SUPERFICIAL DEFECTS ON AISI 1118 STEEL PLATES

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Abstract: *Even in the case of well established technological conditions for steel rolled production at some stages of production line could be observed various defects which causes are difficult to be determined. In the case of analyzed plate the surface defects observed we consider to have origin in the steel casting stage due to high casting temperature , low casting speed and slag entrapment on the slab surface, the defects dimensions have been increased during the rolling stage.*

1. INTRODUCTION

The defects on the surface of rolled plates could have various causes, related to the whole flow route, but mainly to casting or rolling. For each production stage there are various surface defects which have different causes, difficult to be assessed because they have particular origin dependent to specific production line. The aim of present paper is to determine the causes of discontinuous cracks which have been observed on the surface of AISI 1118 steel plate with 50mm thickness

2. PLATE AND DEFECT DESCRIPTION

The observed defects are presented in Fig.1 and consist in discontinuous cracks developed in small plate area (50x170 mm).
The chemical composition for the AISI 1118 slab from which has been rolled the plate subjected to analysis is shown in Table 1.The plate has been rolled on a two stands rolling mill from a slab which has been obtained by continuous casting of steel from an 180t BOF.
From the plate with the following dimensions: 1.969”x75”x208” (50x1900x5000) mm. has been cut by torch a sample, which contains the incriminated defect.

Figure 1. Discontinuous cracks in different parts machined from a AISI 1118 plate

Table 1. Chemical composition of slab

Element	C	Mn	P	S	Si	Cu	Cr	Ni	Mo	Al_t	V
Composition %	0,20	1,31	0,011	0,0073	0,134	0,01	0,01	0,02	0,006	0,038	0,005

3. EXPERIMENTAL PROCEDURE:

From the received sample a large zone has been removed by sawing, to avoid microstructure changes due to previous torch cutting. The new sample obtained has been etched for macroscopic analysis. Results obtained after sample macro-etching are presented in Fig.2, which shows clear centerline segregation for one sample cross section and a network of discontinuous cracks on the plate upper face. This cracks configuration suggests intergranular cracks propagation.
The centerline segregation is a result of the high casting temperature ,1541^{0}C, for a liquidus range of 1508º-1510ºC.

