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CRYOGENIC TREATMENT ON AUTOMOBILE DISC BRAKE PLATE

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ABSTRACT
To study the changes in Mechanical properties of 410 SS grade steel and the effect of change in Wear resistance with different constituents after cryogenic treatment. A Cryo-treatment test system is used for the process. Stainless Steel specimens which are used as Disc Brake Plates are Cryo-treated at 93K for 8 Hours and 24 Hours in the test unit. The Results are compared on the basis of Hardness, Wear and Co-efficient of Friction before and after the Cryo-treatment. The effects of Cryo-treatment followed on mechanical properties (Hardness, Wear and Co-efficient of Friction) are experimentally determined and analyzed.

INTRODUCTION
Over the past few decades, interest has been shown in the effect of subzero treatment on the performance of metals. Subzero treatment is generally classified as either cold treatment at temperatures down to dry ice temperature (193K) or deep cryogenic treatment at near Liquid Nitrogen temperature (77K). In the recent years, many commercial cryo-treatment units are available which are focused on improving the tool life of cutting tools. However scientific research on cryogenic treatment has been very less. This is an unexplored field of cryogenics and requires focused study.

In the case of tools, even though there have been claims of improvement in wear resistance properties of cutting tools by cryogenic treatment, there is no clear understanding of the mechanism by which cryo treatment improves wear resistance. Most researchers believe that cryogenic treatment promotes transformation of retained Austenite to Martensite at cryogenic temperature that improves wear resistance. Others claim that formation of η carbides in the Martensite improves wear resistance.

Previously studying the effects of cryo-treatment on the performance of pressure transducers were experimentally envisaged. During the project, a few samples of the raw material were subjected to strength and hardness tests to determine the changes post cryo-treatment. The tests indicated significant improvement in strength properties by nearly 7-8 % after cryo-treatment.
These observations motivated us to extend the experimental studies of cryo-treatment on the mechanical properties of selected grades of stainless steels which are extensively used for space applications.

LITERATURE SURVEY
R.F.Barron Cryogenic treatment of metals to improve wear resistance [1982].
Nineteen metals, including 12 tool steels, 3 stainless steels, and 4 other steels, were subjected to cryogenic treatments to determine the difference between a 189 K soak and a −77 K soak in improving the abrasive wear resistance. The tool steels exhibited a significant increase in wear resistance after the soak at 77 K and a less dramatic increase after the 189 K soak. There was an increase in the wear resistance after the cryogenic treatment for the stainless steels, but the difference between the two treatments was less than 10%. The plain carbon steel and the cast iron showed no improvement after either cryogenic treatment.
J. D Darwin, D.M.Lal, G.Nagarajan investigated optimization of cryogenic treatment to maximize the wear resistance of 18% crmartesitic stainless steel [2008].
Deep cryogenic treatment (DCT) is a one time permanent process, carried out on steel components in such a way that the material is slowly cooled down to the cryogenic temperature, after which it is held at that temperature for a specified period of time and is heated back to room temperature at a slow rate followed by low temperature tempering. The main advantage of DCT is to enhance the wear resistance. The various levels of DCT process parameters have their own influence upon the wear resistance of the material. In this study, the Taguchi method has been used to optimize the process parameters of DCT for a commercial piston ring, made up of 18% Cr martensitic stainless steel (SR34) to obtain maximum wear resistance.
Effect of cryogenic treatment on mechanical properties of materials. (D.S Nadig. Principal Research Scientist, Centre of Cryogenic Technology, IISC).

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To study the changes in mechanical properties of steels after cryogenic treatment, a cryo-treatment test system has been designed and developed. Steel specimens (07X16H6) which are used as valve materials for LH2 and LOX in cryogenic engine are cryo-treated at 93K for 24 hours in the test unit. The effects of cryo-treatment followed by tempering on mechanical properties (Tensile strength, Impact strength and Hardness) are experimentally determined and analyzed

Effect of Cryogenic treatment on mechanical properties of steel (D.S Nadig, V. K Pavan, M. R Bhatt, P. V Venkitakrishnan)

Cryogenic treatment on metals is a well-known technology where the materials are exposed to cryogenic temperature for prolonged time duration. The process involves three stages viz. slow cooling, holding at cryogenic temperature and warming to room temperature. During this process, hard and micro sized carbide particles are released within the steel material. In addition, soft and unconverted austenite of steel changes to strong martensite structure. These combined effects increase the strength and hardness of the cryo-treated steel. In this experimental study, the effects of cryogenic treatment, austenising and tempering on the mechanical properties of stainless steel (07X16H6) have been carried.

