International Journal of Computer Architecture and Mobility
(ISSN 2319-9229) Volume 3 -Issue 4, June 2015

Study of Castor Oil Based Quenchant with Metal Salts as Quench Accelerators in Heat Treating Medium Carbon Steels

Ashwini K Patil[*], P. Dinesh[*]and S.B.Patil[#]

[*]Department of Mechanical Engineering, [#] Department of Chemistry

M.S.Ramaiah Institute of Technology, Bangalore

mseashwini.patil@gmail.com , dineshrao62@gmail.com.

***Abstract*— Heat treatment of steels is carried out to change or modify its mechanical properties for making it more useful with enhanced properties. Of late the heat treatment is making use of eco friendly vegetable oil based quenchant media. In the present work Castor oil is the quenching medium containing metal salts as quench accelerator (sodium nitrate and potassium nitrate). Medium carbon steels are heat treated using this quenching medium under various soaking temperatures. The heat treated specimens have been subjected to hardness, wear and impact tests to observe the influence of the quenching medium and accelerator on their mechanical properties. The results of these tests indicate that their values increase when quenched in castor oil having quench accelerator as compared to untreated condition. This establishes the fact that castor oil can be used effectively as a quenching medium with metal salts as quench accelerators.**

***Keywords*— Quench accelerators, castor oil, heat treatment, carbon steel, metal salt, mechanical properties**

I. INTRODUCTION

Steel is an alloy of iron with definite percentage of carbon raging from 0.15%-2%. These plain carbon steel are classified on the basis of their carbon content, as their major alloying element is carbon [1]. Plain carbon steel is widely used for many industrial application and manufacturing on account of their low cost and easy fabrication [2]. Traditionally steels are heat treated to obtain enhanced mechanical properties. There are many quenching media, of late the focus is on using eco friendly biodegradable quenchants. The use of water and mineral oil based quenchants is reported with their own advantages and disadvantages [3]. This has led researchers to look for alternative media which is biodegradable and eco friendly. Many vegetable oil based quenchants have been successfully used with encouraging results. Soya bean and Palm oils have been shown to give very good results but with their own limitations [4] [5]. Active research is being carried out to blend base vegetable oils with additives to enhance their performance as quenchants. In the present work Castor oil is chosen as base oil to be blended with metal salts such as KNO_3 and $NaNO_3$ to act as quench accelerator. Quench accelerators break down the film surrounding the metal for better heat transfer and faster cooling and effective quenching. The present work results in establishing the use of such quenchant as a substitute for the traditional quenchants with encouraging results.

II. EXPERIMENTAL DETAILS

A) Specimen Details: Medium carbon steel AISI 4140(EN-19) is used for preparing specimens as per ASTM standards and chemical composition of steel 4140 is as shown in Table1. The specimens are 6 mm in diameter and 28 mm long for wear test as shown in Figure1, 60 mm in diameter and 10 mm thick for hardness test as shown in Figure2. and standard Charpy specimens are used in impact tests [7]. as shown in Figure3.

Table1.Chemical composition of Steel AISI 4140 [8]:

C	Si	Mn	P	S	Cr	Mo
0.39	0.265	0.66	0.02	0.014	0.986	0.299

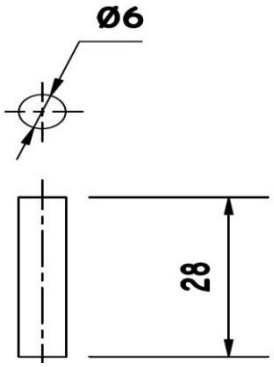

Figure1. dimnesion for wear

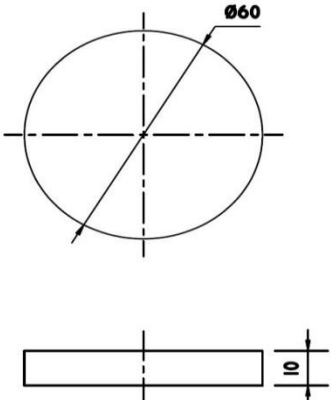

Figure2. dimension for hardness

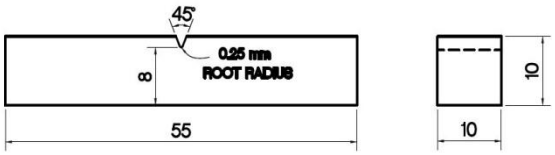

Figure3.dimension for impact

B) Heat treatment of specimen: Heating of the specimens was carried out in furnace as shown in Figure5. The specimens were heated to 850 °C and soaking times are 30, 60 and 120 min were used. The specimen temperature was checked by K type thermocouple. The specimens were then quenched in Castor oil without any metal salts and Castor oil with 5 % by weight of metal salts (Sodium nitrate and Potassium nitrate) respectively. The specimens were allowed to cool to room temperature in the quenching medium and then tempered at 550 °C. After tempering they were allowed to cool down to room temperature. The heat treated specimens were then subjected to mechanical testing.

C) **Mechanical Testing:** The heat treated specimens were subjected to wear test, hardness test and impact test. Two specimens for hardness and three specimens for Charpy and impact were subjected to the test and average value of the results was considered Abrasive wear test was conducted to determine the wear resistance of the material as shown in Figure6, Brinell Hardness test was carried out for determining the hardness as shown in Figure.7 and Charpy Test was conducted to determine toughness of the specimens as shown in Figure 8.

Figure5. Electrical furnace

Figure6. Abrasive belt wear

Figure7. Brinell tester

Figure8. Charpy test

Table2. Consolidated result of the study with 5% metal salt in castor oil

S.No	Quenching Type	Soak time in min	Hardness in BHN	Weight loss in g	Impact energy in J
1	Without heat treatment		252.124	1.77	44.799
2	Castor oil	30	272.295	1.39	88.944
3	Castor oil+$NaN0_3$	30	315.094	1.47	92.868
4	Castor oil+ $KN0_3$	30	304.84	1.25	80.442
5	Castor oil	60	285.497	1.24	84.039
6	Castor oil+$NaN0_3$	60	315.09	1.20	91.56
7	Castor oil+ $KN0_3$	60	304.94	1.49	78.807
8	Castor oil	120	291.585	1.31	86.982
9	Castor oil+$NaN0_3$	120	309.395	1.22	93.849
10	Castor oil+ $KN0_3$	120	299.835	1.85	75.537

Table 2 shows the results obtained from the experiments conducted. It is clear that the mechanical properties undergo a change when subjected to heat treatment. The wear rate is maximum for untreated specimen which reduces when quenched in castor oil with metal salt as quench accelerator. For soak time of 30 min the minimum wear rate is seen in quenching in castor oil containing KNO_3. For 60 min soak time the minimum wear rate is in castor oil containing $NaNO_3$, whereas in 120 min soak time wear rate is minimum for castor oil with $NaNO_3$. This indicates the influence of quench accelerators on wear rate which requires further in depth study. For the various soaking times the hardness is maximum for oil containing $NaNO_3$. This again shows the influence of metal salts on the mechanical properties. As regards the impact strength for various soaking times, castor oil with $NaNO_3$ gives the maximum value. This indicates that metal salts do influence the mechanical

IV. Conclusion

Suitability of castor oil based quenchant with metal salts to act as quench accelerator in heat treatment of medium carbon steels. The study reveals that the metal salts have an influence on the mechanical properties which requires further investigation. The study also establishes the fact that biodegradable quenchants can be effectively used in the heat treatment of steels

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