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THE FORMATION AND CHARACTERIZATION OF WIDMANSTATTEN IN GREY CAST IRON

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Abstract

Mechanical properties are most important parameters which affect bench life at delicate pieces as cylinder heads and motor blocks. Mechanical properties depend on morphological structure of grey cast iron. In this study, formations conditions and structure of widmanstatten morphological structure that forms in grey cast iron and decreases mechanical properties of grey iron in blasting pressure have been investigated. In this context, samples were prepared with traditional sample preparation from cylinder heads which were produced with green sand mould casting. To determine widmanstatten morphological structure, microstructure images at different magnification and resolution have been taken and chemical analysis has been done.

Key words : Grey Cast Iron, Widmanstatten morphological structure.

1. Introduction

The amount of C and Si in grey cast iron changes betwen % 2.5 ile 4.0 and % 1.0 ile 3.0. For grey cast iron, graphite has flake shape and it is surrounded by α ferrit and pearlite matrix. The root cause of that name of grey cast iron is fracture surface is grey. Form of the flake graphite sharp for this reason acts as stress raiser in applied external tensile stress. Consequently grey cast iron is weak and brittle taking into account mechanical properties.

Morphological structure has an important effect on mechanical properties of grey cast iron. Metallurgical quality control is main step of production process.

1.1. Mechanisms of Formation of Widmanstatten Graphite in Grey Cast Iron

Widmanstatten graphite is a morphological structure that a result of existing contamination of Lead(Pb). It is known that other trace elements(Sb, Ar, Bi, Te) cause to that problem. After soldification process, widmanstatten graphites form flake or spike structure shapes in significant crystallografic plane with precipitation of carbon atoms[1].

For heavy cast iron parts widmanstatten forms, for lighter parts spiky and flake structure are encountered[3].

Widmanstatten graphite plates sit in microstructure as forming of 120° grade. Widmanstatten graphite is extremely thin and can not be detected at magnification of 100X. At this situation for detecting widmanstatten graphite, magnification between 400X and 500X is necessary as a result of accurate sample preparation[2].

2. Reasons of Formations of Widmanstaten Mrophological Structure

2.1. Trace Element Effects

As a result of experiment which practised by Wisconsin University and General Motor Cooperations in Laboratory and factory conditions shows that existing of Lead and trace elements, interaction with humidity

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environment, cooling rate, interaction with Calcium and Lead are parameters accelerates widmanstaten formation.

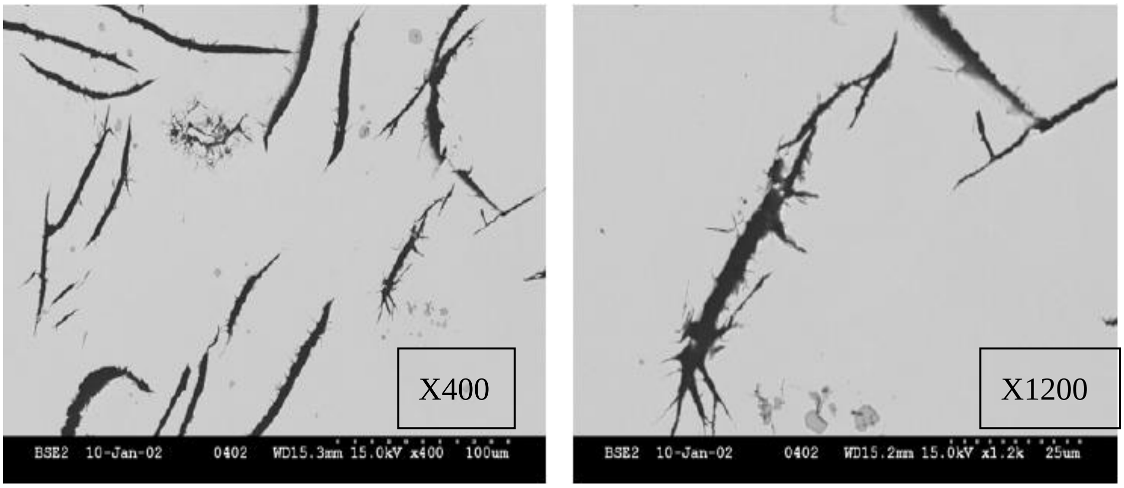


Figure 1. Widmanstatten Graphite at x400 ve x1200

According to literature, the amount of residual lead between %0.002 and 0.004 damages to structure. But only lead contamination does not occur individually without existing of active hydrogen source.

