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Research and application of piping inside grinding robots in nuclear power plant

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Abstract

Technical installations especially that are subject to special safety criteria should always be kept at the best possible level of operation safety. This applies in particular to their innumerable pipeline systems which require a high level of reliability and safety, such as those in nuclear power plants.

Taishan EPR (European Pressurized Reactor) nuclear power plant, which is in Guangdong province in China, has been the first one which succeeds to finish cold function test (CFT) among all the third generation nuclear power stations around the world.

Before CFT, a lot of time has been spent to finish the piping inside grinding work, which is supposed to be the first case of nuclear pipe line inside grinding in China, according to RCC-M code and technical specification, to relieve the weld structure from mechanical constrains, specifically high fatigue stress.

Inside grinding robots are custom made, from DN100 to DN500, including 4 types of robots, to carry out the inside grinding work in pipes instead of human beings when it is impossible for workers to achieve.

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1. Backgrounds

1.1. Improvement of fatigue life

Mr. Daniel Bertaso explains the cause and effect of fatigue life scientifically in his paper at Offshore Technology Conference.

The data from full-scale resonance fatigue tests that had been accumulated over the course of several extensive qualification programs was gathered into a data base to facilitate statistical analysis.

Subsea 7 (former Acergy company) database of fatigue testing consists of over 400 welds accumulated from resonance fatigue tests carried out in projects to qualify welding procedures. Statistical analyses performed on this database considered variables such as diameter, wall thickness, steel grade, ovality, welding process and the effect of grinding the cap.

The results of the analysis indicate that the geometric features of the weld are dominant in controlling overall fatigue life with other factors such as material source and supply condition being of secondary importance.

There are various approaches to achieve the high quality results needed for improving the fatigue life and can be broadly classified as ‘mechanical’ or ‘welding’ methods.

As in the case of mechanical methods, there are various options available for the grinding of the cap, ranging from manual grinding operations to mechanized systems. For grinding of root welds, a number of suppliers have been able to design compact systems suitable for working remotely in the pipe.

1.2. Specification from RCC-M and ASME code

Specifications in order to realize mitigation of fatigue sensitivity as well as UT testing are demonstrated clearly in RCC-M code which we must observe during all the construction process:

1) Welds are considered as flush when their inside and outside surfaces have been machined or ground to eliminate irregularities due to welding or discontinuities due to misalignment.

   The total additional thickness measured at the weld shall not exceed 0.1 t (wall thickness). No concavity is acceptable at the weld, either at the inside surface or the outside surface.

   The finished contour of the weld shall not include a slope greater than 7°, in accordance with the figure below:

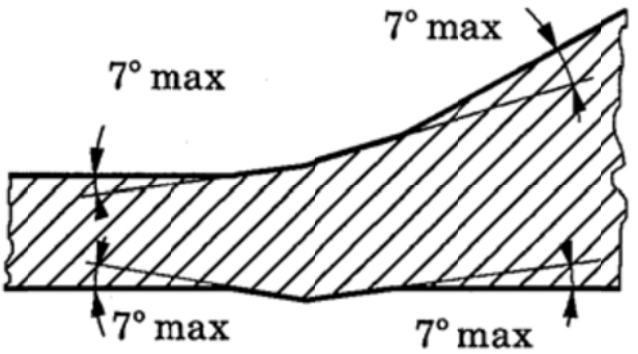

Figure 1. Slope of a finished contour of weld.

2) The welds are defined "as welded" when the above requirements are not met.

There are also similar specifications in ASME. III NB-3683.