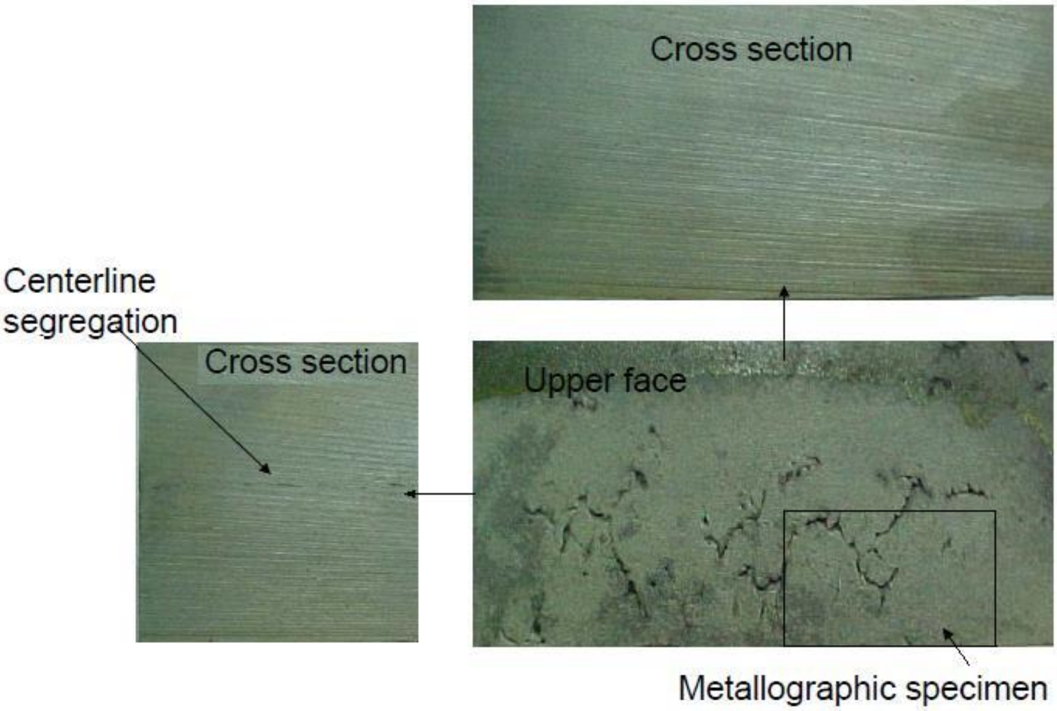

Figure 2. Macro-etching

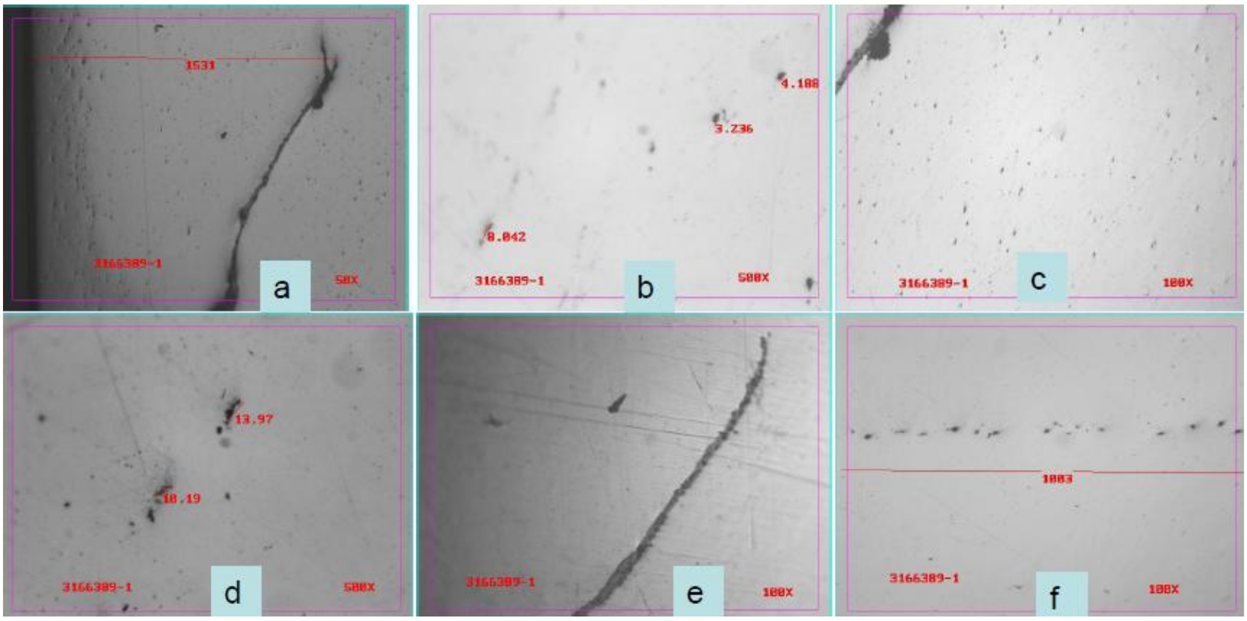

Figure 3 Metallographic analysis of un-etched specimens. 2%Nital Etching

The chemical analysis of sample upper face reveals a carbon content of 0.16% in comparison with the carbon content of bulk, 0.21%, which means a high decarburization of the surface.

The metallographic analysis of un-etched specimens cut from the sample shows the followings:

On the sample cross section (longitudinal view) could be seen the cracks which penetrate into the plate until a depth of 1,5mm, Fig.3a.

Near the crack, but also in another specimen areas there are many D-type non-metallic inclusions, with the dimensions less than 8µm (Fig. 3a-c). The maximum dimensions of the inclusions in this specimen were 18µm (Fig.3d) but also, was found an inclusion row with the length of 1000µm (Fig.3e).