2.2. The Effect of Interaction With Humidity Environment

At experiment that occured in Labratory and factory conditions detrimental effect of lead increase with effect of humidity in enviroment. Humidty is an active hyrogen sources and as a result of combination with Lead decreases surface tension and damages the morphological structure of graphite. Detrimental graphite structure forms with combination of lead and humidty. Nem aktif bir hidrojen kaynağı[3].

2.3. Cooling Rate Effects

Cooling rate is one of important parameters of widmanstaten graphite formation. Lower cooling rates cause to formation of Widmanstaten graphite[3].
At sufficient high temperature, early shake out process is resulted by decreasing the amount Widmanstatten structure[3].

2.4. Calcium Effect of Widmanstatten Structure Formation

According to literature, combination of Calcium and Lead accelerates the formation of widmanstatten graphite.

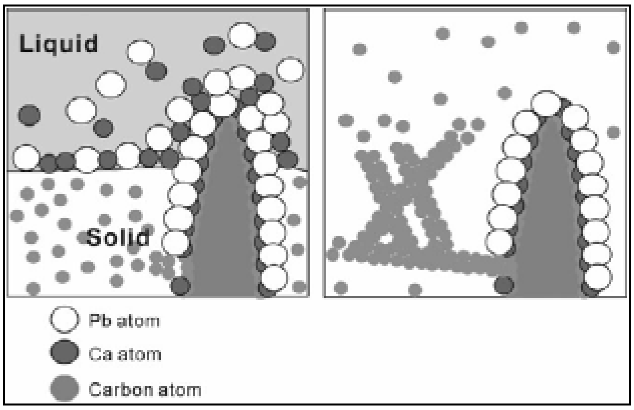


Figure 2. Flake graphite formation by combination of Lead and Calcium

Calcium atoms are bonded with Carbon atoms and covers flake graphite surface of CaC_2 at liquid and solid interface. But CaC_2 can not cover the surface completely. Similarly it is examined that Sr and Ba have the same effect of Ca. Ca_2Pb plate causes to diffusion of carbon atoms to ostenite phase. At this condition, the growth of last graphite is not possible and Carbon atoms which enters to austenite phase are precipiated as orientated crytals of Widmanstaten graphite[3].

3. Chilling Tendency of Castings Contain Lead(Pb)

Accoding to the experience of foundaries, increased chill amount is encountered du to excessive Lead contamination. Chill contains lead form chevron shape at interface of metal and mold in chill sample [3]

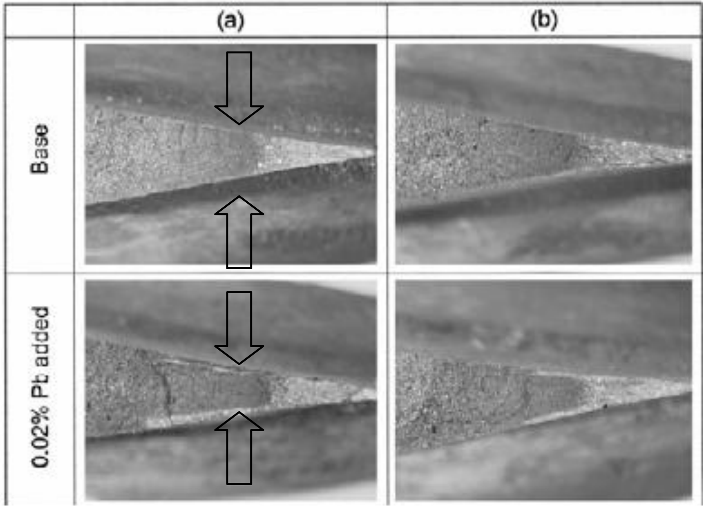


Figure 3. Chevron shaped chill at grey cat iron contain 0.02% Lead

The Aim Of This Study

During this practise, traces elements that affect the widmanstaten structure was investigated with higher magnification and resolution by scanning electron mciroscopy and the qualitative and quantative analysis have been done by EDX analysis.