CRYOGENIC TREATMENT

Cryogenic treatment follows a procedure where the test samples are cooled down to cryogenic temperature at a definite rate, held for longer time duration and warmed to room temperature at a definite rate. This cryo-treatment cycle can be operated for various conditions of temperature, duration, rate of cooling and warming.

In the case of steels, three important changes take place during the process, viz.

1. The lattice structure of the atoms changes due to stresses being relieved.
2. The soft, tough and ductile FCC structured Austenite of the metal is almost converted to strong BCC structured Martensite, which is very strong.
3. Existing carbon atoms are evenly dispersed.
4. Many small carbide particles are created which fit between the existing larger atoms.

This results in more uniform and dense arrangement of the atom structure

MATERIALS AND METHODS

STAINLESS STEEL (SS410)

Stainless Steel 410 is a martensitic stainless steel that provides good corrosion resistance with high strength and hardness. It is magnetic in both the annealed and hardened conditions. A wide range of properties can be developed with different heat treatments. Applications requiring moderate corrosion resistance and high mechanical properties are ideal for this alloy.

Table 3.1: Chemical Composition Range OF 410 SS Grade

Grade		C	Mn	Si	P	S	Cr	Ni
410	Min	-	-	-	-	-	11.5	0.75
	Max	0.15	1	1	0.04	0.03	13.5	

DISC PLATES
MATERIAL CONSTITUENTS

Zr	Fe	Mn	Cr	Cu
0.03	85.54	1.69	12.27	0.22

Figure 3.1 Disc brake plate

TESTS CONDUCTED

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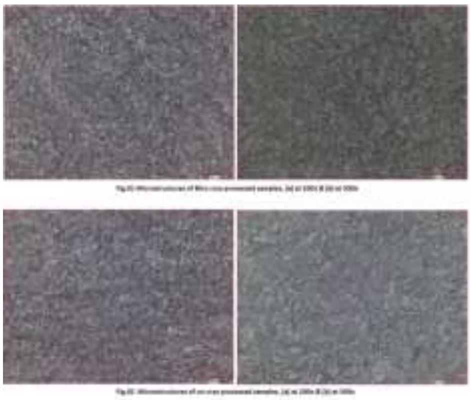
- **HARDNESS**
- **WEAR**.
- **MICROSTRUCTURE:**



NVN,Microstructureis defined as the structure of a prepared surface or thin foil of material as revealed by a microscope above 25× magnification.The microstructure of a material (which can be broadly classified intometallic,polymeric, ceramicandcomposite) can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior, wear resistance, and so on, which in turn govern the application of these materials in industrial practice. Microstructure at scales smaller than can be viewed withoptical microscopesis often called ultrastructure or nanostructure.

RESULTS and DISCUSSIONS

HARDNESS TEST:

Method of Testing		As per IS 1586 Part I : 2012		
No. Of samples		Three		
Type of Inspection		Hardness Measurement		
Results				
Sl. no.	Sample Identification	Hardness Measured in HRC		
		1st value	2nd value	3rd value
1	Sample A Uncryo	35.1	36.8	35.9
2	8hrs Sample A Cryo	36.7	35.7	36.3
3	24hrs Sample A Cryo	38.4	39	38.6

Table 4.1: Hardness Table

CHANGE IN WEIGHT:

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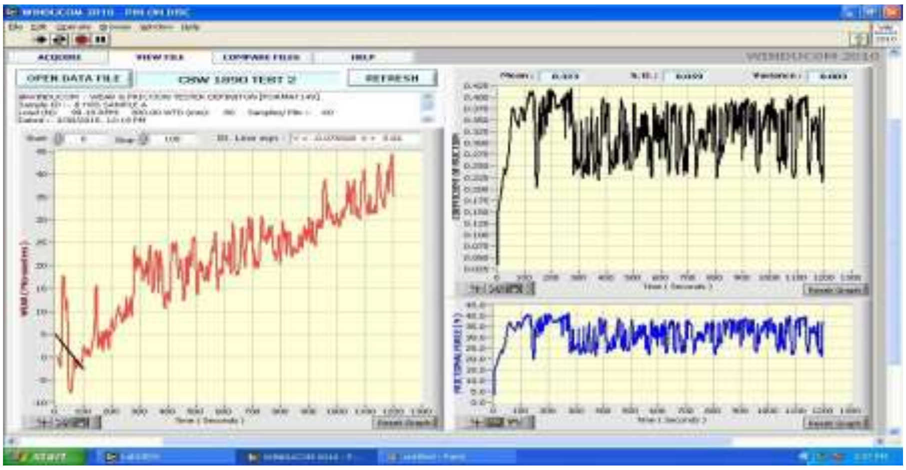
Method Of Testing		As per IS 1586 Part I : 2012		
No. of Samples		Three		
Type Of Inspection		Wear Test		
Results				
Sl. no.	Sample Identification	Weight Measured		
		Initial Weight	Final Weight	Change in weight
1	Sample AUncryo	2.8805	2.8591	0.0213
2	8hrs Sample A Cryo	2.5668	2.5562	0.0154
3	24hrs Sample A Cryo	2.5597	2.5442	0.0140

