Alleviation of internal cracks in continuous casting bloom of steel 100Cr6 induced by soft reduction process

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cracking zone, and propagate along the following soft reduction process. Figure 2 shows the temperature distribution and cracking zone under different reduction position,

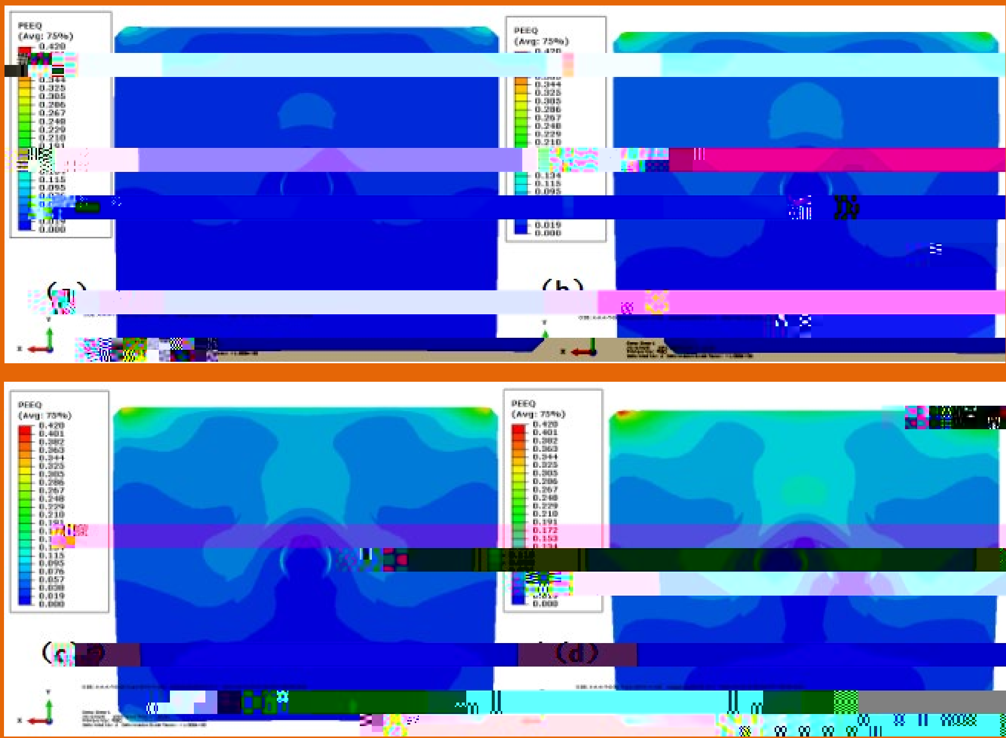

Fig. 6 - Equivalent strain of as-cast bloom under different reduction amount (centre solid fraction 0.79): (a) 4mm; (b) 6mm; (c) 8mm; (d) 10mm.