The SEM Analysis of Grey Cast Iron

At this practise, microstructure images was taken with EBSD tecniques of SEM at different magnifications. The aim of selection of EBSD technique shows elements have different atom numbers in microstructure at differrent contrast level. Consquently at different contrast level is determined of traces elements as qualitatively and quantitatively,

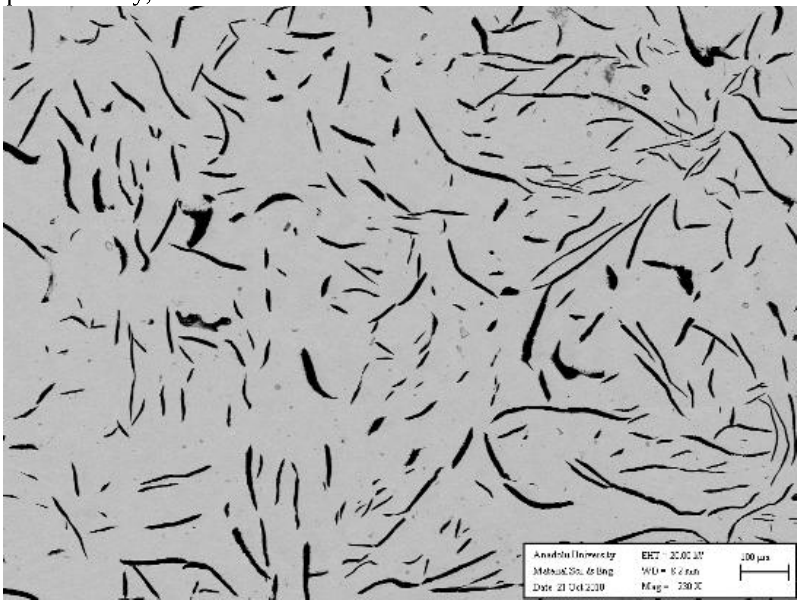


Figure 4. Microstructure images at 230X magnifications.

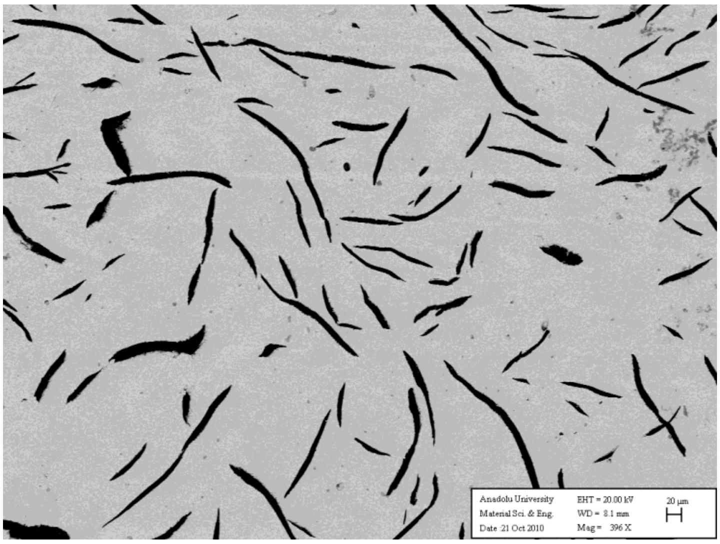


Figure 5. Microstructure images at 396X magnifications.