Table 4.2 Change in weight

WEAR TEST:

GRAPH 4.1: SAMPLE A- WITHOUT CRYO-TREATMENT



GRAPH 4.2: SAMPLE A- WITH CRYO-TREATMENT OF 8 HOURS

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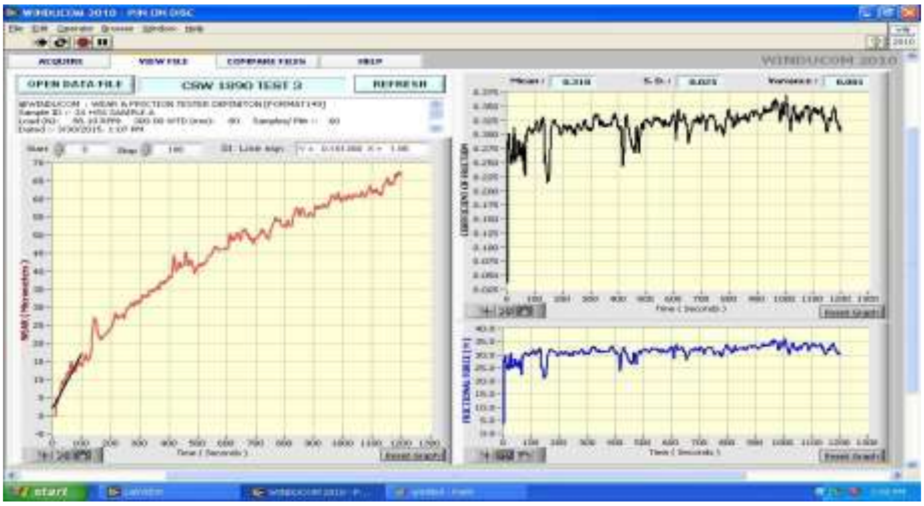


GRAPH 4.3: SAMPLE A- WITH CRYO-TREATMENT OF 24 HOURS

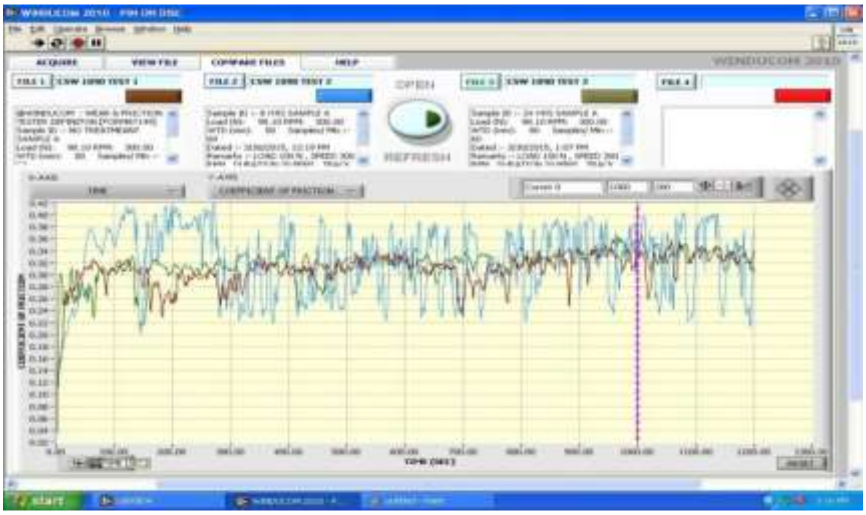
SUMMARYOF RESULTS:

Sample	Test number	Treatment (hours)	Wear (µm)	Coefficient of Friction	Frictional Force (N)
A	1	0	175	0.35	35
	2	8	45	0.42	40
	3	24	68	0.37	36

Table 4.3 Summary of the Result

ANALYSIS:

