WEAR CONDUCT INVESTIGATION OF AISI 410 MARTENSITIC STAINLESS STEEL BY CRYOGENIC PROCESS

M. Bala Theja[1*], K. Hemachandra Reddy[2]

Article History: **Received:** 11/10/2021 **Revised:** 22/12/2021 **Accepted:** 13/01/2022

Abstract

Martensitic stainless steels discover wide applications due to their ideal blend of quality, hardness and wear resistance in cryogenic condition. AISI 410 martensitic stainless steel, subjected to cryogenic hardening was considered using pin on disc tests took after by metallurgical examinations using scanning electron microscopy and energy dispersive spectroscopy. The microstructure includes martensite with randomly scattered carbides in the matrix. In this paper, it is used to enhance the wear conduct investigation of martensitic stainless steel 410 by cryogenic hardening process.

Keywords – *AISI 410 martensitic stainless steel, Cryogenic hardening, Microstructure, Pin on disc test, Wear resistance*

[1*]Associate Professor, Department of Mechanical Engineering, SVR Engineering College, Nandyal,A.P., India, Email: balathejaphd@gmail.com

[2]Professor, Department of Mechanical Engineering, JNTUA college of Engineering, Ananthapuramu, A.P., India

***Corresponding Author:** M. Bala Theja

*Associate Professor, Department of Mechanical Engineering, SVR Engineering College, Nandyal,A.P., India, Email: balathejaphd@gmail.com

DOI: - 10.53555/ecb/2022.11.01.20

I. INTRODUCTION

Stainless steels are present day materials. Stainless steel is the non specific name for different assorted steels used essentially for their impenetrability to disintegration.

Martensitic stainless steels can be high or low carbon steels worked around the sort 410 formation of iron, 12% chromium and up to 1.2% carbon. They are the most tempered and set. Tempered martensite gives steel extraordinary hardness and high quality. Untempered martensite is low in sturdiness and thus fragile.

To accomplish the coveted smaller scale structure and mechanical properties, martensitic stainless steel is subjected to a suitable hardening heat treatment. In any case, for a given length of treating, a predictable reducing in hardness with increase in hardening temperature every now and again does not happen in view of complex nature of the treating conduct. Or maybe in certain alloy steels, discretionary hardening is seen in the midst of the hardening heat treatment.

Utilization of cryogenic treatment, to improve the properties and service life of tool materials have been broadly inquired about from as ahead of schedule as 1940s. Until 1960 endeavours of sub zero treatment were made by directly immersing tools and metal parts in liquid nitrogen. Increments in hardness and wear resistance were the major valuable impacts, observed in components subjected to sub zero treatment apart from improved surface finish, reduced coefficient of friction at the interface between work piece and tool.

Cryogenic hardening is a cryogenic treatment process where the material is cooled to very low temperatures. By utilizing liquid nitrogen, the temperature can go as low as -190ºC. It can have a profound effect on the mechanical properties of certain materials like expelling residual stresses and improving wear resistance on steels. In addition to seeking enhanced stress relief and stabilization, or wear resistance, cryogenic treatment is also sought for its ability to improve corrosion resistance by precipitating micro fine carbides.

Mechanical achievement in refrigeration cycles cross prepared the advancement of cryogenic treatment systems that were able to carry out effective crack less cryogenically treated parts. The first ever sub zero treatment system as built up by Ed Busch in 1960s. It was further redesigned by Diminish Paulin with a feedback temperature control system, on cooling and warm up circuits.

This was an exact report regarding the hardening behaviour and wear conduct investigation of AISI 410 martensitic stainless steel with an objective of perceiving a sensible heat treatment remembering the true objective to finish needed properties without the risk of breaking in the midst of heat treatment and subsequent organisation. This paper presents the results of this examination of wear conduct investigation of AISI 410 martensitic stainless steel by cryogenic hardening heat treatment.

II. RESEARCH METHODOLOGY

The specimens were set up out of AISI 410 martensitic stainless steel. Since it is a relative report on the impacts of cryogenic treatment, three specimens were prepared. Initially all the specimens were subjected to conventional heat treatment. At the end of conventional heat treatment, two specimens were subjected to cryogenic treatment.

Fig 1 Crogenic Freezer

A cryogenic freezer appeared in Fig 1 was utilised for heat treating the AISI 410 martensitic stainless steel.

III. EXPERIMENTATION

A. Microstructure Test

polished using progressively finer grades of sand paper up to 1200 mesh. Microstructure of the specimen was measured by using metascope metallurgical microscope as shown in Fig 2. The etchant used was kalings reagent with a The pin on disc apparatus has a PC based magnification of 100X

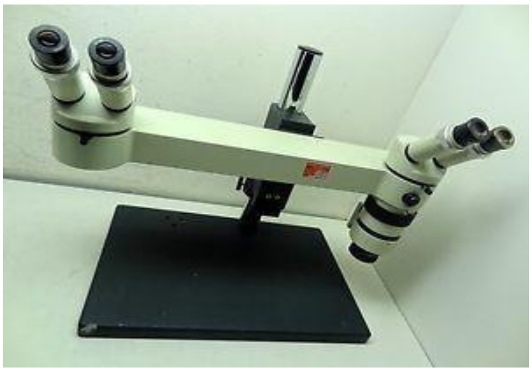

Fig 2 Metascope Metallurgical Microscope

B. Pin-on disc Wear Test

Magnum pin on disc wear tester with stationary pin and rotating disc configuration as shown in Fig 3 was used for conducting sliding abrasion wear study.

