Transactions, SMiRT-24
BEXCO, Busan, Korea - August 20-25, 2017
Division V

INVESTIGATION OF POSSIBLE METHODS TO REDUCE SUSTAINED AND EXPANSION STRESSES OF AS BUILT PFBR HIGH TEMPERATURE PIPING FOR MEETING CREEP FATIGUE LIMITS

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ABSTRACT

This paper discusses the possible methods adopted to reduce sustained and expansion stresses of As Built PFBR (Prototype Fast Breeder Reactor) piping to meet Creep Fatigue limits of RCC-MR code. PFBR sodium piping have very low pressure (700 KPa) and at the same time have high temperatures (550°C). The thickness designed for these sodium systems is considerably lower than the standard thickness because of very low design pressure, which leads to higher stress indices like B2 and C2 for the elbows and tee branches. The As Built PFBR piping has been observed to have considerable changes in dimensions, changes in support locations and changes in the valves & flow meter masses when compared to the original piping analyzed, which have resulted in higher sustained and expansion stresses. Fatigue life at elevated temperatures reduces drastically, when calculated for the reactor life of 40 years. With the above constraints built in, the high temperature piping should also compulsorily have lower sustained, expansion and peak stresses to meet the creep fatigue life of 40 years. Change in cold load with actual spring stiffness of variable hangers, change in hot load of constant hangers, addition of new supports to reduce sustained stress, use of class 1 branch flexibility and increase of bend radius of elbows have been done to reduce the sustained and thermal stresses in order to meet the creep fatigue limits of RCC-MR.

INTRODUCTION

PFBR is a 500 MWe fast breeder reactor coming up at Kalpakkam, India. The As-built PFBR piping having considerable changes in layout, support location, bend (elbow) radius, changes in the weight of valves and flow meters have resulted in considerable increase in sustained and thermal stresses in many cases. Due to this effect, fatigue life and creep life of piping have come down drastically in many cases. The changes that have been made in the PFBR piping in order to reduce the sustained and thermal stresses, so that creep fatigue limits of RCC-MR code is met are discussed.

CASE OF VARIABLE HANGER USED INSTEAD OF ROD HANGER TO REDUCE STRESS

A typical case has been observed in Safety Grade Decay Heat Removal (SGDHR) Plugging Indicator and Sampler piping (Figure.1), where a variable hanger used instead of rod hanger reduces the expansion stress at the TEE junction from 225MPa to 144Mpa. Initially rod hanger was specified at node 340. With change in as built support locations and piping dimensions, rod hanger doesn't allow any vertical thermal displacement at TEE node 1125, thereby producing a thermal stress of 225MPa at TEE node 1125. Introducing a variable hanger at node 340 allows a vertical thermal displacement of 3.7mm at TEE node 320 and 2.2mm at TEE node 1125. This has reduced the expansion stress from 225MPa to 144Mpa at TEE node 1125 in the as built piping. Further, this has also helped in maximum allowable number of cycles from 382 to 1908 cycles at TEE node 1125, when the rod hanger is changed to variable hanger, higher than the actual number of cycles of 861.