The analysis of the specimen upper face reveals not only a crack but, a network of cracks which connect oxide filled holes (Fig.4); these holes represent the tips of larger cracks.

The metallographic analysis of etched specimen reveals the followings:

–The sample surface is highly decarburized, Fig.5.

–The cracks are propagated in the decarburized layer until a depth of (780-1500)µm, main part of the crack is filled by iron oxide and both sides of the crack which are decarburized, more or less, Fig.6.

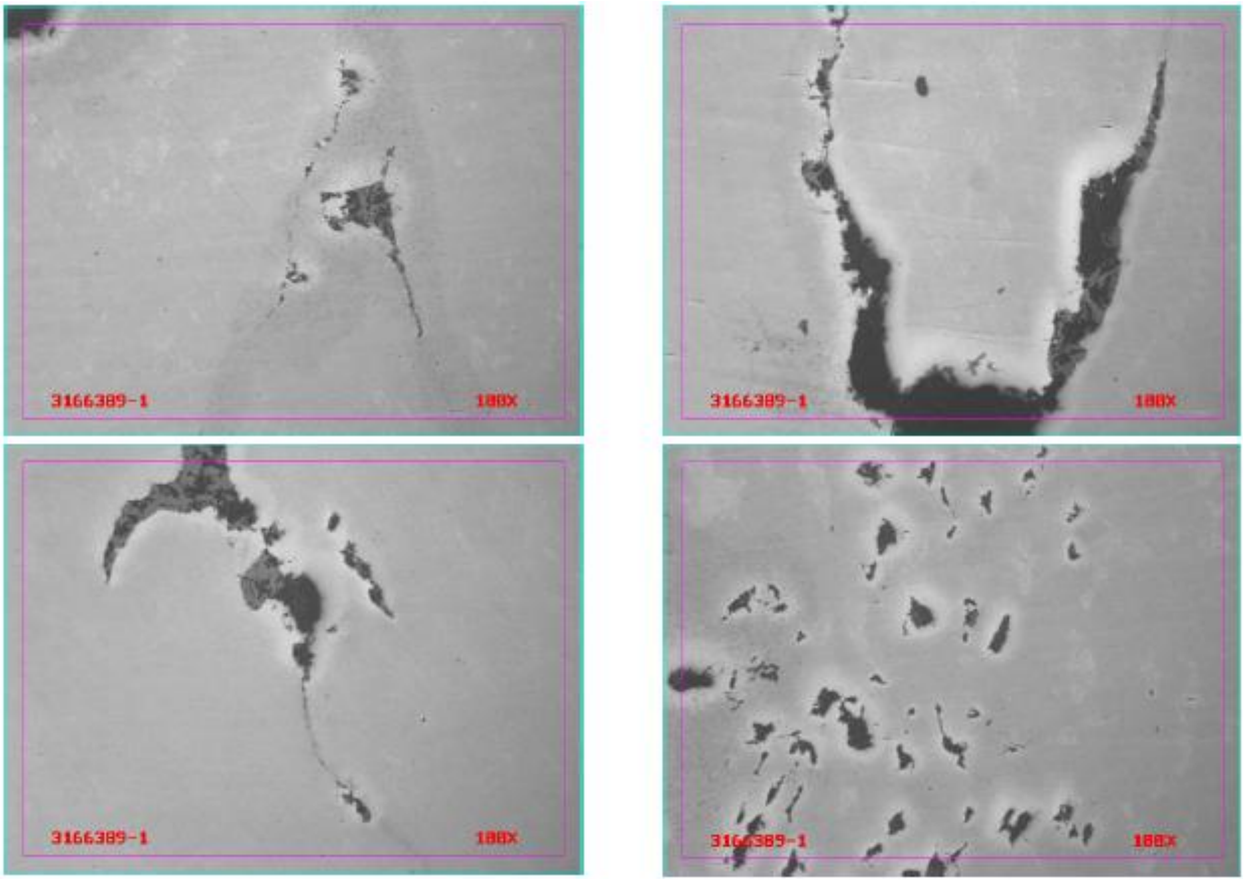

Figure 4. Cracks filled with oxides

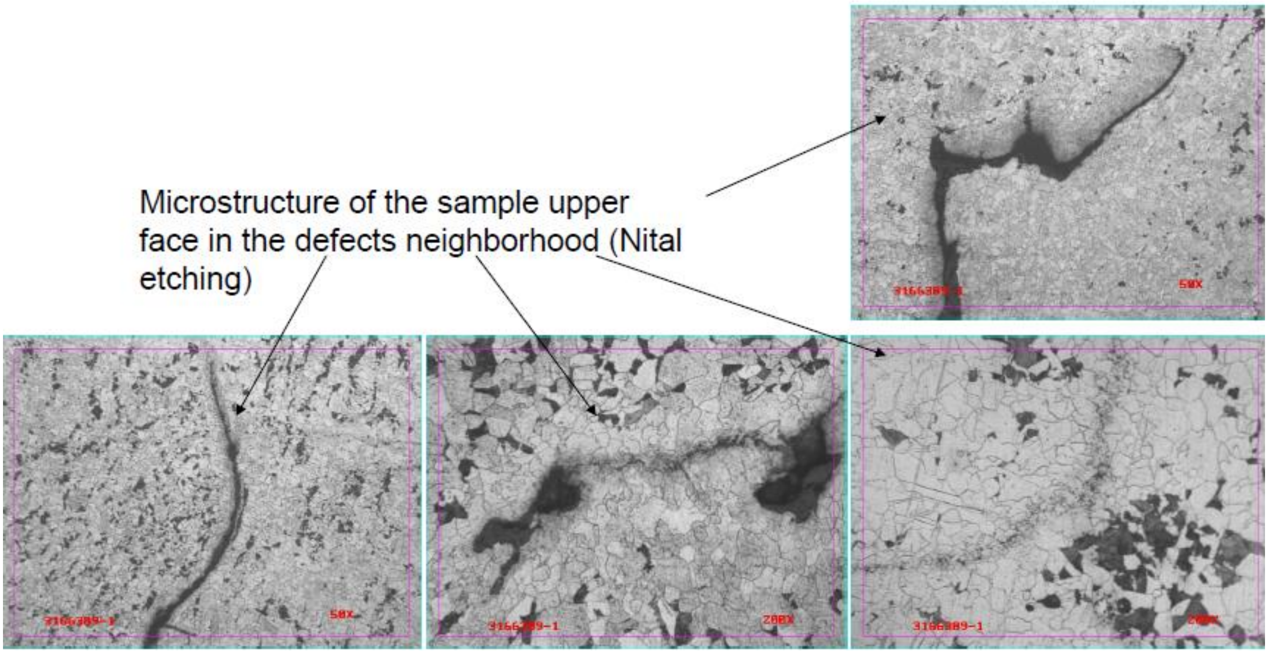

Figure 5. Metallographic analysis of etched specimen.

