International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

COPY RIGHT

IJIEMR Transactions, online available on 4th Jan 2021. Link :http://www.ijiemr.org/downloads.php?vol=Volume-10&issue=ISSUE-01

DOI: 10.48047/IJIEMR/V10/I01/69

Title **Effect of Micro Segregation in Case Carburised Steel**

Volume 10, Issue 01, Pages: 344-348

Paper Authors

B. Ramesh Chandra

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

To Secure Your Paper As Per UGC Guidelines We Are Providing A Electronic Bar Code

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Effect of Micro Segregation in Case Carburised Steel

B. Ramesh Chandra[a]
[a]Department of Metallurgical Engineering, JNTUH College of Engineering, Hyderabad, India

Abstract
It is generally known that pearlite and ferrite are usually organised in layers in hot rolled low alloy steels. This pattern appears as a banded structure in longitudinal section. The segregation of substitutional alloying elements during dendritic solidification causes microstructural banding. Case carburising is one such technique in which the influence of phase change within the case is critical in achieving the component's desired hardness and wear properties.The purpose of this study was to determine the impact of microstructural changes in steel that occur when it is carburized in the presence of banding for ordinary forged steel. For this, a typical carburising steel, 14NiCrMo13, was carburized and microstructural tests were performed.Banding was detected at all phases of the manufacturing process. The steel case undergoes a differential phase transformation when it is carburized in the presence of banding, with alternate layers of various percentages of martensite and retained austenite in the case and martensite and bainite in the core.
Keywords: Case Carburising, Steel, Banding, Micro segregation

Introduction
Steels are often presumed to be homogeneous in structure for design purposes. They aren't, unfortunately. The composition of ingots cast from a single ladle of molten steel is revealed by macro chemical analysis. These surveys also reveal that the composition of each ingot varies from the bottom to the top, and from the centre to the edges. Part-to-part composition variability, as well as differences within each part, will be evident in a series of forgings made from a single ingot. Such deviations, on the other hand, rarely deviate from the intended steel's specification range. The variability that occurs on a microscale over extremely short distances is of more importance. Micro segregation is the term for this variation.

Kirkaldy Et al determined which process leads to the evolution of bands of distinct phases in a seminal 1962 paper [1]. Because segregation patterns can be seen with specialetching techniques [2,3], it was known that banding coincided with chemical microsegregation, but it was unclear how segregation causes bands. Jatczak et al. [5] and Bastien [6] postulated two alternative methods, which Kirkaldy refers to as "pre-segregation" and "trans segregation."
Tensile, hardness, and impact testing were used to investigate the effect of banding on the mechanical properties of steel. Banding has only a little effect on tensile parameters like yield strength and ultimate tensile strength [7], although Grange [4] reported that the reduction in area was reduced when compared to an unbanded

microstructure, implying a poorer ductility. Whether impact attributes change with the degree of banding is a topic of debate in the literature. The Charpy impact energy reduced as the anding increased, but the material got more anisotropic, according to SakirBor [7]. For brittle fracture, Owen et al. [3] found no change in Charpy impact energy, but they did see a difference in the ductile range.

From the literature, the aim of the present study is to determine the effect of micro segregation in steel by varying the carburising heat treatment process.

Experimental Procedure

In the present work melts of 14NiCrMo13steel as specified in table-1 were made in a Electric Arc Furnace. Molten steel was homogenized by purging inert gas and then cast into ingots of 3ton weight having an average cross section of 450x450mm, by up-hill teeming. Solidified ingots were subsequently rolled in a 2- high, 860mm reversible blooming mill, and cooled under controlled conditions, surface conditioned and subsequently rolled to Ø125mm 550mm 3-high, 4-stand bar mill.

Table-1 Showing specification of the steel under study.

Element	%C	%Si	%Mn	%Ni	%Cr	%Mo	%P	%S
Specification	0.11-0.15	0.20-0.26	0.65-0.75	3.10-3.35	1.40-1.50	0.10-0.14	0.015 Max	0.015 Max

The raw material was analysed for chemistry and micro structural banding. Grain size of the raw material was evaluated. Mechanical properties such as tensile and impact studies were also analysed in hardened condition.Banding Investigations were performed on materials taken from industrial forging to evaluate in real life conditions as this steel is forged extensively and used for various components of automotive industry. The forging flow lines, raw material chemistry and microstructure were also analysed. The forging was again subjected to gas carburising in a sealed quench furnace.

