

Research on mechanism of effect on plate quality of intermediate crack of slab

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Abstract. Mechanism of transformation from intermediate cracks of slab to defects of plate is studied. It can be seen that there are dimension 10~50μm inclusions MnS precipitating around intermediate cracks of slab. After rolling, there are 10~500μm inclusions MnS around defects rolled on plate. Then the transformation of defects can be summarized as: The intermediate cracks form during solidification and the inclusions MnS precipitate around intermediate cracks. After rolling, the defects of plate form because the seaming of cracks by rolling are restraint by inclusions MnS. Then the hydrogen atoms assemble around defects to form hydrogen molecules, which makes the defects worse because of volume expansion of hydrogen. Moreover the optimizations of hydrogen reduction, desulphurization and crack reduction are suggested to reduce the influence on quality of intermediate cracks.

1.Introduction

The intermediate crack is one of serious defects of slab, with the increasing of demand of customer and development of material processing. Some references describe the formation reason of intermediate crack as stress on solidification frontier and element segregation. ^[1-3] But some references describe that as bulging strain, straightening strain and misalignment strain. ^[4] But most references describe that as sulphur content and parameters of slab processing. ^[5-7]

There are most of researches on intermediate crack but less of researches on effect on plate quality of intermediate crack. ^[8] The research on effect on plate quality of intermediate crack was studied on this article.

2.Experimental

2.1 Chemical composition

The chemical composition is shown in Tab. 1. The Ceq is 0.42%. However phosphorus content is 0.02% and sulphur content is 0.0058%.

Table 1. Chemical composition of sample/%

C	Si	Mn	P	S	Alt	Als	Ceq
0.173	0.37	1.46	0.02	0.0058	0.032	0.03	0.42

2.2 Sampling

The samples are taken on slab actual processing in steel plant. And the evolution of intermediate crack is studied by taking slab and rolling plate respectively. The sampling schedule is shown in Fig. 1. As shown in figure, the slab thickness is 250mm and rolling plate thickness is 14mm.

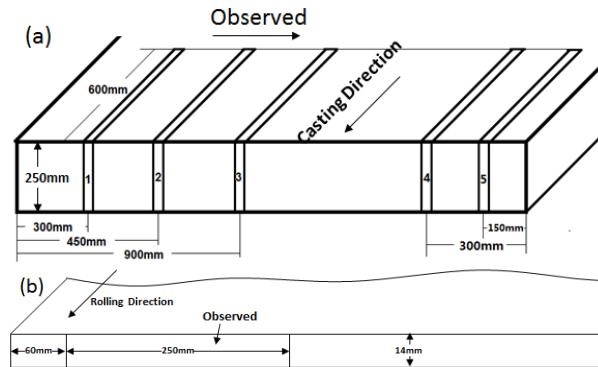
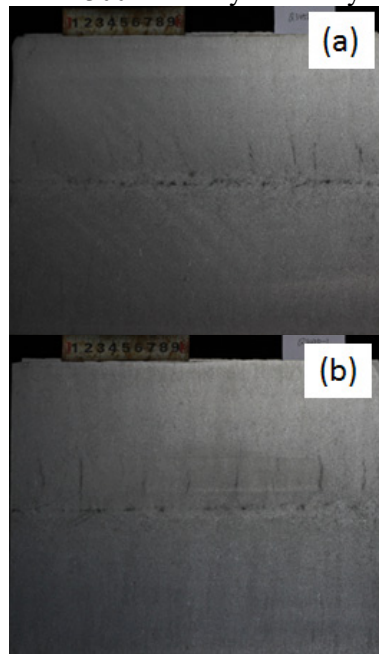


Fig.1 Location of samples (a) Slab (b) Plate

3. Results and Discuss

3.1 Analysis of intermediate crack of slab

The morphology of intermediate cracks is shown in Fig. 2. The observed surface is shown in Fig. 1 (b). There are severe intermediate cracks at 1/4 position of thickness observed in Fig. 2 (d), which is 300mm away boundary of slab. The morphology of intermediate cracks are shown in Fig. 2. The observed surface is shown in Fig. 1 (b). There are severe intermediate cracks at 1/4 position of thickness observed in Fig. 2 (d), which is 300mm away boundary of slab.



