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CREEP ANALYSIS OF HOT REHEAT LIVE STEAM PIPING SYSTEM

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ABSTRACT

Site inspections of Hot Reheat Piping system have indentifed cracking at a number locations at butt welds between pipe runs and elbows.Furthermore,it was discovered that pipe runs are instaled with wall thickness of SCH60(ANSI/ASME code[3]),and elbows with wall thickness of SCH30 what is not according to design documentation.This wall thickness discrepancy creates a stress enhancement at the connections between elbows and piping runs.Also,because the elbows are more flexible,there could be a propensity for a creep strains to be concentrated in the elbows as the piping system stresses will be relaxed at these lower strength elbows rather than being distributed throughout the main piping runs.So,a detailed finite element analysis,including elastic and creep analysis, is performed to determine if the secondary stresses during relaxation,or if the stress enhacement of the wall thickness discrepancy,play significant roles in the cracking detected in the piping system.

Keywords: pipes, crack , creep, stresses

1. FOREWORD

During scheduled site inpection of Hot Reheat Live Steam system,lot of cracking have been indentifed at butt welds between pipe runs and elbows[1]. It was also discovered that pipe runs and elbows are not installed according design documentation[2].It could be that wall thickness discrepancy cause stress enhancement at connections between elbows and piping runs.Furthermore,
elbows are installed with lower wall thickness and therefore more flexible and weaker.There could be a propensity for creep strains to be concentrated in the elbows with further localization at weld heat affected zones.Also,piping system stresses will be relaxed at these lower strength elbows rather than in main piping runs.So, secondary stresses caused by relaxation in the piping system may act as primary stresses on the elbows [4,5].This phenomenon,of secondary stresses having characteristic of primary stresses resulting in strain localization in a creep weak zone,is commonly referred to as "elastic follow up".

2. STRESS ANALYSIS FOR NORMAL OPERATING CONDITIONS

Initial stress calculation is performed for normal operating conditions(weight+pressure+thermal expansion) of the system, considering the highest pipe design parameters (e.g. temperature & pressure) [7].Calculation model is created considering "as built" design documentation [2,6] for pipe routing,material and pipe supports.

Distribution of calculated Von Mises equivalent stresses(given in MPa) is shown on Figure 1.
Calculation results are mainly evaluated at elbows.Concentration of stresses at elbows is evident and maximum calculated stresses appear at elbows A & B , signed by arrows on Figure 2.
Stresses in main piping runs are predominantly due to pressure.

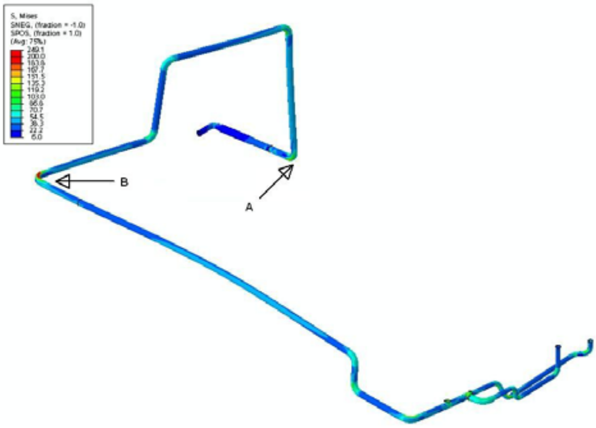

Figure 1. Distribution of Von Mises equivalent stresses for Normal Operating conditions

3. ANALYSIS OF SECONDARY STRESSES

Secondary stresses,expressed also as Von Mises equivalent stresses(MPa),are based on subtraction of stresses for Normal Operating(weight+pressure+thermal expansion) from Sustained loads(weight+ pressure).That means,present stresses due tu Thermal Expansion only .

Secondary stresses which distribution is presented on Figure 2,are identifed at two elbows.These elbows would,therefore,expected to be most vulnerable to creep strain accumulation if the secondary stresses act as primary stresses.

Some minor bending stresses appear at main straight piping run,but not in the vicinity of welds.So,it is unlikely to cause any problems with long-term serviceability.

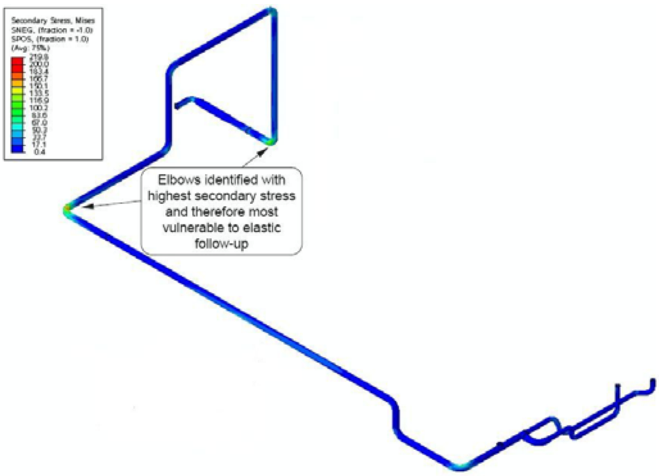

Figure 2. Distribution of Secondary stresses

4. CREEP ANALYSIS

Creep analysis was performed using previously calculated solution for Normal Operating conditions as a starting state [7].

