Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 20 (2018) 113–118

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

2nd International Conference on Materials Manufacturing and Design Engineering

Minimization of Distortion in Heat Treated AISI D2 Tool Steel: Mechanism and Distortion Analysis

Tushar Sonar[a]*, Sachin Lomte[a], Chandrashekhar Gogte[b], V. Balasubramanian[c]

[a] *Department of Mechanical Engineering, Maharashtra Institute of Technology, Aurangabad, 411001, Maharashtra State, India*
[b] *R & D Department, MIT Academic and Research Institute, Aurangabad, 411001, Maharashtra State, India*
[c] *Centre for Materials Joining and Reserch (CEMAJOR), Annamalai University, Chidambaram, 608002, Tamilnadu State, India*

Abstract

Heat treatment is used for the advancement in mechanical properties of the material depending on their application. Quenching is general stage in heat treatment process which involves rapid cooling of the formerly austenitized part succeeding to phase transmutation from austenite to martensite in steel. It results in the distortion of a mechanical component. This also affect on its surface integrity. This investigation presents the distortion behavior of heat treated AISI D2 Tool steel using standard Navy C-ring test. Deep cryogenic treatment was performed to reduce the transformational stresses and induce the reversed residual stresses to reduce the distortion potential of AISI D2 Tool steel. Results showed minimum dimensional deviation in deep cryogenic treatment as compared to conventional heat treatment. The hardness and surface finish is also improved by 1.26% and 13.43% as compared to conventional heat treatment. The improved surface finish is a measure of reduced distortion in deep cryogenically treated AISI D2 Tool steel.

Peer-review under responsibility of the scientific committee of the 2nd International Conference on Materials Manufacturing and Design Engineering.

Keywords:Heat treatment; Cryogenic treatment, Quenching; Distortion; Navy C-ring etc.

1. Introduction

Heat treatment is used to achieve the advancement in mechanical properties of steel components. It involves a

* Corresponding author. Tel.:+91-7507491023.
E-mail address: tushar.sonar77@gmail.com

Peer-review under responsibility of the scientific committee of the 2nd International Conference on Materials Manufacturing and Design Engineering.
10.1016/j.promfg.2018.02.016

quenching stage, which results in undesirable distortions in the component [1]. The distortion of heat treated parts affects on its functional performance and leads to the production and economical losses [2-3]. The distortion encountered during the process of hardening the tool steels are the changes in the size and shape of a mechanical component. D2 Tool steel is an air hardening, high carbon, high chromium tool steel widely used for the cold working of metals. It is used for making cutting tools and dies. Distortion control is the major requirement in Heat treated AISI D2 Tool steel applications. The use of Navy C-ring test to study the distortion behaviour of the material during quenching in heat treatment has been reported in the literature [1] [4-13]. The distortion of the mechanical component is analyzed by observing the dimensional changes of heat treated Navy C-ring specimens machined from the same material. The distortion of the Navy C-ring is generally considered to be comparable to those of the actual heat treated component [1-13]. Manivannan et al. [5] studied the distortion in heat treated 1010 steel C ring samples and concluded that the distortion due to nitrocarburisation process is less as compared to the carbonitriding and carburizing process. Li et al. [6] performed Navy C ring test on quench treated and deep cryogenically treated cold work die steel Cr8Mo2SiV and observed that the variation in cooling rate and temperature distribution between the gap and core regions of the specimen are prominent. The gap opening and core region of the ring showed a more rapid and a slower cooling rate respectively. There is a latent possibility of hardening crack at the gap region of the Navy C-ring during quenching. The changes in the cooling rate and thermal gradient are notably less in DCT than in QT. Nan et al. [7] studied distortion of nitro-carburized 1010 steel using Navy C-ring test and concluded that nitocarburizing performed at 565°C for a period of 5 hours resulted in lesser distortion. Da Silva et al. [1] investigated distortion of AISI 4140 steel in oil quenching and confirmed that simulation and experimental results are in good agreement. Leskovšek and Ule [8] observed the dimensional changes of HSS using Navy C-ring test and concluded that the dimensional stability of the navy C-ring was improved due to the deep cryogenic treatment after vacuum heat treatment. Diekman [9] claimed that the cryogenic treatment of the workpiece before heat treatment results in less distortion in heat treatment and thus the less amount of grinding is required to flatten or to resize the workpiece. Lomte [14] admitted that deep cryogenic treatment affects on the intensity of residual stresses which can be considered as a measure of durability of any tool steel.

In the literature, there is a lack of systematic investigation on the distortion behavior of AISI D2 Tool steel. The research is focused mainly on the comparison of experimental results with simulation. This research paper aims at investigating the effect of heat treatment on the distortion behavior of AISI D2 Tool steel using a standard Navy C Ring Test and minimizing the distortion using a deep cryogenic treatment. For the precise measurement CMM is used.

2. Experimental work

AISI D2 Tool Steel confirming to TAC-21/X160Cr12 grade as per IS 1570 (Part 6) was selected with chemical compositions as shown in table 1.

Table 1 Chemical composition of D2 Tool steel

Elements	C	Mn	Cr	Ni	Mo	S	P	Si	V	W
Wt %	1.61	0.30	11.50	0.15	0.43	0.014	0.018	0.25	0.16	0.077

The Navy C-ring samples were manufactured by VMC machine as per the standard dimensions as shown in fig.1. The D2 Tool steel samples of size 20 mm X 20 mm X 12 mm were machined for surface roughness, hardness and microstructural tests. The samples were then machined by surface grinder with 0.02 mm as a depth of cut. All the samples were cut and machined with the same cutting conditions before treatment. Navy C-ring and metallographic samples were subjected to vacuum heat treatment and deep cryogenic treatment as per the heat treatment schedule depicted in table 2.The dimensions of the D2 Tool steel Navy C-ring specimens were measured by CMM (Cordimesur 6.10.5) before and after heat treatment. The dimensions were measured at three sections: top, middle and bottom. The average of 3 readings was taken as a final reading of each dimensional parameter. To study the microstructural changes, the metallographic samples were first polished and then etched by the Picral etchant (4g Picric acid and 100ml Ethanol). The samples were then examined under an Optical microscope at 500X. The Surface Roughness values (R_a and R_t) were measured using a Taylor Hobson, Seltronic 3 profilometer with a cutoff