Welding Residual Stress Simulation of Complex structure of Strengthen and Thicken Platform

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0 Introduction

In order to deal with the global economic development at full speed and the increasing requirement of energy, many countries expand their seafloor oil field exploitations from shallow sea to abysmal sea and ice-covered ocean. So that the need of high-quality and new technology is increasingly demanded, for instance, legs of marine drilling platform have been made by steel of Z direction with yield strength over 690Mpa and thickness up to 210mm.[1-2] Welding as a flexible and efficient joint way, related to many courses such as electric arc physics, heat passage and mechanics, has now been widely used in vessels and marine architectures industry, in which process the heating and cooling, the incoordinate plastic deformation and welding residual stress will reduce safe reliability and assembling accuracy. Consequently**,** welding residual stress simulation of complex structure of strengthen and thicken platform will either be easier to seize its construction regulations or improve efficiency by accumulating building experiences, which would save manpower and material resources, bringing enormous economic and social benefits.

1 Complex structure physics models

Considering the structure distinguished features of the deepwater rig, complex welding joint of “lead block basis & pillar”, shown as Fig.1,is chosen to be analysis here. Since the model is symmetrical, we calculate a typical seam among exospore and carrier plate and resistance plate, overlooking deforming heat causing by force field effecting temperature field, so as to simplify the calculating process, reducing nonlinearity and promoting efficiency.

Simplified model is shown as Fig. 2.

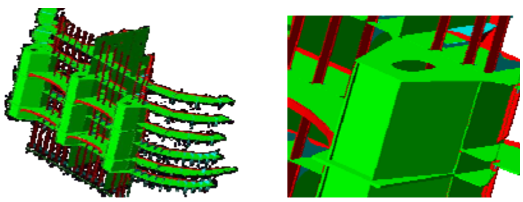


Fig.1 lead block basis & pillar

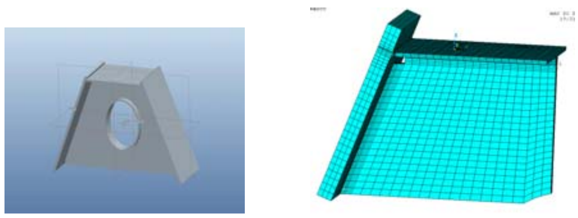
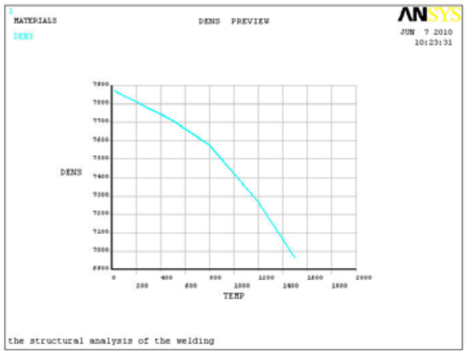


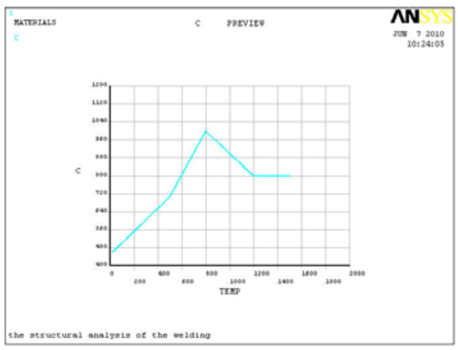
Fig.2 simplified lead block basis & pillar real model

2 Definition of material attributions

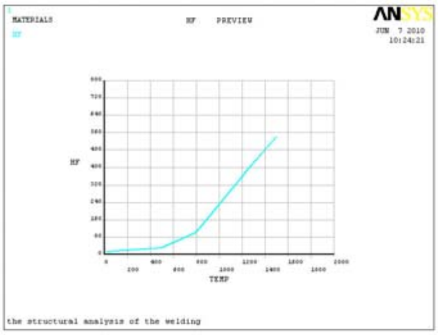
During welding process, large temperature gradient results to material nonlinearity, which demands physical parameters changing along with temperatures when we define material attributions. Generally, physical parameters at high temperatures are in deficiency but influence the calculating result heavily, which could be obtained through experiment and interpolation. When doing welding thermal stress calculation, which is part of thermoelasticity, plastic analytical selection should be chosen as bilinear isoclinic strengthens and the yield stress changing along with temperature and the shear modulus should also be set. During welding process there are two kinds of phase transformation latent heat: solid phase transformation latent heat and the melt one. The former is so much smaller than the latter that it is often being ignored. When defining material attributions in ANSYS, we deal with melt latent heat through setting enthalpy. Material parameters of EQ70 steel is given in Fig. 3.