Table-2 Showing carburising process parameters

Material	14NiCrMo13	Furnace type	Sealed quench furnace
Process	Carburising	Case depth	2.00 mm
Carburising Temperature	930 °C	Carburising Time	36 Hours
Hardening Temperature	820 °C	Tempering Cycle	180°C for 4 Hours

.

The process graph for carburising is shown below in fig. 1.

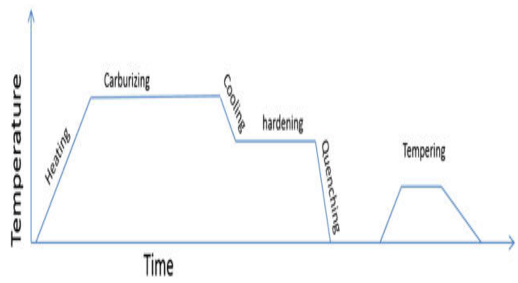

Fig.1 Showing time vs temperature graph for carburising.

Post carburising the samples were prepared for metallographic analysis as before mentioned sample preparation steps.

RESULTS & DISCUSSIONS

Chemical Composition

The chemical composition was measured using optical emission spectrometer. The sample were selected from mid radius of the raw material section.The results from chemical composition are shown in below table 3.

Table 3 Showing chemical composition of the steel.

Element	%C	%Si	%Mn	%Ni	%Cr	%Mo	%P	%S
Specification	0.11-0.15	0.20-0.26	0.65-0.75	3.10-3.35	1.40-1.50	0.10-0.14	0.015 Max	0.015 Max
Observed	0.12	0.21	0.67	3.18	1.44	0.11	0.010	0.005

As can be seen, the chemical composition of the investigated steel is within the range required by the specification.

Optical Micrography

The raw material and forging macro etching was carried out and the pictures of macro structure are show below in figure 2:The fig. 2 shows raw material macro structure and is better than C2R2S2 condition of standard ASTM plates. The material looks free form harmful impurities and centre looseness with equiaxed grains

Fig. 2Showing raw material macro structure.

Fig. 3 (a) Shows the raw material at 100x.

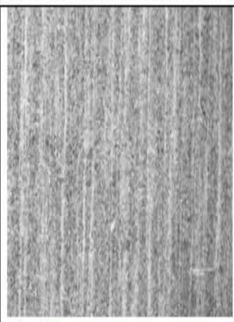

Fig. 3 (b) Showing banding lines at 25x

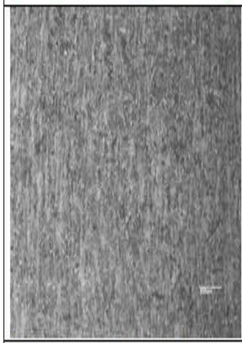

Fig. 3(c) shows forged section at 25x

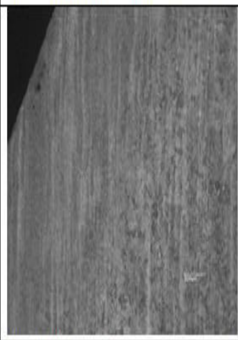

Fig. 3 (d) shows the carburised case and core at 25x.

The microstructure was captured at each stage of manufacturing and the banding or segregation lines and their behaviour at each stage Viz. from rolling →forging→ carburizing was studied.

The microstructure analysis was done in hard stage to compare the banding effect with similar basic condition. For this all the samples of raw material, forging and carburised parts were hardened from 820°C. It was observed that the effect of banding was noticed at all stages of manufacturing. Figure 3(a), (b) shows the banding line in a as received material at various magnification.Perlite banding in hot rolled steel is manifested by the formation of dark lines in polished and etched sections aligned parallel to the rolling direction. However, the 5% Nital etched specimens was not able to resolve the lines of banding. This can be attributed to the reduction ratio that has been imparted to the steel. As it was rolled down form the ingot to 125 RCS section the resultant reduction had caused to thin down the banding lines to a thickness of <100µm or less. The effect of banding was known clearly only at higher magnification. Further, 5% Nital, etched specimen appeared very dull under optical microscope.