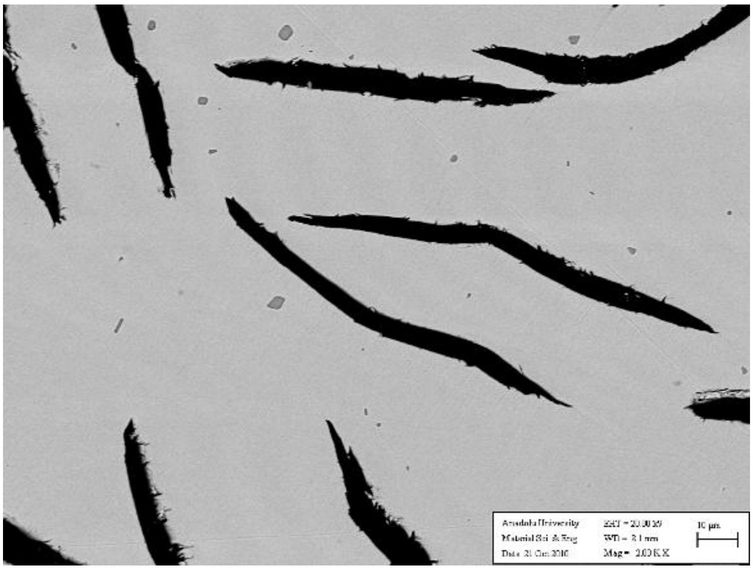


Figure 6. Microstructure images at 2000X magnifications

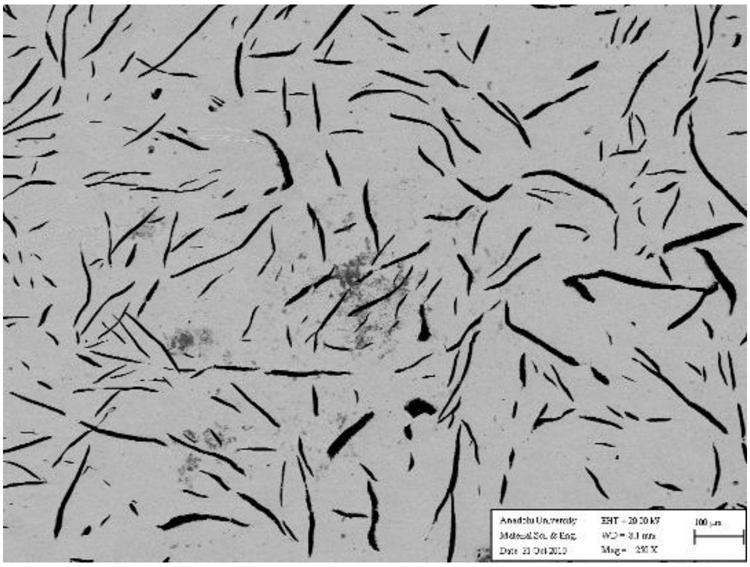


Figure 7. Microstructure images at 250X magnifications

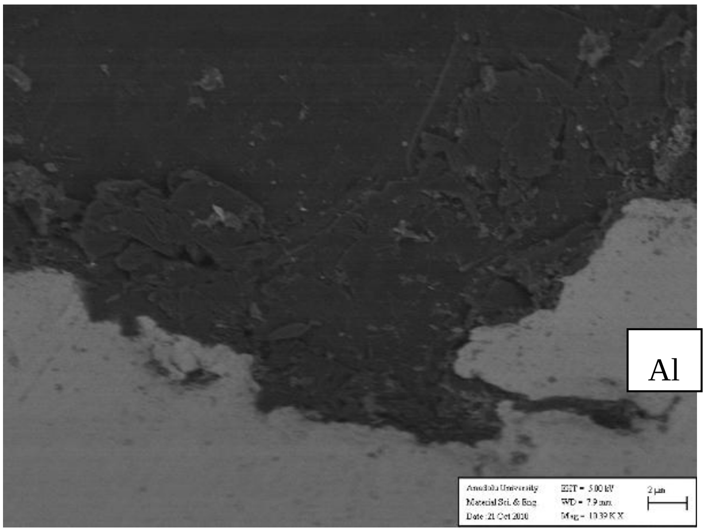