COEFFICIENT OF FRICTION FOR SAMPLE A



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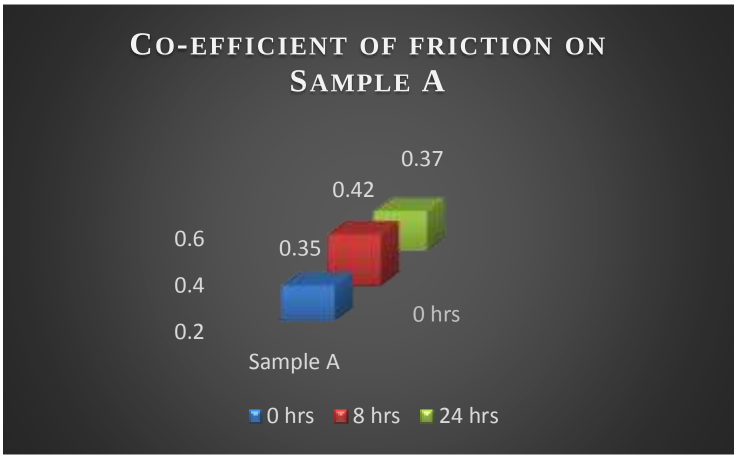
Result Graph 4.4 : Co-Efficient of friction for Sample A

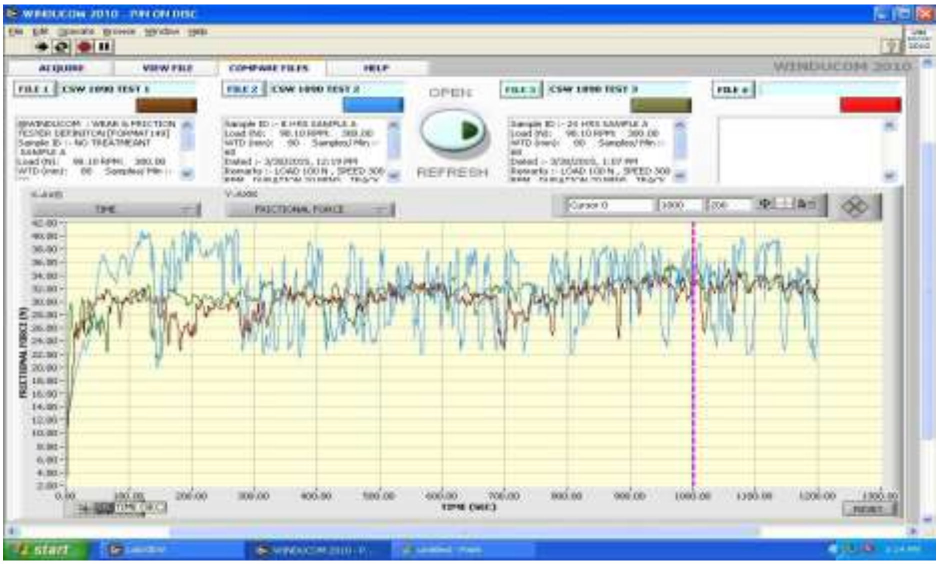
Sample	Test Number	Treatment time (hr)	Co-efficient of friction
Sample A	1	0	0.35
	2	8	0.42
	3	24	0.37



Bar Graph 4.5

X-Axis: Samples Y-Axis: Co-Efficient of Friction Z-Axis: Time

FRICTIONAL FORCE FOR SAMPLE A



Result Graph 4.6:

Sample	Test Number	Treatment time (hr)	Frictional Force (N)
Sample A	1	0	35
	2	8	40
	3	24	36