In the Fig 3(c), the intensity of the banding at lower magnification is observable but is not clearly resolved even with the 25x magnification lens. This can be attributed to the further reduction that has been imparted during forging of the cone. Also the uniform flow of the rolled micro structure is disturbed and we can observe slight curvature of the flow lines.

In the Fig 3(d) the carburised case and core is shown. Note the effect of banding still exists even after carburising

Heat Treatment Cycle

The hardened and tempered carburised parts was sectioned and heat treatment parameters were analysed and are shown in below table 4. The hardness cut off was taken at 513HV1.

Table 4 Showing heat treatment results.

Parameter	Result
Case Depth	2.04 mm
Case Hardness	57 HRC
Core Hardness	38 HRC

Mechanical Properties:

The mechanical properties of the steel were measured in hardened and tempered condition. For this the steel samples were heated to 820°C and soaked at this temperature for 60 minutes. The samples were then quenched in oil. Theses quenched samples were tempered at 180°C for 4 hours. The samples were then machined to standard specification and mechanical tests were carried out. The results are shown in table 5 below.

Table-5 Showing mechanical properties of the steel under study.

Parameter	Hardness	Yield point	UTS	% Elongation	%RA	Impact Charpy V notch
Specification	38-43 HRC	135 Min	175 KSI Min	10% Min	75% Min	75 Min
Observed	39.7	160.48	182.24	16.4	64.17	131.3

Hardness Profile

The Hardness was measured using Rockwell hardness C scale with a load of 150Kg as per ASTM E18 and results are as follows in table 6:

Table 6 Showing bulk hardness.

Parameter	As rolled	Forging	Carburised core
Hardness	42	39	38

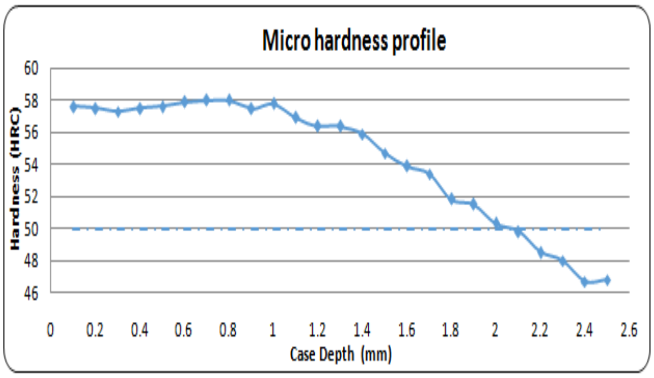

Fig. 3 Showing micro hardness profile of carburised part.

CONCLUSION:

Industrial grade 14NiCrMo13 was used in the present study to evaluate the effect of carburising over micro structure.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

- The steel was manufactured in an electric arc furnace, ladle refines, vacuum degassed and ingot casted. The steel was subsequently rolled to 125 RCS and then forged.
- The forged component was carburised at 930°C for 36 hours in a sealed quench furnace to obtain 2.00mm case depth and surface carbon of 0.58%C. The carburised component was then hardened at 820°C and quenched in oil and then again tempered at 180°C for 4 hours.
- The carburised case microstructure showed fine tempered martensite and retained austenite.

REFRENCES:

[1] G. Krauss. Steels: Processing, Structure and Performance. ASM International, 2005.
[2] L. E. Samuels. Optical Microscopy of Steels. ASM, 1980.
[6] W. S. Owen, M. Cohen, and B. L. Averbach. The influence of ferrite banding on the impact properties of mild steel. Welding Research Supplement, pages 368–s—374–s, August 1958.
[4] R. A. Grange. Effect of microstructural banding in steel. Metallurgical Transactions, 2: 417–426, 1971.
[5] W. S. Owen, M. Cohen, and B. L. Averbach. The influence of ferrite banding on the impact properties of mild steel. Welding Research Supplement, pages 368–s—374–s, August 1958.
[6] C. F. Jatczak, D. J. Girardi, and E. S. Rowland. On banding in steel. Transactions of the
ASM, 48:279–305, 1956.
[7] A. Sakir Bor. Effect of pearlite banding on mechanical properties of hot-rolled steel plates. ISIJ International, 31(12):1445–1446, 1991.