An Investigation on Texture-Property Correlation in CRNO Steels

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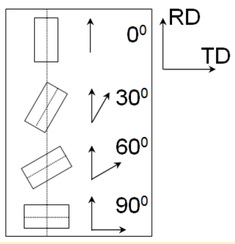
INTRODUCTION

Major applications of CRNO (Cold Rolled Non-Oriented) steels are core material for electrical motor, rectifiers, generators, small size core transformers etc. They posses low core loss and high permeability for such applications. Two important metallurgical factors that are responsible for the above said properties are grain size and texture. As grain size increases, hysteresis loss decreases due to increase in domain width and eddy current loss increases. So, there is an optimum grain size which determines the sum of hysteresis loss and eddy current loss to a minimum value. For example, the optimum grain sizes are100 micron and 150 micron for 1.85% and 3.2% Si steel respectively. Material with a texture favorable for magnetic properties shows lower core loss than those with an unfavorable texture, although they have same grain size. Texture components like (001)<*uvw*> and (111)<*uvw*> are considered respectively as good and bad texture components. (111)<uvw> is the worst texture for magnetic properties. Unlike CRGO (Cold Rolled Grain Oriented) steels, a specific orientation cannot be considered in CRNO steels which are used in cores for rotating machines and in these machines the angle between directions of the applied electric field and rolling direction vary continuously. Keeping this in mind, the present study deals with investigating textural and magnetic properties of two fully processed CRNO steels of 1.4 (wt.%) Si and 2.0 (wt.%) Si. Four sets of samples were prepared for the present investigation: (1) in the rolling direction (A1-0, A2-0); (2) 30˚ to the rolling direction (A1-30, A2-30); (3) 60˚ to the rolling direction (A1-60, A2-60) and (4) 90˚ to the rolling direction (A1-90, A2-90). In this way an attempt has been made to link the texture and magnetic properties of CRNO steels.

EXPERIMENTAL DETAILS

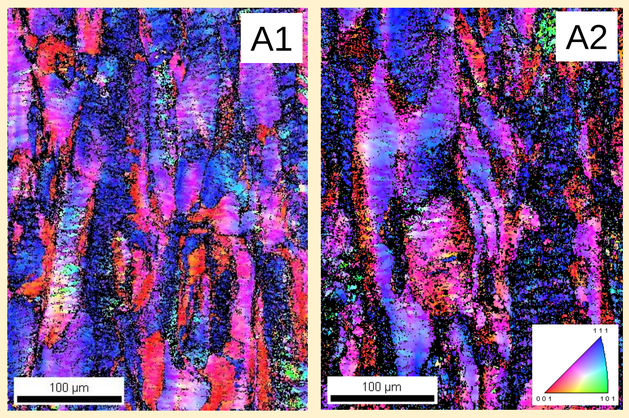
Chemical Composition (wt.%)	A1	A2
C	0.027	0.024
Si	2.000	1.400
P	0.024	0.020
S	0.008	0.025
Mn	0.210	0.190
Al	0.128	0.075
Fe	Balance	Balance

Sample Preparation



Characterization	
Electron Backscattered Diffraction (EBSD)	FEI Quanta SEM
Bulk Texture (XRD)	Panalytical MRD
Magnetic Properties (Core Loss and Magnetic Permeability)	Brockhaus Messtechnik