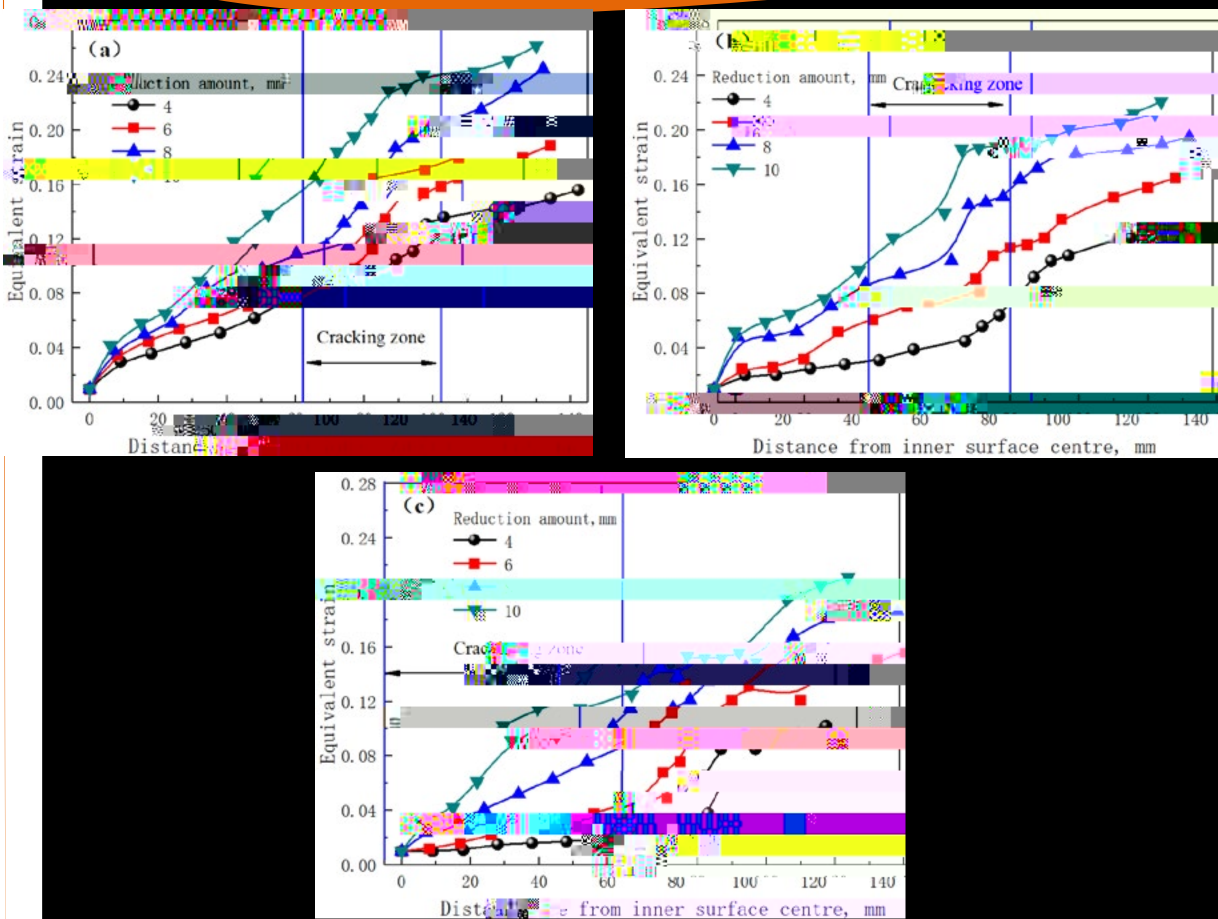

Fig. 8 - In uence of reduction amount and reduction zone on the maximum equivalent strain of cracking zone.

Fig. 9 - Area of cracking zone, centre solid fraction and maximum equivalent strain in cracking zone under a number of withdrawal units.

When the centre solid fraction of as-cast bloom reaches 0.79, internal brittleness temperature range is disappeared and the equivalent strain is smaller than the critical strain when the reduction amount is less then 5mm. The relationship between cracking zone area, centre solid fraction and maximum equivalent strain in cracking zone has been established under a number of withdrawal units, as shown in Figure 9. Although the internal cracks can been effectively alleviated as the increase of centre solid fraction, a deformation implemented in the mushy region for simultaneously improving the center segregation and center shrinkage cavities. In the present work, withdrawal unit was mainly implemented for improving the center shrinkage cavities when center solid fraction of as-cast bloom reached 0.9. Therefore, a novel soft reduction technology for eliminating internal cracks, center shrinkage cavities and center segregation of as-cast bloom has been designed, which aims to provide theoretical basis for improving the internal quality of steel 100Cr6. In the control stage of center segregation, the reduction amount was enhanced to improve the homogeneity of as-cast bloom (withdrawal units 2#, 3# and 4#) without forming of internal crack. In the control stage of center shrinkage cavities, the as-cast bloom was compressed to improve the compactness of as-cast bloom (withdrawal unit 5#).

OPTIMUM DESIGNED EXPERIMENTS OF STEEL 100CR6 INDUCED BY SOFT REDUCTION PROCESS

According to the above simulated results and theoretical analysis, optimum designed experiments of steel 100Cr6 are shown in Table 1. Shrinkage cavities and center segregation euown in T

Tab.1 - Optimum designed experiment case.

of as-cast bloom. In order to weaken the internal crack, the reduction amount of reduction roll is both decreased for withdrawal unit 1# and 2#. However, the internal cracks are also clearly observed under the application of case 2, and the center shrinkage cavities are also located in the centerline of as-cast bloom.

Fig.11 - Effect of designed experiment cases on centerline segregation grade.

The maximum equivalent strain in the cracking zone for withdrawal unit 1# is more larger than the critical strain, therefore withdrawal unit 1# should be avoid to make reduction operation. Case 3 is a novel soft reduction technology, withdrawal units 2#, 3# and 4# are taken to control center segregation without internal crack, and withdrawal unit 5# is added to control center shrinkage cavities. The longitudinal morphologies of as-cast bloom indicated the internal crack and center shrinkage cavities can both be eliminated under case 3 as compared with case 1 and case 2. Figure 8 shows the effect of designed experiment cases on centerline segregation grade. The prepared drill samples were analyzed using the carbon-sulphur analyser, and the solute segregation ratio was calculated by taking the solute content at each location divided by the ladle composition. Although the total reduction amount of case 1 is 4mm larger than that of case 2, the centerline segregation grade difference is small. In addition, the center segregation generated by the optimum designed experiments of case 3 was remarkably improved in comparison with that induced by the conventional soft reduction process. According to the results of optimum designed experiments, the internal cracks were effectively alleviated and center shrinkage cavities were nearly eliminated.

CONCLUSIONS-

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T[redacted] present work is nancially supported by The National Key Research and Development Program of China No. 2[redacted]17YFB1103700. The authors are also grateful to Dr. Zhifang Lu in Xingtai Iron and Steel Corp., Ltd for discussing on the accuracy of strain analysis in as-cast bloom during soft reduction operation.

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