Figure 8. Microstructure images at10390X magnifications

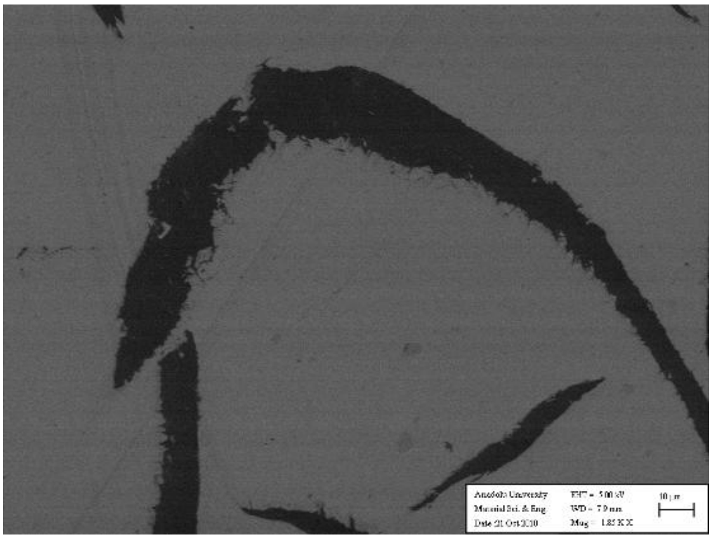
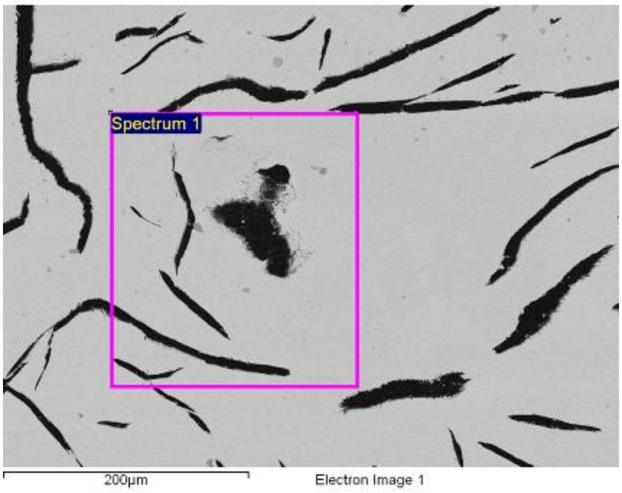


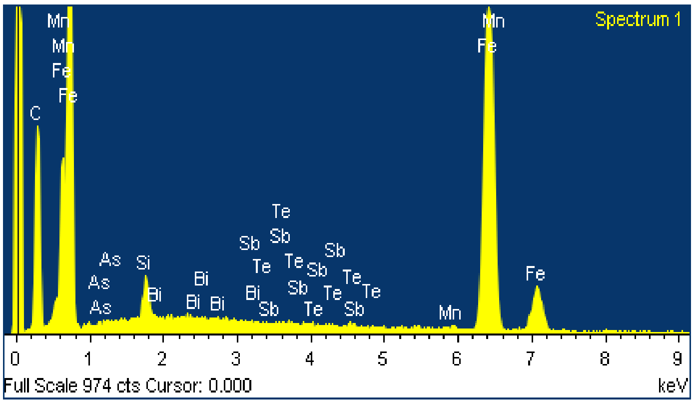
Figure 9. Microstructure images at 1850X magnifications