EBSD

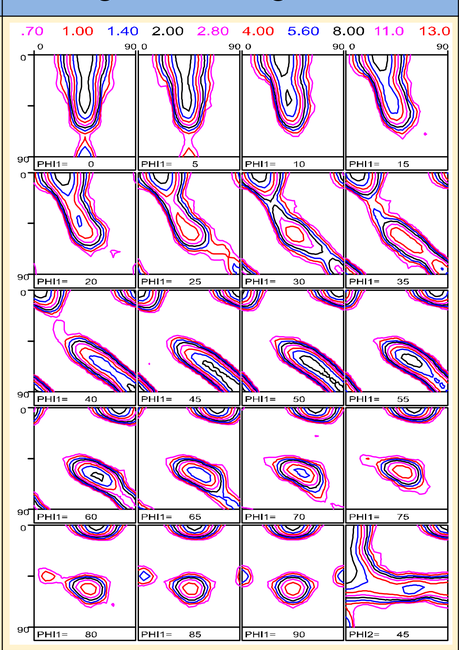
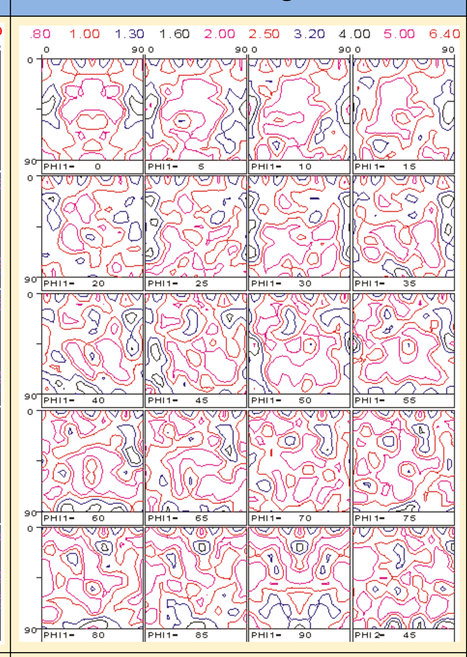
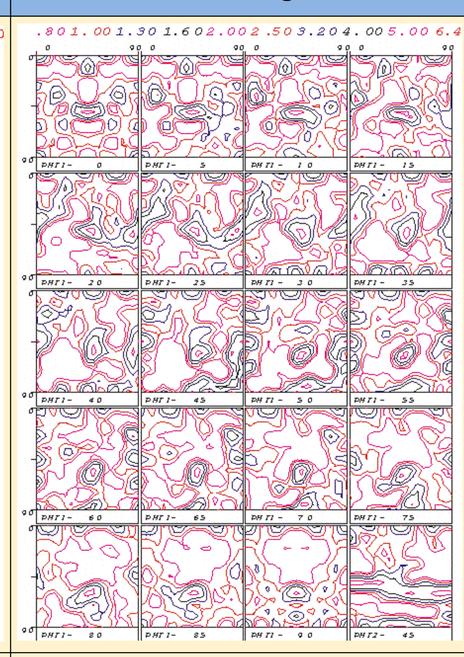
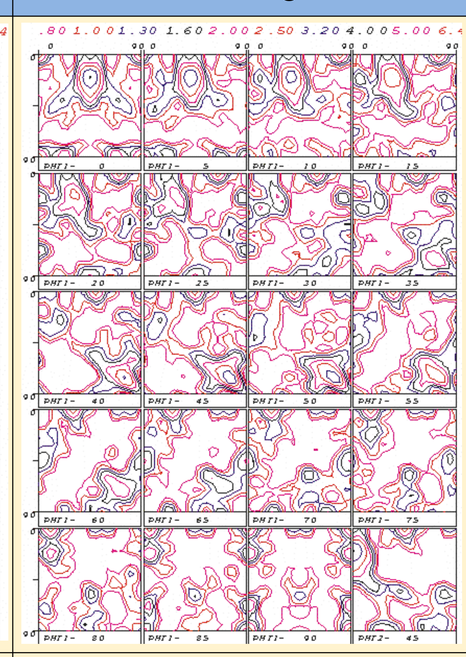
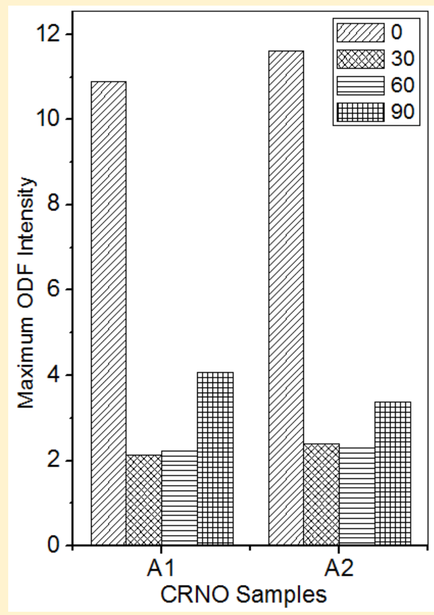
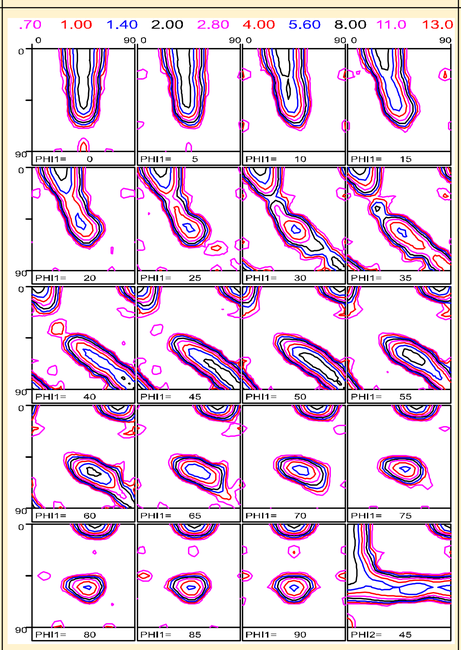
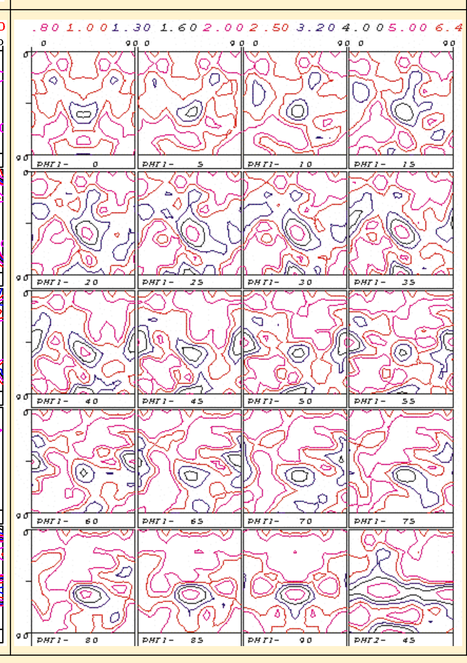
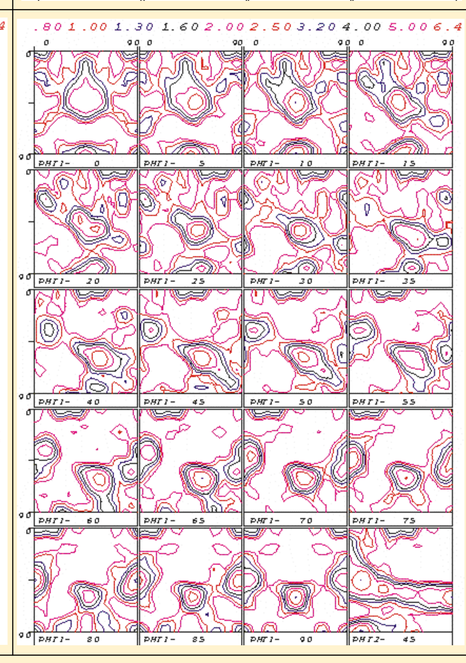
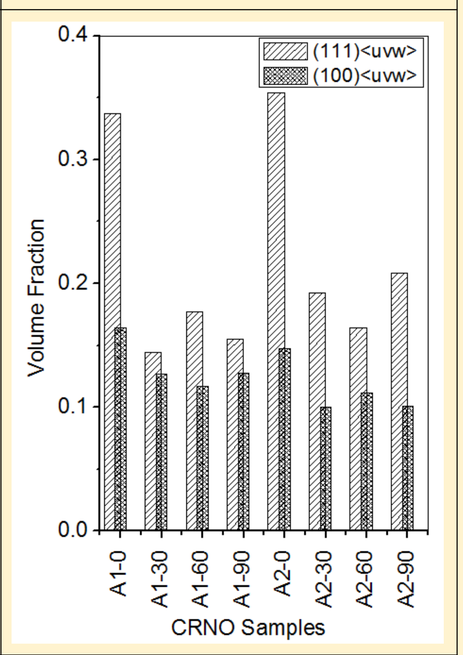