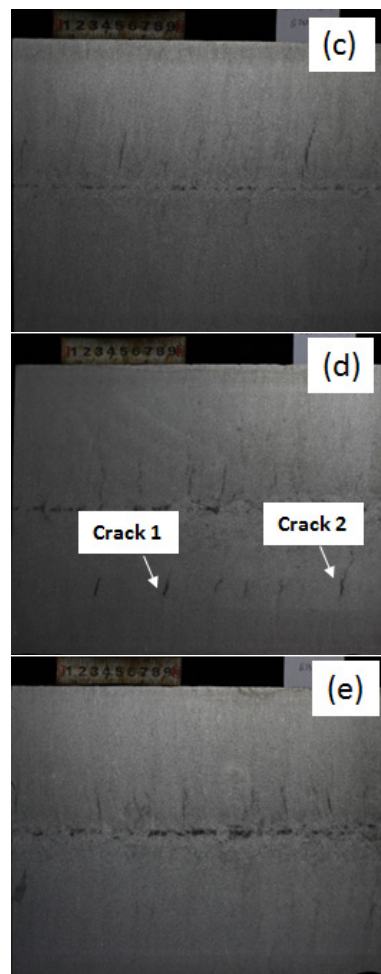
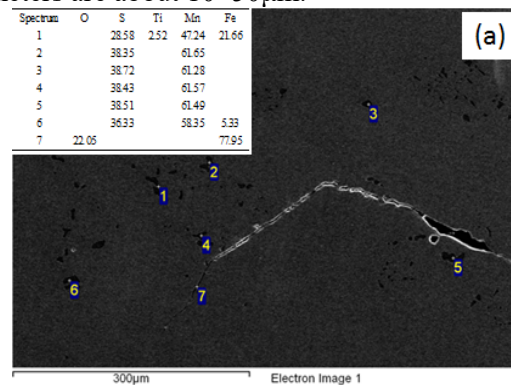


Fig.2 Morphology of intermediate crack of slab (a) slab 1 (b) slab 2 (c) slab 3 (d) slab 4 (e) slab 5

The analysis of intermediate cracks, shown in Fig. 2 (d), is studied by SEM. And the chemical composition of inclusions is analysed, shown in fig. 3. As shown in Fig. 3, the inclusions are most spherical MnS. And the diameters are about 10~50 μ m.



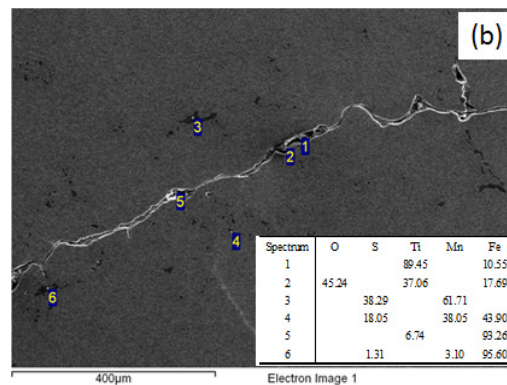


Fig. 3 Composition analysis of Crack (a) Crack 1 (b) Crack 2

3.2 Analysis of micro defects of plate

The slab was rolled to be 16mm thickness plate. The morphology of plate defects is shown in Fig. 4. As shown in figure, there are severe black defects not only at the 1/4 thickness of plate but also at center of plate. And the inclusions around defects are studied by SEM.

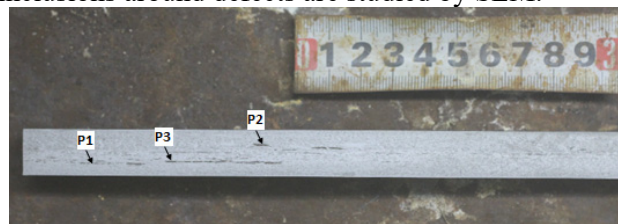


Fig.4 Image of macrostructure of plate

The chemical compositions of inclusions are shown in Fig. 5. As shown in figure, the inclusions are most MnS, and a little of SiO₂. The shape of inclusion is spindle. The inclusions MnS is easy to deform after rolling because of low melting point.