2. SEM EDX Analysis

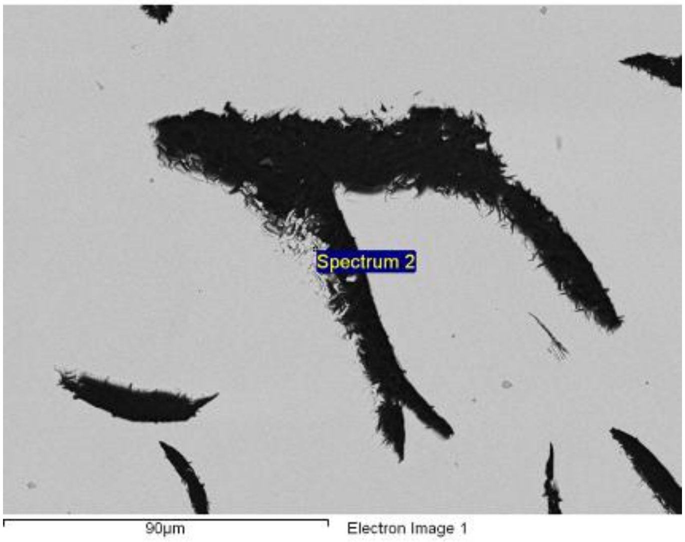
2.1. EDX Analysis for Spectrum 1



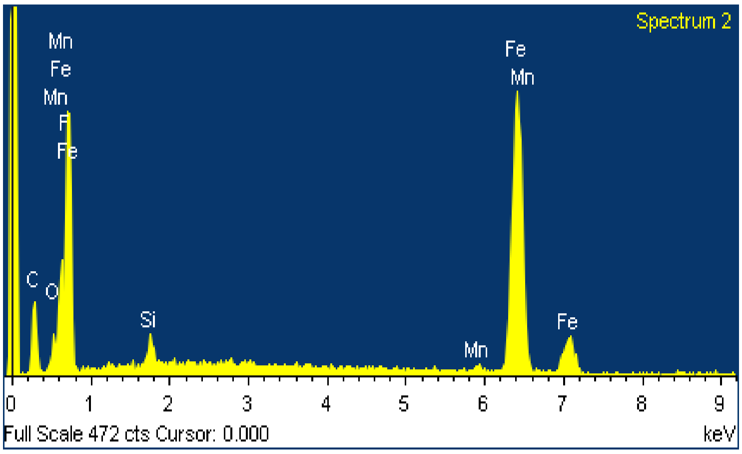
Element	Weight %	Atomic %
C K	43.81	77.86
Si K	1.75	1.33
Mn K	0.37	0.14
Fe K	54.08	20.67
As L	0.00	0.00
Sb L	0.00	0.00
Te L	0.00	0.00
Bi M	0.00	0.00
Totals	100.00	



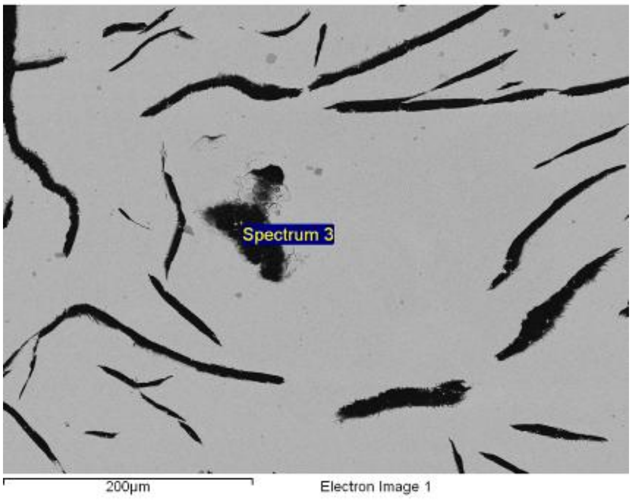
2.2. EDX Analsis for Spectrum 2



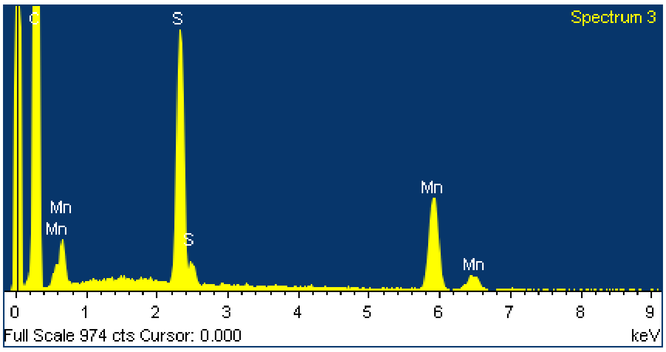
Element	Weight%	Atomic%
C K	25.81	57.64
O K	4.99	8.36
F K	0.00	0.00
Si K	1.57	1.50
Mn K	1.09	0.53
Fe K	66.55	31.96
Totals	100.00	



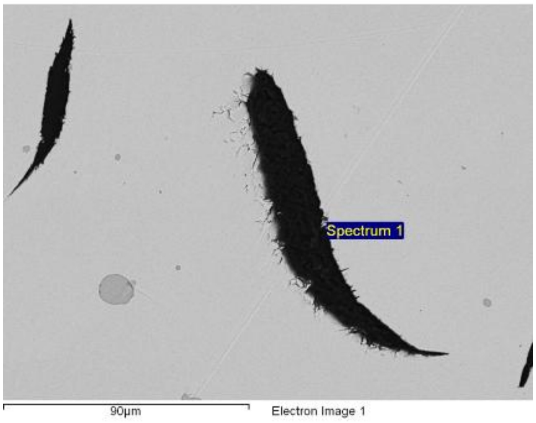
2.3. EDX Analysis of Spectrum 3



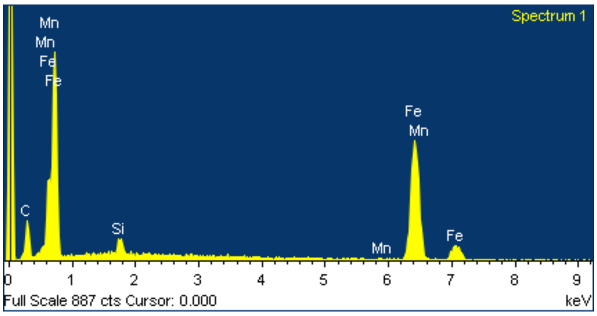
Element	Weight%	Atomic%
C K	87.29	96.02
S K	5.36	2.21
Mn K	7.35	1.77
Totals	100.00	