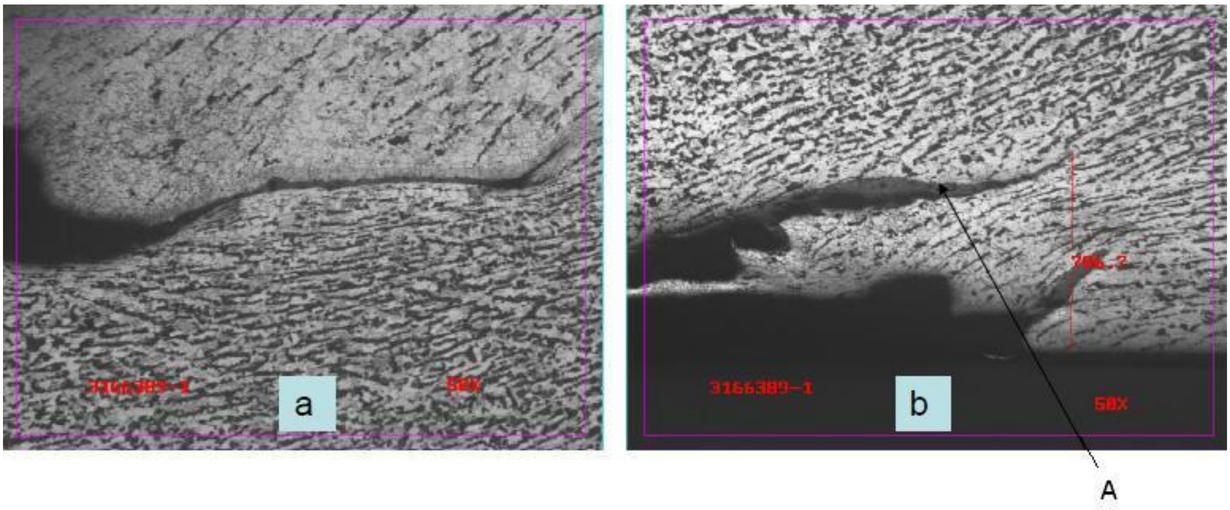

Figure 6. Metallographic analysis of etched specimen. 2%Nital Etching

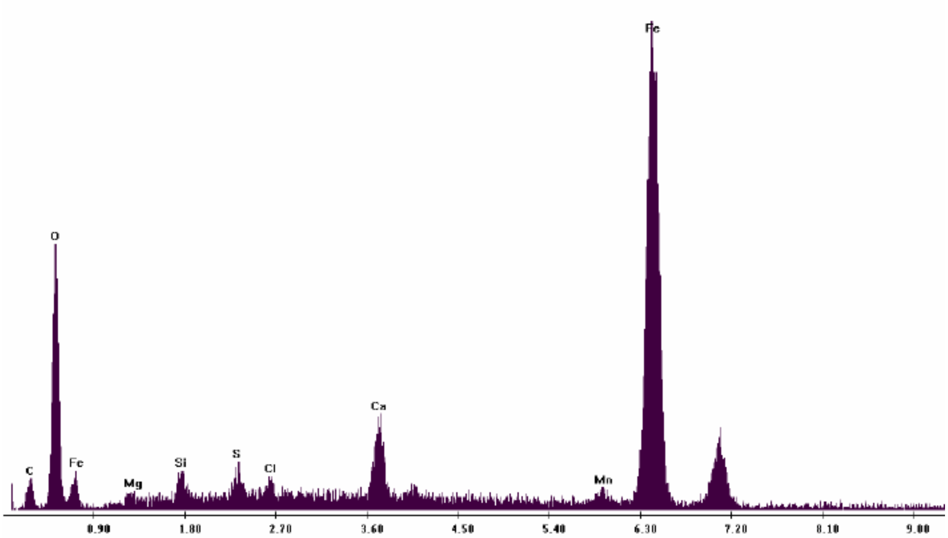

Figure. 7 Chemical composition of A area from fig.6

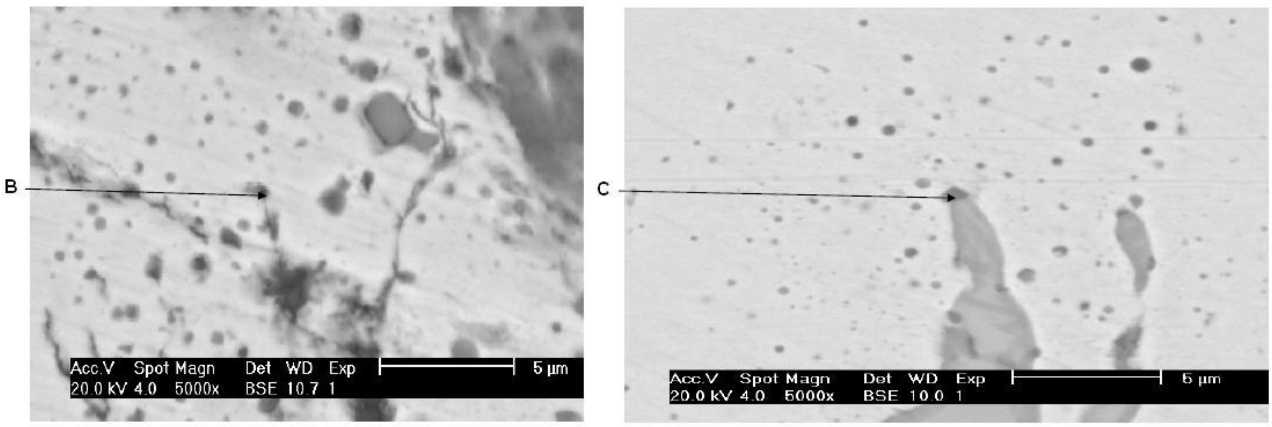

Figure 8 Position of areas from the unetched specimen surface analyzed by EDAX (oxides and slag inclusion)

–The grain size increases from 15µm, in the bulk, to 25-30µm in the decarburized zone result which is normal for the case of mono-phasic regions in comparison to bi-phasic regions.

-the through cracks cross section specimen analysis, from Fig.6.reveals the presence of complex oxides on the crack tip, which chemical composition is shown in Fig.7.
The SEM analysis of specimens:
-the un-etched specimen surface from Fig.4 has been analyzed for determining the chemical composition of the oxides observed on this surface. The analysis showed the predominant presence of grey iron oxide and besides it, dark grey areas of slag with different chemical composition, Fig. 8,9,10.
The high aluminum ratio (Fig.10) from B area in Fig.9 is the result of aluminium oxide clusters analysis. Usually alumina clusters are inclusion which occur below the slab top surface only, mainly on low carbon, aluminum killed steels. The inclusions occur randomly anywhere through the length of the slab.