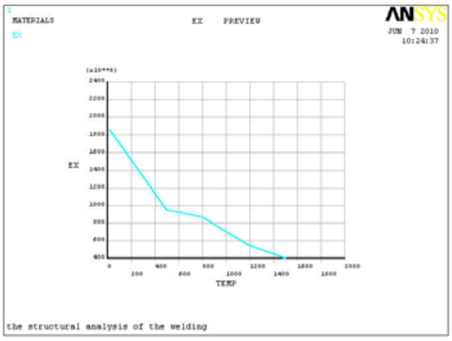
A） density



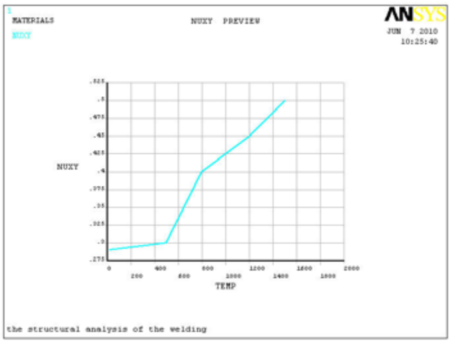
B） specific heat



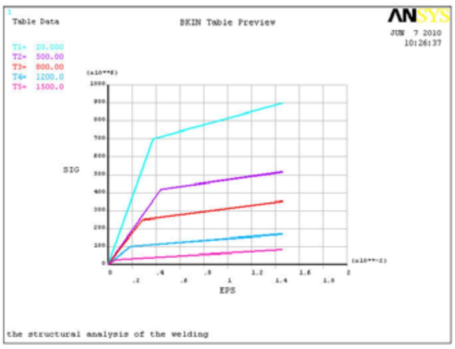
C） HF



D） modulus of elasticity



E） Poisson's ratio NUXY



F） stress and strain curves

Fig.3 physical parameters at high temperatures of material EQ70

3 Unit type of finite element and zoned format of lattice

With indirect coupling pattern, thermal analysis uses thermal unit solid 70 with 8 joints, while stress analysis uses structure unit solid 185.

During welding process, heat producer is highly concentrated, which results to denser lattice in weld seam and vicinity in order to improve accuracy, and more sparse away from weld seam since it can reduce amount of the calculating points, and then cut down calculation time. The whole lattice zoned format is from dense to spare.

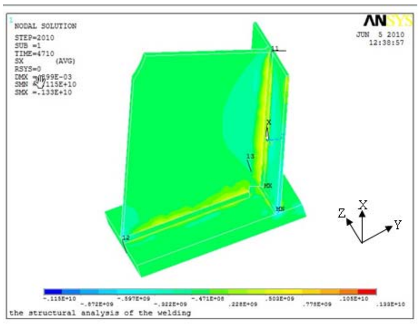
Lattice is zoned specifically as below: longitude 1cm, 5mm on cross section, generally the lattice is distributed from dense to spare then to invariant from the seam to around.

4 Value imitating results and analysis

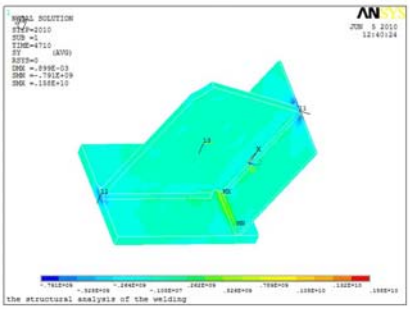
4.1 Imitating results

（1） lead block basis & pillar three-dimensional stresses

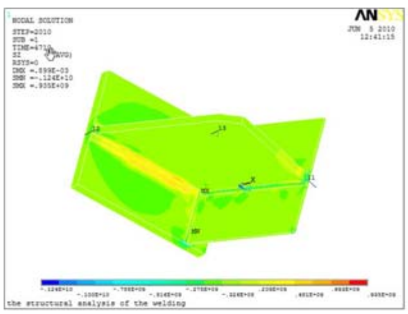
Lead block basis & pillar three-dimensional stresses distribution Fig.s are shown as Fig. 4.