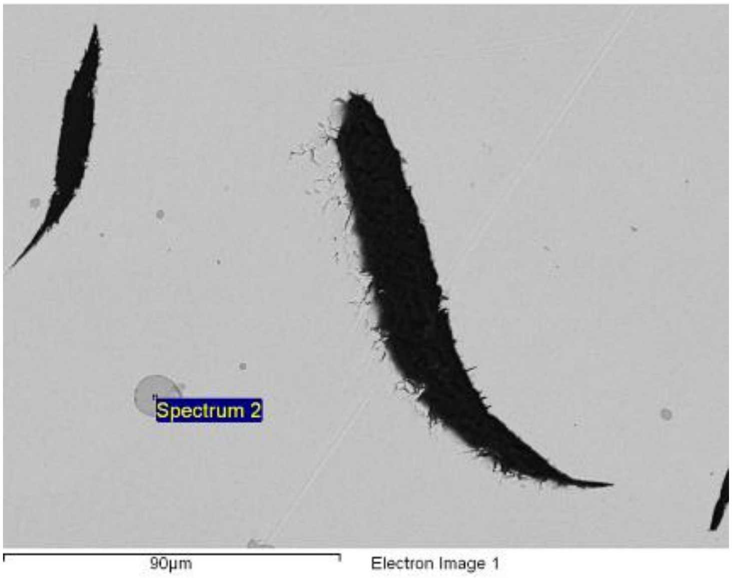
2.5. EDX Analysis Of Spectrum 1



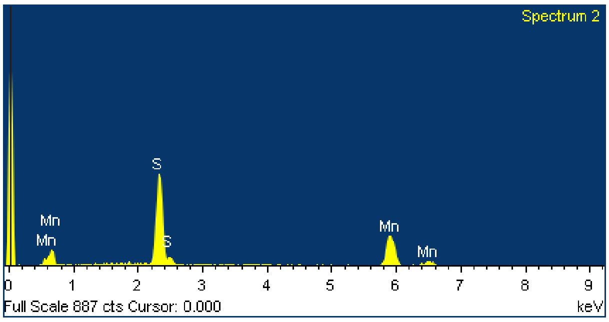
Element	Weight%	Atomic%
C K	29.57	65.33
Si K	2.58	2.43
Mn K	0.42	0.20
Fe K	67.43	32.04
Totals	100.00	