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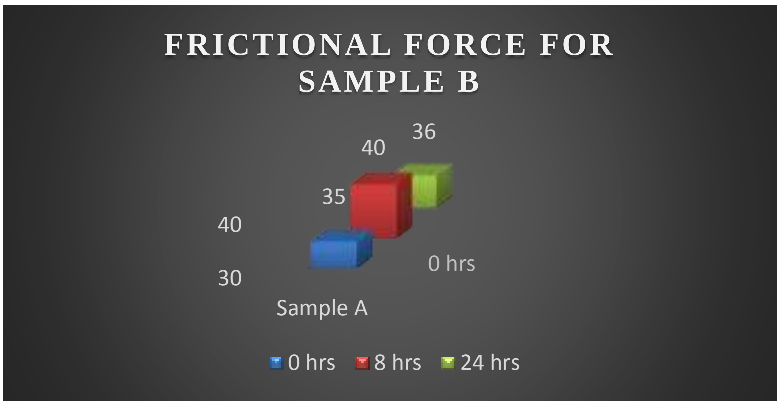
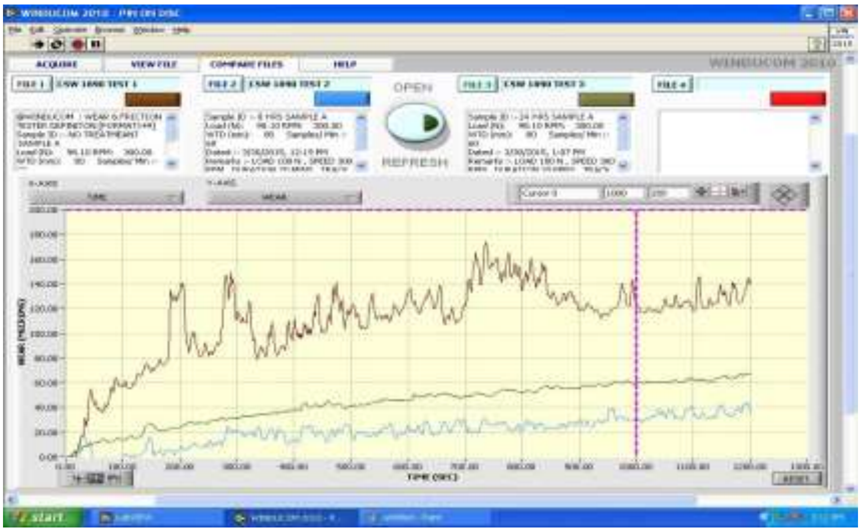


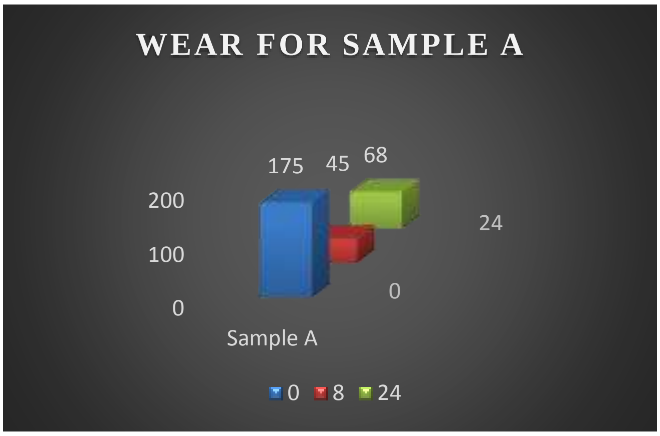
Bar Graph 4.7
X-Axis: Samples Y-Axis: Frictional Force Z-Axis: Time

WEAR FOR SAMPLE A



Result Graph 4.8

Sample	Test Number	Treatment time (hr)	Wear (μm)
Sample A	1	0	172
	2	8	45
	3	24	68



Bar Graph 4.9
X-Axis: Samples Y-Axis: Wear Z-Axis: Time

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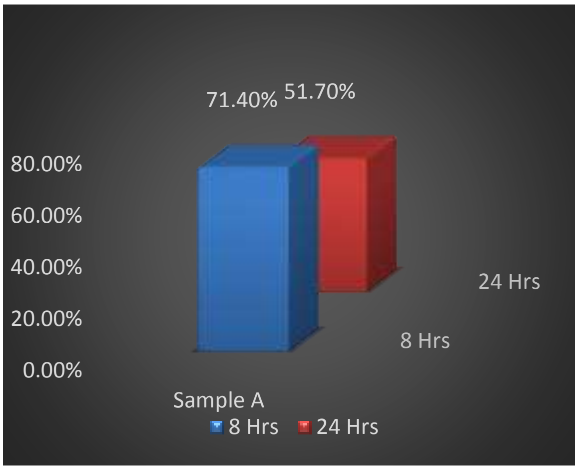
Summary of Analysis:

Wear Resistance for Sample A

Sample	Test no.	Treatment (Hours)	Wear(µm) at 1200 seconds (300rpm)
A	1	0	140
	2	8	40
	3	24	65

Percentage wear resistance at 8 hours with respect to 0 hours = $\frac{140-40}{140} \times 100$ = 71.4%

Percentage wear resistance at 24 hours with respect to 0 hours = $\frac{140-65}{140} \times 100$ = 51.7%



Bar Graph 4.10

X- Axis: Sample Y-Axis: Wear Resistance (%) Z-Axis: Time

CONCLUSION

The main objective of this experimental study was to study the effects of cryo-treatment on the mechanical properties of selected steel. In realizing the objectives of the project, cryo-treatment was carried out. The test results have shown consistent trend as per the theoretical background. It is evident that the process of cryo-treatment has enhanced the properties appreciably. Cryo-treatment process could alone improve the mechanical properties significantly. These treatments were carried continuously with minimum time gap between them.

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