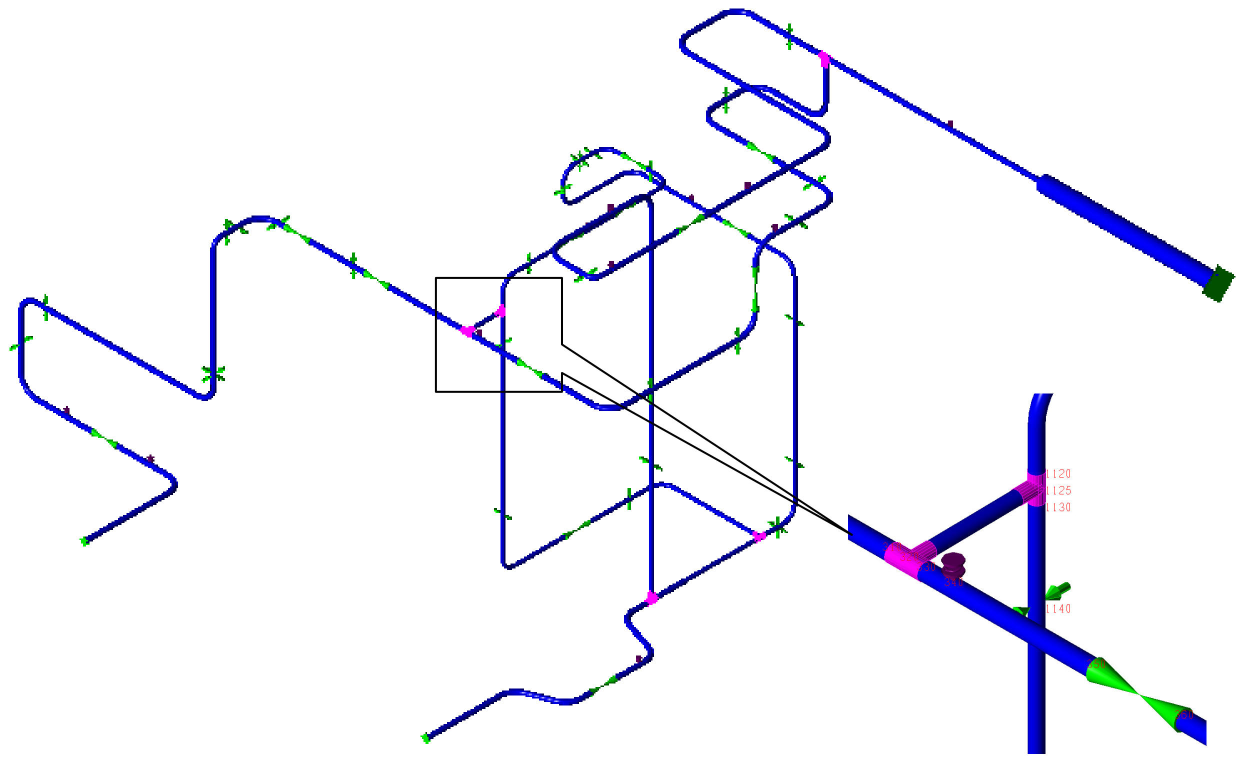

Figure.1. SGDHR Plugging Indicator and Sampler piping showing hanger at TEE junction

CHANGE IN COLD LOAD WITH ACTUAL SPRING STIFFNESS OF VARIABLE HANGERS

Many cases have been observed in the variable hangers, where the actual spring stiffness alone is fed and the piping software chooses the hot load and cold load based on the as built spring location and changed piping dimensions. The theoretical cold load of the variable spring is chosen such that it is within the range of the variable spring. This theoretical cold load should not increase the sustained stress. In such case, the original specified as built hanger is mainltained, otherwise a new variable hanger is specified.

CHANGE IN HOT LOAD OF CONSTANT HANGERS

In the case of constant hangers also, the same approach that was followed for variable hangers has been followed. Based on the piping load requirement, the constant hot load was either increased or decreased within the load range of the constant hanger and the sustained stress was checked. If the sustained stress is within the allowable range, then the old constant hanger itself is maintained. Otherwise, a new constant hanger that satisfies the sustained stress allowable limits is recommended.

ADDITION OF NEW SUPPORTS TO REDUCE SUSTAINED STRESS

In cases, where the sustained stress was very high making it difficult to meet the creep fatigue criteria of RCC-MR, there is a necessity to bring down the sustained stresses. In such cases, additional supports were added to make the unbalanced piping system balanced arising out of relocated piping support and changed piping dimension. These additional supports were added in such a way that both sustained stress and expansion stress was kept minimum to meet the creep fatigue criteria of the respective acceptance code.

CHANGE IN LAYOUT OF PIPING

When there is scope to change the layout of the as built piping locally, so that the expansion stress can be reduced considerably, the layout can be changed with loops and bends to reduce the expansion stress.

CHANGE IN BEND RADIUS

When sustained stress and thermal stress cannot be reduced with the available piping support configuration and piping layout, and when there is no possibility to change the piping layout due to non availability of space, the last option left is to change the bend radius of the piping which reduces the B2 and C2 stress indices considerably and at the same time gives enough flexibility to the piping.

CLASS I BRANCH FLEXIBILITY

WRC 329 gives a number of suggestions to improve the stress calculations at intersections. When reduced branch connections apply for intersection models, the model becomes more flexible and when reduced geometry requirements do not apply, the model becomes stiffer. The software allows to use class I branch flexibility as per the rules of ASME Sec III Subsection NB.

CONCLUSION

Change in cold load with actual spring stiffness of variable hangers, change in hot load of constant hangers, addition of new supports to reduce sustained stress, change in layout of piping, use of class 1 branch flexibility and increase of bend radius of elbows have been done to reduce the sustained and thermal stresses in order to meet the creep fatigue limits of RCC-MR. These are the several methods that have been adopted to qualify the as built PFBR piping for the sustained and thermal limits, and to satisfy the creep and fatigue rules of RCC-MR.

REFERENCES

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