Furthermore,previously used calculation model remains also for creep analysis.

Calculated results for creep stresses & creep strains are evaluated as follows .

4.1. Creep Analysis – Stress Distribution

Stresses have been calculated after 200 000 hours of creep and expressed as Von Mises equivalent stresses .Stresses have redistributed and relaxed from the elastic state .

Maximum values in main piping runs are approximately as expected hoop stresses due to internal pressure (~ 40 MPa).Stresses at SCH30 elbows are higher,but approximatelly equal to the hoop stresses due to internal pressure (~ 70 MPa).

As the stresses are close to those for internal pressure alone,it shows that generally , stresses in the piping system are not significant and do not appear to present any threat to long-term serviceability.

Stress history for elbows A & B with highest secondary stresses is presented on Figure 3 . Elbow B maintains at higher stresses than elbow A. Both elbows relax the stresses to the nominal hoop stress for SCH30 pipe,namely a hoop stress of approximately 70 MPa.

Because the stresses are able to redistribute in a relatively short time,secondary stresses do not act as primary stresses.That means,there is no significant "elastic follow-up".

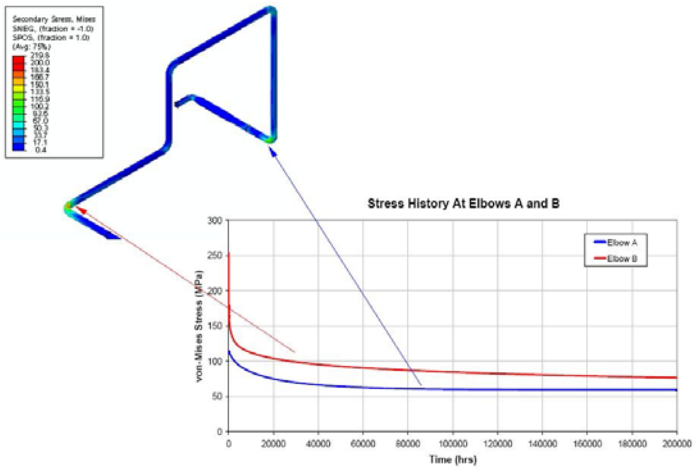

Figure 3. Stress history for elbows with highest secondary stresses

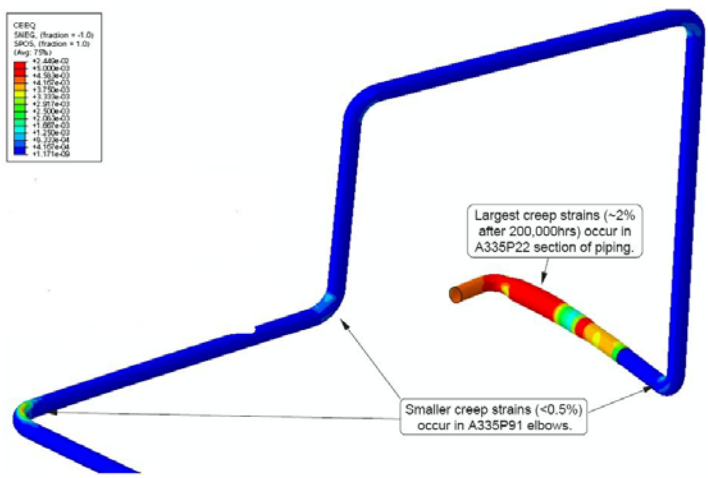

Figure 4. Accumulated creep strains after 200 000 hours of creep

4.2. Creep analysis – Creep Strains

Figure 4 shows contours of accumulated creep strain(absolute value) after 200 000 hours of creep. Creep strains of approximately 2% occur in the section made of A335P22 material[3].This section has lowest creep strength and operates at highest temperature because is closest to desuperheater.

Creep strains in elbows made of A335P91 material [3] are quite small (< 5%)indicating that relatively little creep strain is needed to relax the stresses.Hence there is no evidence of "elastic follow up".

5. CONCLUSION

Stress & creep analysis of concerned piping system is performed due to discrepancies between "as built" design and valid design documentation.Furthermore,second reason for analysis was existance of cracking which have been found out at the connections between piping runs and elbows.

Stress analysis identified two elbows with moderate secondary stresses that might have resulted in strain localization.That was a starting point for creep analysis.

A creep analysis did show some strain localization to the previously identified elbows,but the strains were not sufficiently large to cause serviceability concern.The locally high stresses were effectively reduced by creep deformation,indicating that the secondary stresses do not have a long-range effect and are unlikely to result in "elastic follow-up" at the elbows.
Therefore,it can be concluded that the presence of elbows with wall thickness SCH30 in the piping system with wall thickness SCH60 is not a particular concern.In the case of elbows with the same wall thickness as piping runs,stresses and overall deformations would be quite similar.

6. REFERENCES

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