Fig 3 Pin-on disc apparatus

The wear tests were conducted at a constant room temperature of 29ºC and relative humidity 60%, under dry condition. Cylindrical pins of diameter 8mm and length 28mm were prepared from AISI 410 bar of 40mm cylindrical cross section. Ends of the pin were polished using progressively finer grades of sand paper up to 1200 mesh.

The pin on disc apparatus has a PC based controller and friction monitor as shown in Fig 4, used to control the parameters of the pin on disc contraption. The parameters required are speed in rpm and load in N. In light of the parameters, the framework will create the estimations of coefficient of friction andestimations of frictional force for the given day andage in the interim of 5 minutes.

Fig 4 Wear and friction monitor

The weights of the specimens were recorded using a digital balance as shown in Fig 4 before loading them on wear tester.

Fig 4 Digital balance

Disc of Ø165mm and thickness 8mm with four holes of Ø4.5mm on pitch circle of Ø155mmwere made out of 410 steel. Surface of disc was polished to the same finish as that of pins, beforeconducting the wear study. The sliding abrasion wear tests were conducted for a constant sliding velocity of 4m/s and load of 10N with the speed varying between 500- 1000rpm during the wear test. Weight loss of each pin was measured at the end of each test

IV. RESULTS AND DISCUSSIONS

A. Case depth through Optical Microscope

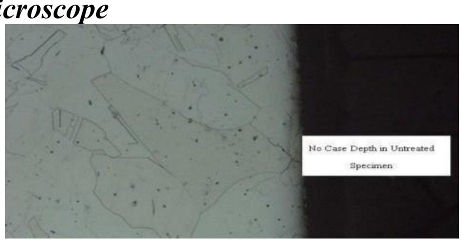

Fig 5 Untreated specimen

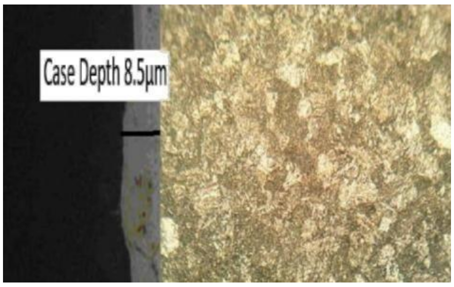

Fig 6 Cryogenic hardening specimen (-80ºC)

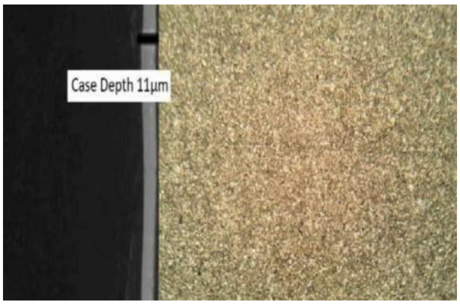

Fig 7 Cryogenic hardening specimen (-100ºC)

From the above optical microscope results, it is noted that as the time of heat treatment increases, case depth also increases. It was noted that in an untreated specimen, no case depth was found. In cryogenic hardening specimens, the case depth was found to be 8.5, 11µm respectively.

B. Pin-on disc wear test

The wear specimens were subjected to cryogenic hardening heat treatment.

C. Morphology of worn pin

To characterize the wear behaviour of both untreated and cryogenic hardening specimens, the scar of pin after wear test, was examined under scanning electron microscope. Fig 8 and Fig 9 shows the SEM images of cryogenic hardening specimen before pin on disc test at 500X and 1000X magnification.

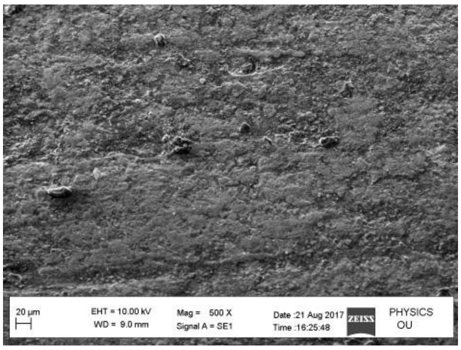

Fig 8 Cryogenic hardening specimen at 500X

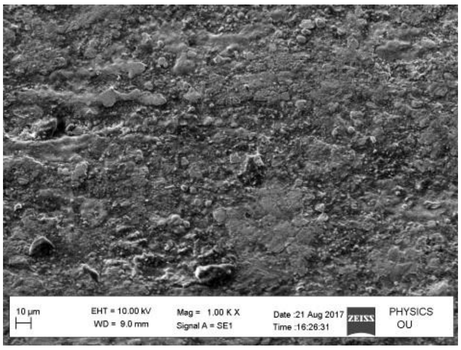

Fig 9 Cryogenic hardening specimen at 1000X

Fig 10 and Fig 11 shows the SEM images wear scar of cryogenic hardening specimen after pin on disc test at 500X and 1000X magnification.

