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DETERMINATION OF REASONS OF CRACKING OF OUTSIDE SHELL OF CONVERTER HOOD BY MEANS OF EXPERIMENTAL ANALYSIS METHODS OF STRENGTH.

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A tensometrical measurement of relative deformation in four points of quick changes of converter hood shape was proposed. In case, that some of relative deformations exceed the value of relative deformation at lower yield point, at determination of principal normal stresses it is necessary to consider the real working diagram of material. The construction change resides in preventing the movement of higher levels of stresses on the hood shell. As the most convenient we have chosen the elimination of stress concentrates - boundary effects where the thickness change of material and without any sharp transitions corner welds.

After converter change there were wade construction changes in the system of hood cooling. But after then arose various cracks at several points regularly almost every two days. Consequence of these cracks was the outflowing water from the cooling system. Such situation was extremly dangerous.

So it was necessary to determine the reasons of such intensive cracks and to perform measures for removing of cracking process.

Also it was necessary to suggest the proper solutions from the technical point of view.

After detailed analysis we can see three groups of reasons of cracking of converter shell:

1) Insufficient compensation of cooling pipeline. So it is necessary to use new compensators and by such way to eliminate the thermal expansivity.

2) For the original pressure conditions the construction was designed correctly, but for the changed conditions is insufficient.

3) Processes of degradation in the material are so intensive and expressive, so it is necessary to change all the body of converter hood.

During the experiments arose another cracks and deformations at the internal shell of hood.

In the following part of this article an experimental identification of reasons of cracking of the hood shell are discussed and a proposal of its prevention is presented.

A tensometrical measurement of relative deformation in four points of quick changes of converter hood shape was proposed (see fig. 1).

For analysis of the influences which can evoke increased stress at points where frequent damages occur a following measurement sequence has been chosen:

1. The sensors have been applied at empty and cooled down hood and at disconnected flange of exhaust hydraulic line.
2. After connecting the active and compensating sensors to half-bridge and balancing the tensometric canals following measurements were proposed
   - measurement of deformation changes at assembled flange joint and its tightening
   - measurement of deformation time changes at filling of the system with water of temperature 17 C
   - measurement of deformation time changes at starting up the first and second pump while with time record we have followed a possibility to read the static and dynamic components on switched-on pump.
   - measurement of relative deformation time changes at filled system, switched-on pump and at increasing temperature caused by starting up the converter to service.

To determine the state of stress of outside shell of the hood tensometric sensors HBM 10/120LG11 have been applied with ohmic resistance 120.+ 0.35% and factor k 2.05 + 0.5%. Sensors have been placed to tensometric rosettes and for thermical compensation the own compensating qualities of sensors have not been utilized. We have used individual compensation sensors applied on non loaded elements placed at close proximity of active sensors.

For application of the sensors tensometric adhesives M BOND 300 of firm VISHAY have been used and the sensors have been protected with protection gel SG 250 of firm HBM.

Points of application of tensometric sensors on outside shell of the hood are in fig. 1.

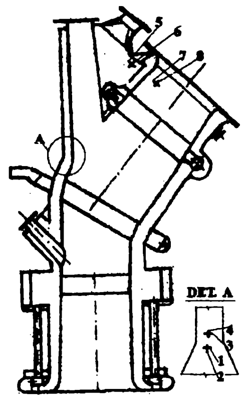

fig.1

Because in each measured point there is biaxial plane stress and the measured values of relative deformation represent principal relative deformations in a point, provided that Hook's law is enforced the values of principal normal stresses whose changes are identical to the lays of principal relative deformations are determined from generalized Hook's law.

In case, that some of relative deformations exceed the value of relative deformation at lower yield point, at determination of principal normal stresses it is necessary to consider the real working diagram of material, resp. the dependance of intensity of state of stress on intensity of relative deformation [1].

According to mechanical tests mechanical quantities of used material from selected samples of the hood shell have been determined: R_e=348 MPa, R_m=480 MPa, A_5=26,9%, while the structure of the hood corresponds to the normalisation state. If we consider the sort of used material it means 11 416.1 and modules of elasticity at 20°C E=2.05.10^5 MPa Poison's number μ= 0.3 then the relative deformation at lower yield point ε_k = 348/2.06.10^5= 1,69.10^{-3} and relations for principal normal stresses in circumferencial and meridian lay will be:

$$\sigma_o=2,264.(\varepsilon_o+0,3.\varepsilon_m),$$

$$\sigma_m=2,264.(\varepsilon_m+0,3.\varepsilon_o),$$

while for ε_o and ε_m we substitute values of relative deformation. In case that the relative deformation exceeds the value of 1.69.10^{-3} in any lay, the introduced relations for determination of state of stress can not be used and the state of stress in given point must be determined according to plasticity theory.

After connecting the exhaust hydraulic line and tightening the screws of flange joint the maximum relative deformation at point 1 has been $0{,}002.10^{-3}$ (see fig.1)

Because increases of relative deformations and their lays at above mentioned procedures of hood loading at measuring points 3,4,5,6,7 and 8 according to fig.1 did not exceed the value of $\varepsilon_k = 1{,}69.10^{-3}$,at the following we introduce just the time responses of relative deformation increase for measuring points 7 and 8.