The P3 of Fig. 4 is split into half to study the interior inclusions. And the results are shown in Fig. 6. All the interior inclusions are MnS. The shape of inclusion is spindle. And the max diameter of inclusion is 500µm.

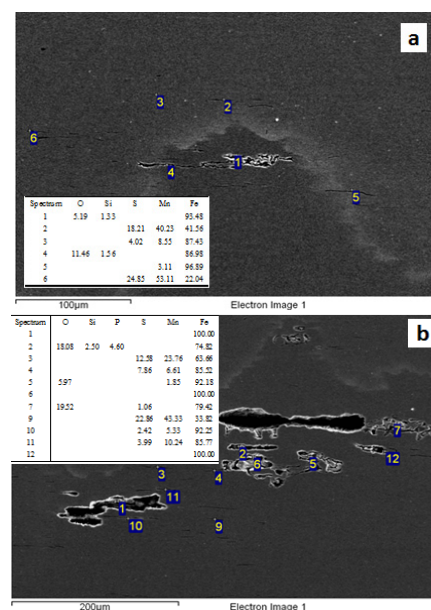


Fig.5 Analysis of inclusions around defects (a) P1 (b) P2

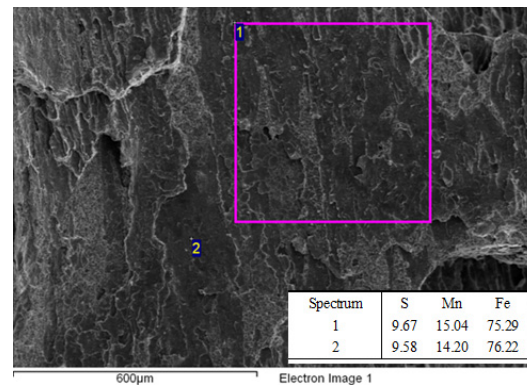


Fig. 6 Analysis of inclusions in P3

3.3 Evolution model from intermediate cracks of slab to defect of plate

The evolution model from intermediate cracks of slab to defects of plate is shown in Fig. 7. The intermediate cracks come into being during solidification. Then the inclusions MnS precipitate around the intermediate cracks. The low melting point inclusions MnS are elongated to spindle shape, which stops the metallurgical bonding of steel structure, which produces the plate defects.

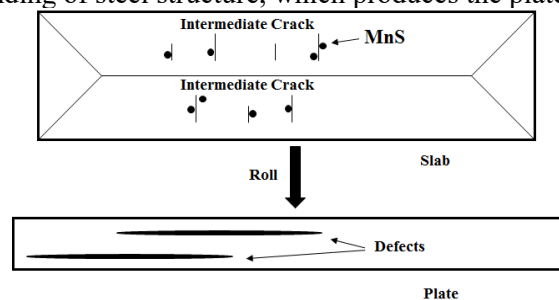


Fig.7 Sketch of evolution from intermediate cracks of slab to defects of plate

The hydrogen atom would gather at the plate defects and become gas, which makes the volume of hydrogen increase sharply. Then the plate defects can deteriorate the properties of plate.

4.Improvement measures

The following measures are proposed through studying the evolution of intermediate cracks.

1. The plates should stack to cool over 48h in order to hydrogen release.
2. To decrease inclusions MnS through Desulphurization.
3. To release hydrogen through increasing RH time.
4. To decrease crack induced by strain through optimize soft reduction and secondary cooling.

5.Conclusions

Through analyzing formation of intermediate cracks of slab and defects of plate, the formation mechanism of effect on defects of intermediate crack was drawn. Then the following conclusion can be drawn.

1. There are several intermediate cracks found around 1/4 position of slab. And 10~50μm inclusions MnS can be observed around cracks.
2. There are 10~500μm inclusions MnS found around several defects of plate that induced by rolling.
3. The intermediate cracks came into being while solidification. Inclusions MnS precipitated around intermediate cracks. Then the defects formed because inclusions MnS prevented the metallurgical bonding of intermediate cracks while rolling.
4. Three improvement measures have been proposed such as hydrogen decreasing, sulfur decreasing and intermediate cracks controlling.

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