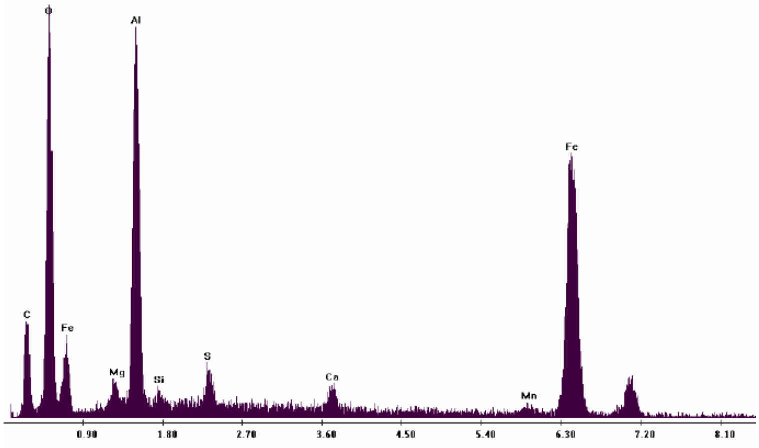

Figure. 9 Chemical composition of B area from fig.8

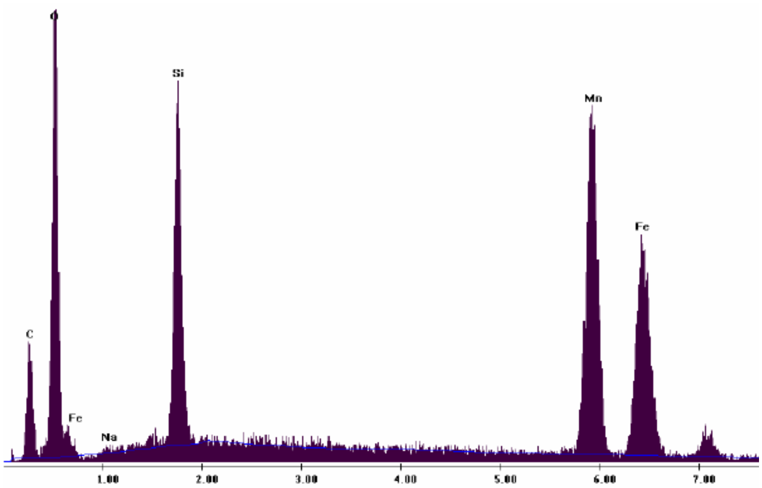

Figure. 10 Chemical composition of C area from fig.8

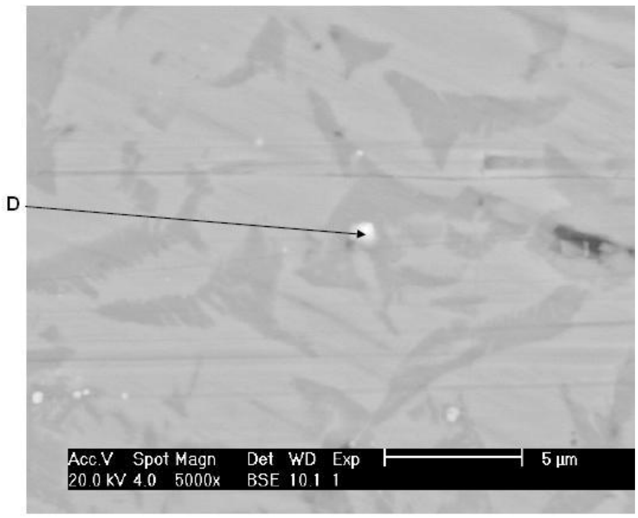

Figure 11. SEM analysis of crack area (inclusions)

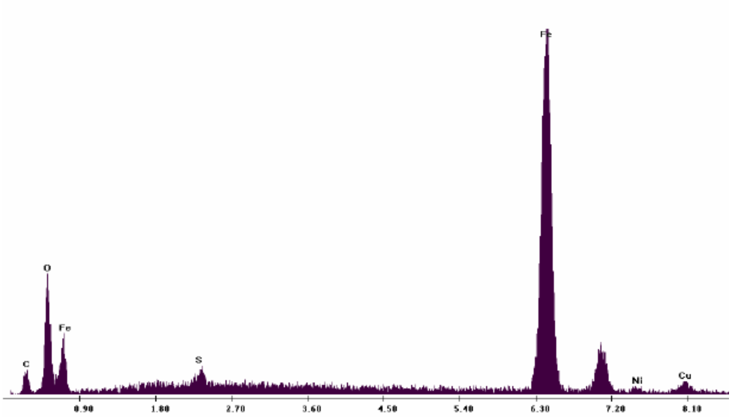

Figure. 12 Chemical composition of D area from fig.11

In the same crack area could be observed small (500nm), spherical, white, inclusions which contain besides S,O,Fe, small quantities of Cu and Ni, Fig.11,12.
The chemical composition of this area are revealed in EDAX analysis from Fig.12

4. CONCLUSIONS:

- The defect consists in a network of discontinuous cracks on the plate upper face in a small plate area (2"x7") (50x170 mm). This cracks configuration suggests intergranular cracks propagation.
- The chemical analysis of sample upper face reveals a carbon content of 0.16% in comparison with the carbon content of bulk, 0.21%, which means a high surface decarburization.
- The pronounced centerline segregation is a consequence of high temperature in tundish(1541ºC) and consequently low casting speed even, the liquidus temperature is 1508º-1510ºC.
- Near the crack, but also in other specimen areas there are many D-type non-metallic inclusions, with the dimensions less than 8µm. The maximum dimensions of the inclusions in this specimen were 18µm but also, was found an inclusion row with the length of 1000µm.
- The cracks have been extended during rolling from initial cracks existent before slab reheating due to casting slag entrapment on the slab surfaces.
- Another source of initial cracks could be grain boundaries melting at the reheating temperature, of a thin layer from the slab surface, due to Cu diffusion at these boundaries.