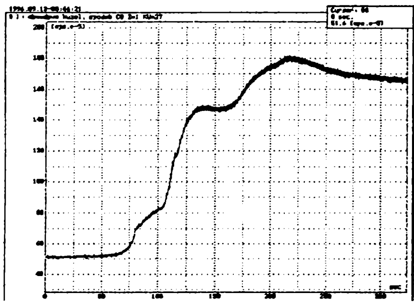

fig.2

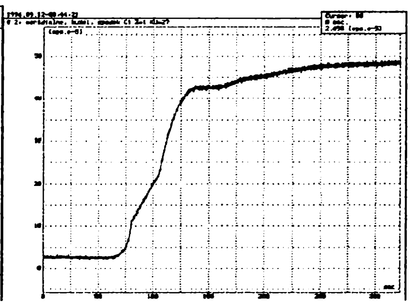

fig.3

Increases of relative deformations in points 1 and 2 from filling of the hood with water of temperature 17° C evoked by hydrostatic pressure are in fig.2 and in fig.3. The maximal value in circumferential lay reached a value of $1{,}8.10^{-3}$ which is higher than $\varepsilon_k = 1{,}69.10^{-3}$. At the given point elastic and plastic deformations have been reached.

In fig.4 and fig.5 there are time changes of relative deformations which consider the influence of statical and dynamical components of increase from the pump at points of measurements 1 and 2. From fig.4 the increase of relative deformation is $0{,}48.10^{-3}$ from the hydrostatic pressure and $0{,}55.10^{-3}$ from circumferential lay (measuring point 1).

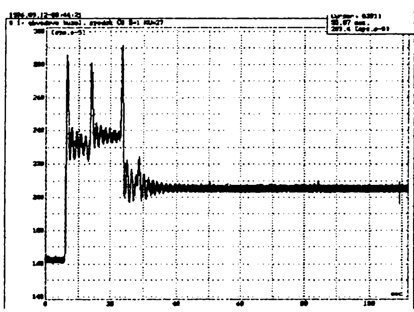

fig.4

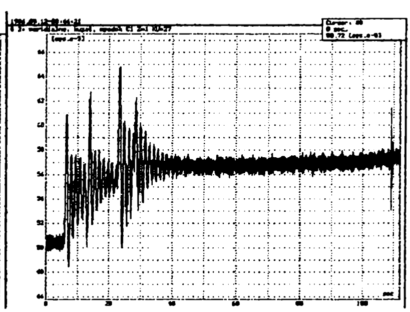

fig.5

During the service of the converter at reaching water temperature in the hood higher than 100°C the amplitudes of relative deformations have expressively increased and their qualities have been strongly changing in time. This fact is documented in measured point 1 in fig.6 and in measured point 2 in fig.7. For the measuring point 1 the maximum amplitude of increase is $1{,}1.10^{-3}$.

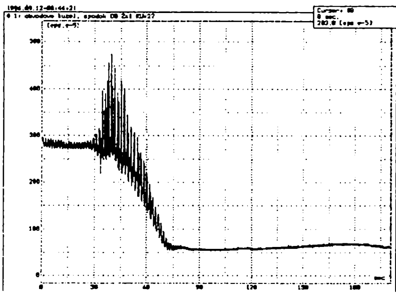

fig.6

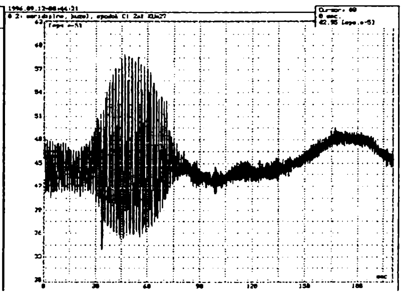

fig.7

According to detailed analysis of results with determination of influence of certain factors we can state the following conclusions:

- The values of relative deformation at points of measurements on outside shell of the hood have been so high that at points of measurements elastic-plastic deformations have been formed.
- So it has not been possible to determine the state of stress by principle of superposition and extended Hooks law.
- This fact evokes a need for registering time changes of relative deformations and not stresses.
- After the analysis of reasons we have come to a conclusion which was also proved by measurements (besides the others also of material thickness) that the original construction at the original hydrostatic pressure has been dimensioned rightly with relatively low degree of security to minimal lower yield point of the used material.
- Boundary effects - formation of boundary bending moment in meridian and circumferential lay as a result of quick transitions - evoked multiple increase of assumed diaphragme state of stress. At decreased thickness onto original thickness of the material at the point of measurement the stresses expressively increase.
- Analogously as stresses from hydraulic pressure the values of stresses from influence of pumps have increased (static and dynamic components).

- The service of the converter has also expressive share on the stress of the shell of hood, first of all the time changes of temperature gradient.
- The regular breakdown of the hood shell is influenced by the high values of average stresses from hydrostatic pressure of water and hydrostatic pressure of the pump and also by the dynamic component of the pump pressure but first of all by strong time changes of stresses probably as a result of creation of gas pores gradients of thermal changes and also degradation processes in the material of the hood shell.

The above mentioned facts have lead us to propose measures for decreasing at first place the stress values from hydrostatic pressure of water and pressure of the pump on the hood provided that this can not be changed and service conditions can not be
changed either. It was shown that using of materials with higher strength and bigger lower yield point is not sufficient. So a minimum interference to the construction of outside shell has been proposed. The construction change resides in preventing the movement of higher levels of stresses on the hood shell. As the most convenient we have chosen the elimination of stress concentrates - boundary effects where the thickness change of material has been proposed from original 10mm to 12mm at maximum width 300mm and without any sharp transitions corner welds.

After the performed changes the measurement has been repeated for selected regimes of filling, outlet and working of the pumps until time changes of relative deformations occure which fully unambiguously confirm the convinience of proposed adjustment also at present hydrostatic pressure and present pumps.

Literature

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