Inverse Pole Figure maps of CRNO samples in the rolling direction

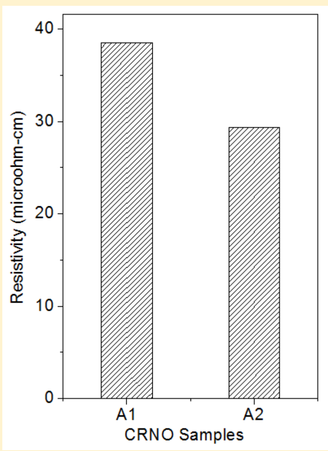
Analysis of Results

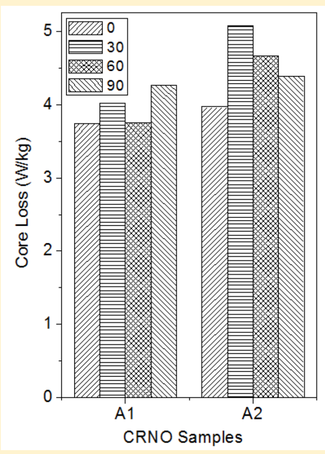
The black regions in the micrographs indicate the low confidence index (<0.5). This shows that the samples were not properly annealed. The grain size of both CRNO samples was nearly equal.

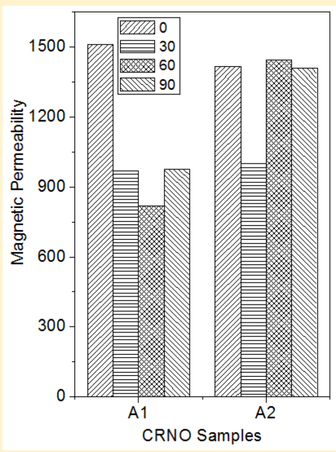
BULK TEXTURE

Sample	Along the Rolling Direction	30⁰ to the Rolling Direction	60⁰ to the Rolling Direction	90⁰ to the Rolling Direction	Analysis of Results
A1					
A2					

MAGNETIC PROPERTIES







Analysis of Results

Sample A2 (low Si content) showed low resistivity, high core loss and somewhat good magnetic permeability. The best textured sample (A1-0) showed lowest core loss and highest magnetic permeability.

SUMMARY

- Textural development in CRNO steels was independent of Si percentages. However, it was strongly dependent on angular orientation of CRNO sheets – texture development was higher in rolling direction compared to other angular directions.
- The electrical resistivity increased with increase in Si percentages. However, the magnetic permeability and core loss didn't show any trend with composition i.e. variation of Si percentages.
- The sample with highest texture had highest permeability and lowest core loss.
- The samples other than rolling direction had insignificant texture developments and didn't show any link/trend between texture and magnetic properties.

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