A） SX distribution



B） SY distribution



C） SZ distribution

Fig.4 lead block basis & pillar three-dimensional stresses distribution

（2） Calculation results selecting different paths

Distribution of residual stress of three seams center section paths and seam mixing path are shown as Fig. 5 to Fig.11.

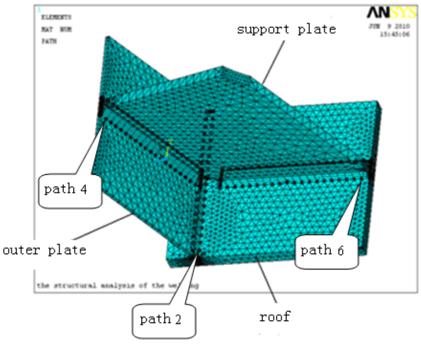
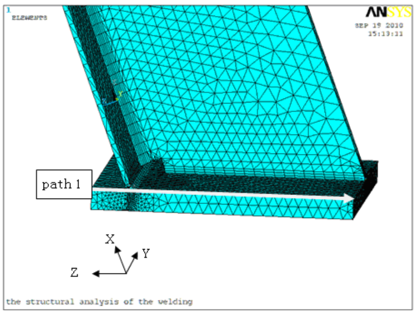
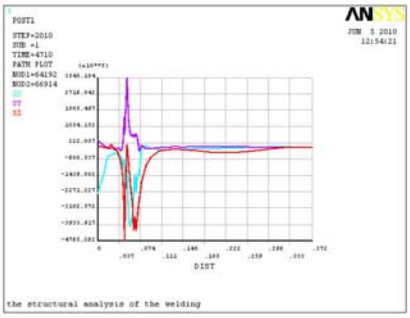


Fig.5 selections of paths on seams



A） path 1 diagrammatic sketch



B） stress distribution on path1

Fig.6 path 1 and stress distribution

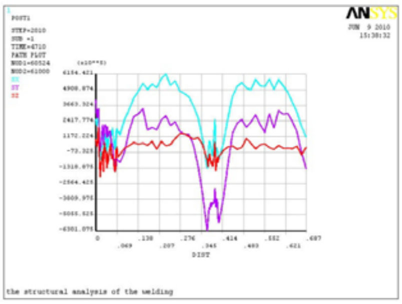
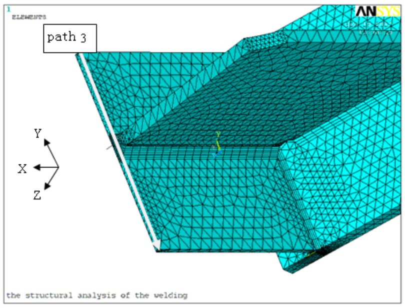
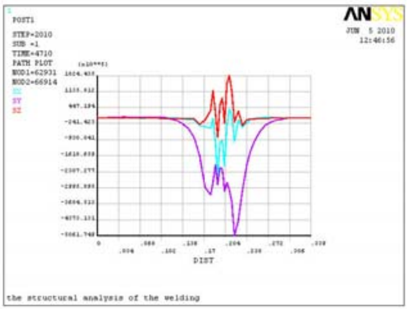


Fig.7 distribution of residual stress on the seam between carrier plate and exospore(path 2)