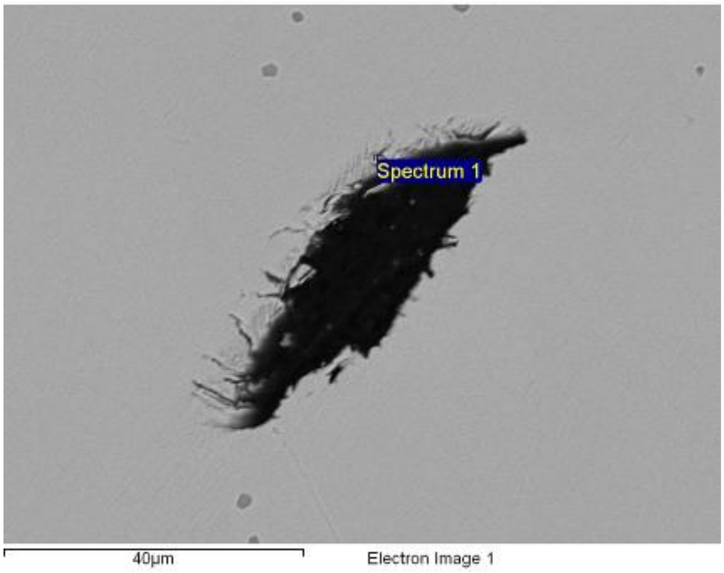
2.6. EDX Analysis Of Spectrum 2



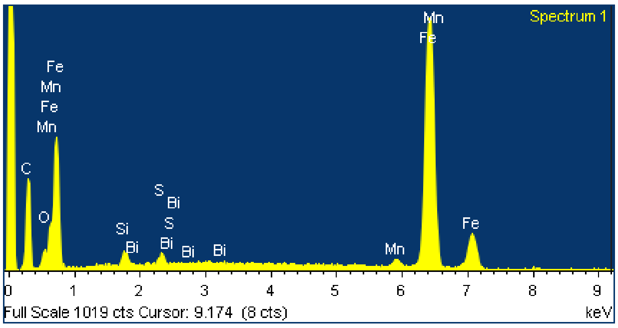
Element	Weight %	Atomic %
S K	46.70	60.02
Mn K	53.30	39.98
Totals	100.00	



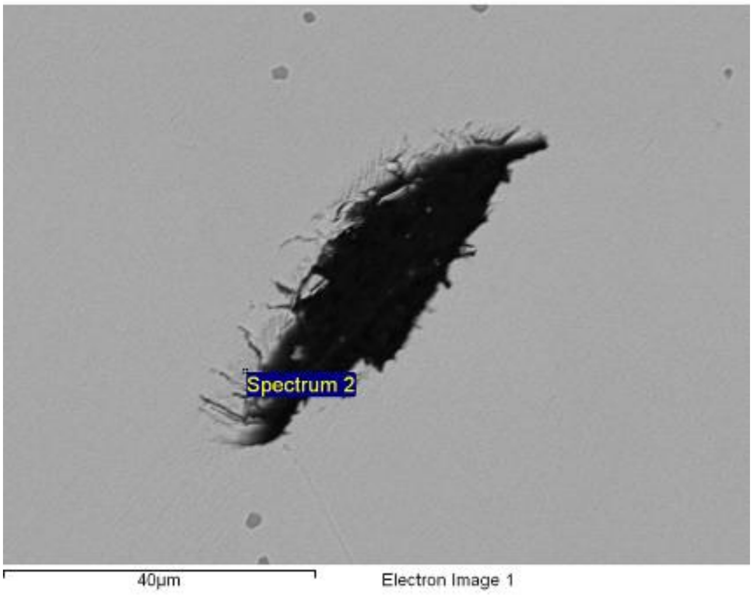
2.7. EDX Analysis Of Spectrum 1



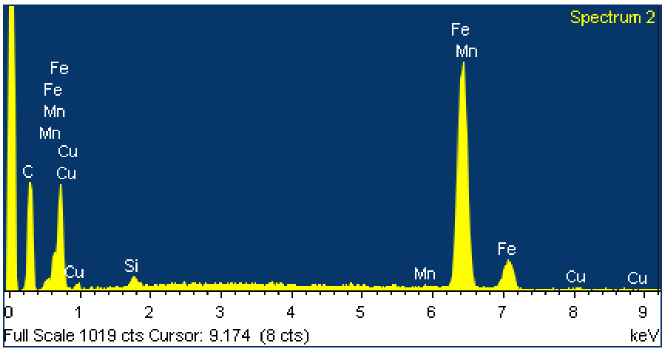
Element	Weight%	Atomic%
C K	31.54	65.34
O K	3.28	5.10
Si K	0.86	0.76
S K	0.76	0.59
Mn K	1.48	0.67
Fe K	61.69	27.49
Bi M	0.39	0.05
Totals	100.00	



2.8. EDX Analysis Of Spectrum 2



Element	Weight%	Atomic%
C K	38.30	74.09
Si K	0.64	0.53
Mn K	0.37	0.16
Fe K	60.22	25.05
Cu K	0.47	0.17
Totals	100.00	



3. Results and Recommendations

At different magnifications values by EBSD tecniques point and area analysis have been practised. At microstructure images,the amonut of trace elements (Pb, As,Sb, Bi …) can not be detected by EBSD tecniques. The ppm amounts of trace elements restiricts to detect these elements in microtructure. For quantitative analysis of cast iron contains Widmanstatten structure can be detected ICP(Inductivelt coupled plasma) and XRF (X –ray fluoresence).

References:

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