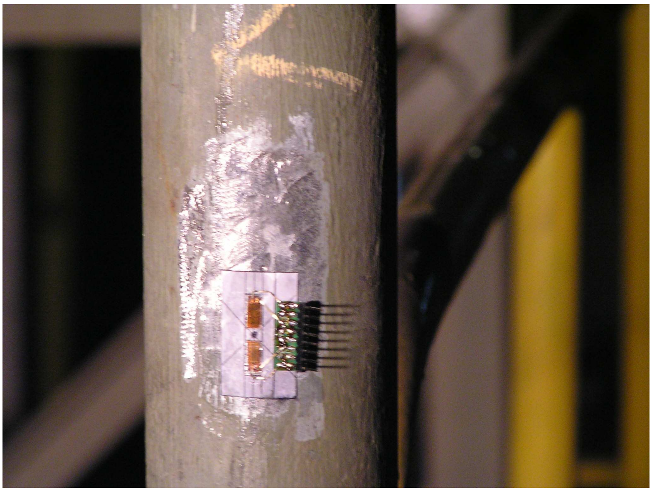

Fig. 10. The measurement of tensile force in tension member using hole drilling method

Conclusions

A method of tensile forces measurements for power boiler tension members was presented. In this method numerical and experimental investigations were combined. This method allows to determine optimal distribution of tensile forces. A dependency of tension member vibration frequency on a tensile force was used. It was defined criterion of the correct tensile force. It guarantees a uniform stress state of combustion chamber upper areas. The method determined an optimum distribution of hanger rod tensile force. A diagnostic methodology of the tensile force measurement was used for new generation power boilers in Power Plant Turów. The method contributed to increase of the time of combustion chamber walls trouble - free work.

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