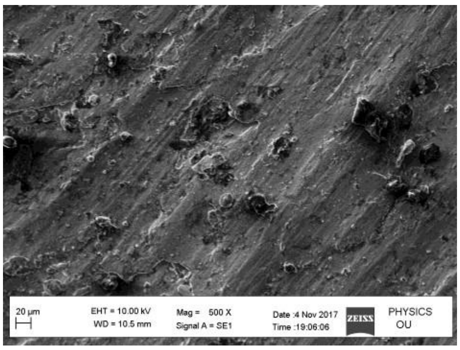

Fig 10 Cryogenic hardening specimen at 500X

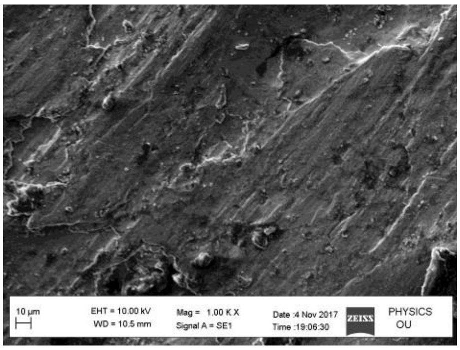

Fig 11 Cryogenic hardening specimen at 1000X

D. Energy dispersive spectroscopy x-ray analysis

Fig 12 shows the energy dispersive spectroscopy x-ray analysis of AISI 410 martensitic stainless steel cryogenic hardening specimen.

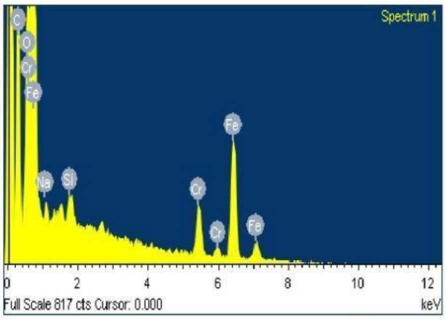

Fig 12 Cryogenic hardening specimen

V. CONCLUSIONS

Outcome of the above experiments assist to infer the following conclusions 1. Cryogenic treatment carried out at -100C promoted complete transformation of tomartensite. 2. Within the range of test variables used for sliding abrasion wear test, mild oxidative mode ofwear was dominant. The main reason for the reduction in the wear rate was due to the strengthening of martensite matrix by fine precipitates of carbides. The above results assist to infer that AISI 410 has exhibited wear behavior response under cryogenic treatment.

REFERENCES

1. G. Prieto, J.E. Perez Ipina, W.R. Tuckart (2014) Cryogenic treatments on AISI 420 Stainless steel: Microstructure and Mechanical properties, *Materials Science and Engineering A* 605, 236-243
2. Kamran Amini, Amin Akhbarizadeh, Sirus Javadpour (2012) Investigating the effect of holding time on the microstructure of 1.2080 tool steel during deep cryogenic heat treatment, *Vacuum* 86, 1534-1540
3. Madhi Koneshlou, Kaveh Meshinchi Asl, Farzad Khomizadeh (2011) Effect of cryogenic treatment on microstructure, mechanical and wear behaviours of AISI H13 hot work tool steel, *Cryogenics* 51, 55-61
4. Shahong Li, Lihui Deng, Xiachun Wu, Yong'an Min, Hongbin Wang (2010) Influence of deep cryogenic treatment on microstructure and evaluation by internal friction of a tool steel, *Cryogenics* 50, 754-758
5. Das D, Dutta AK, Ray KK (2009) Influence of varied cryo treatment on the wear behaviour of AISI D2 Steel. *Wear*, 266(1-2) 297-309
6. Akhbarizadeh A Shafyei, Golazar MA (2009) Effects of cryogenic treatment on wear behaviour of D6 tool steel, *Mater Des*, 30, 3259-3264
7. Darwin J Mohan Lal, D Nagarajan (2008) Optimization of cryogenic treatment to maximize the wear resistance of 18% Cr martensitic stainless steel by Taguchi method, *J Mater Process Technol*, 195, 241-257
8. Wilkins C (1999) Cryogenic processing: the big chill, *EDM Today*, 36-44
9. Meng F Tagashira K Shoma H (1994) Wear resistance and microstructure of cryogenic treated Fe-1.4Cr-1C bearing steel, *Scripta Metal Mater*, 31(7), 865-868
10. Barron RF (1982) Cryogenic treatment on metals to improve wear resistance *Cryogenics*, 22, 409-414