A） path 3 diagrammatic sketch



B） stress distribution on path 3

Fig.8 path 3 and stress distribution

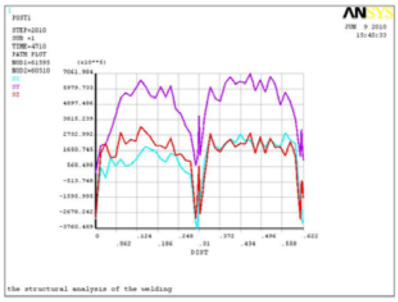
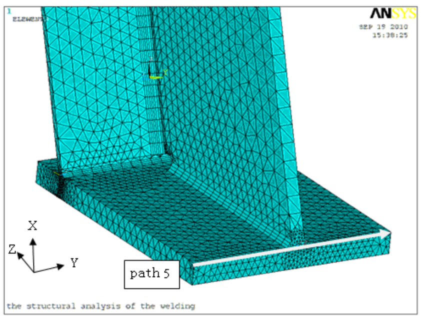
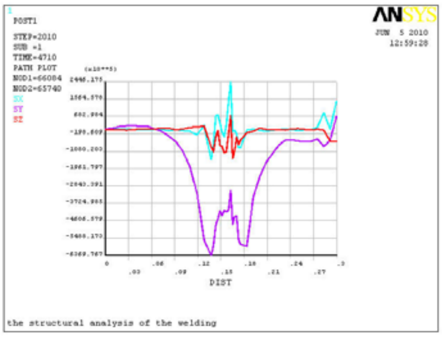


Fig.9 distribution of residual stress on the seam between exospore and assistance plate(path 4)



A） path 5 diagrammatic sketch



B） stress distribution on path 5

Fig.10 path 5 and stress distribution

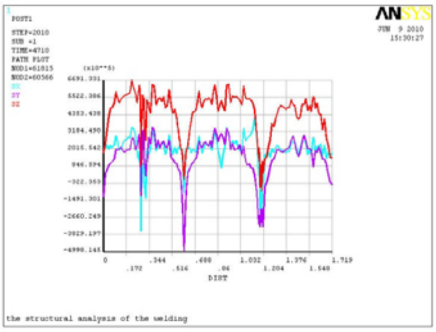


Fig. 11 distribution of residual stress on the seam between the carrier plate and assistance plate (path 6)

4.2 Distribution of residual stress and results analysis

Besides longitudinal stress σ_x and transverse stress σ_y exists in thick plate structure, its longitudinal residual stress is caused mainly by shrinking of seam's cooling. Under certain situations, contrary phase changes repeat. Transverse stress which is perpendicular to the seam direction, results from transverse shrink of cooling seam directly and from longitudinal shrink of the seam indirectly. Moreover, instinct cooling processes of the surface and the inside and possible repeated phase changes are factors of transverse stress. High thickness welding structure contains not only longitudinal and transverse stress, but also stress along thickness direction. Experiments and researches in recent years indicate that, these three internal stresses distribute quite nonuniformly in the direction of the thickness, which distinguish remarkably if using different bonding technology[3-5].

From Fig.5to Fig.11 show welding residual stress changes along with the distance from the seam, transforming between tensile and compressive stress. Isotropic residual stresses will reach their maximum at the middle of the thickness, beginning to decrease from the middle to each surface. Residual stress changes fastest around the seam and it also relates to the thickness of the plate.

Fig.6 and Fig.7 show the distribution of residual stress of the seam between exospore and carrier plate. The stress changes severely at the seam with both compressive and tensile stress summits appearing, because internal stress causing by nonuniform temperature field reaches the yielding limit of the material, which makes the local deformations. The residual stress of mixing seam reaches the maximum, among which the stress of Y direction has the highest peak at about 630Mpa. This kind of stress should be diminished by local processing.

5 conclusion

This article uses finite element to do Welding Residual Stress Simulation of Complex structure of Strengthen and Thicken Platform about the distributions of temperature field and stress field, which imitate clearly the stress changes of the points in stress field and the distributions of the temperature field and final residual stress of thicken plate. Though considering simplified model, calculation contains the real structure's influence to restrictions, which means the result could reflect the stress distributing features of the seam in real structure. Each seam do affects to each other but since the long distance between them, this kind of effect is quite small to the distribution of residual stress. The calculation results indicate that the maximum residual stress on complex structural welds locates on weld edges. Some points reach or surpass the material's yielding strength, so after welding, stress diminishing measures must be taken to improve the distribution of the residual stress.

References

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