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Scientific Study on Effect of Various Parameters on Hardenability to Get Required Hardness

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Abstract- Most industrial work in world is interdisciplinary. During working on a project, one may come across problems which are new to them. This paper describes scientific study approach to solve such industrial problems. This study shows knowing the background of problem and effect of problem will be very useful to decide a solution. This approach is given with an example, which describes this approach very efficiently. Also it can be seen very effectively that history of that problem must be taken into consideration. Reason behind failure to get core hardness in hardenability is studied. SAE 8620 which is a nickel chromium molybdenum alloy is tested for Jominy end quench hardenability test. As requirement of hardness at core is very crucial to get. Various parameters like effect of percentage of carbon in alloy, effect of quenching media, and carburisation and specimen size for Jominy test are studied and conclusion is made.

1. INTRODUCTION

Every day one can get across different problems. One such problem can be discussed here. In steel industry you have to give material with specifications provided by customer, which will serve the purpose for their use. Even if specifications are met, customer is unable to serve his purpose then what to do? You have to think upon each and every minute aspect of a problem. In such cases one should know the history of a sample.

Jominy end quench test is employed to know hardenability of steel which is ability of material to get hardened [1]. Here, for SAE 8620 type steel which is mainly used for gears and transmission parts, to get core hardness more than 32 HRC then it is very important to look at initial stages also. SAE 8620 is a low alloy case hardened steel and carburised to get hardened surface. Also, core must be tough. Therefore effect of various parameters on hardenability curve obtained in Jominy end quench test is studied.

2. FLOWCHART FOR STUDY

Following process flow is used to get results.

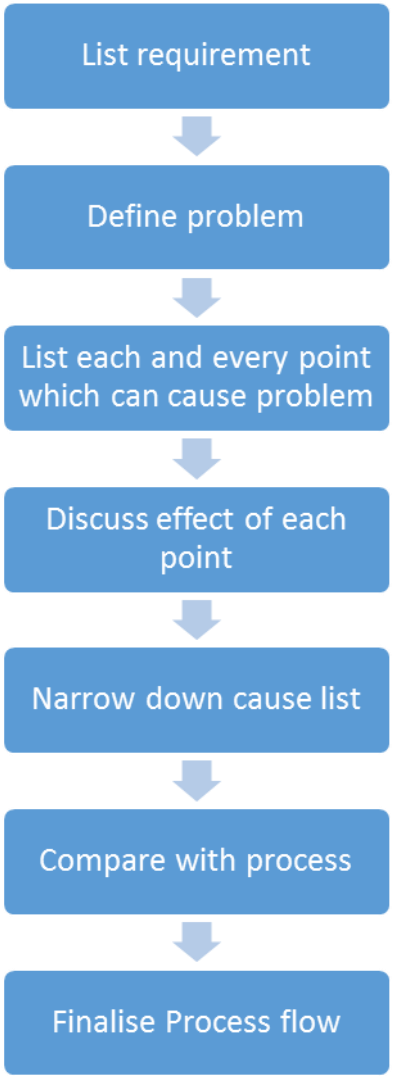

Figure 1: Flowchart used for study

3. MATERIALS USED:

SAE 8620 is taken for the study. It's a Ni-Cr-Mo alloy with low carbon content. Typical Chemical Analysis shows the following chemical composition.

Table 1: Typical chemical composition of SAE 8620

C	Si	Mn	Ni	Cr	Mo
0.2%	0.25%	0.80%	0.55%	0.50%	0.20%

3.1. Requirements:

To use it for gear suppose we require a hardness of 37 HRC at 7 mm in Jominy hardenability test and core hardness of material must be minimum of 32 HRC at 10 mm for sample of 20 mm diameter.

3.2. History of sample

As rolled sample is used for Jominy test. Following processes are carried out on sample before checking the core hardness.

1. Forging
2. Homogenization
3. Carburizing
4. Oil quenching

4. PROBLEM STATEMENT

After Jominy end quench test performed for given sample, it is seen that requirement of hardness in Jominy test is met, but core hardness is less than 32 HRC i.e. 30 HRC. Therefore study is mainly focused on following findings:

i. Possible reasons for above mentioned problem
ii. Background of that reasons
iii. Solution based on reasons and study

5. POSSIBLE REASONS:

From various literature and following the process flow mentioned above in figure (1) following reasons are listed for the given problem.

i. % C in core may be less than specified for given grade of steel.
ii. Carburizing may not be throughout
iii. Quenching media used in quenching process may have less cooling rate.
iv. Any inclusion is there which shows such effect

6. EFFECT OF VARIOUS PARAMETERS ON HARDENABILITY

Various parameters listed in point 5 are studied and relevant points are listed here.

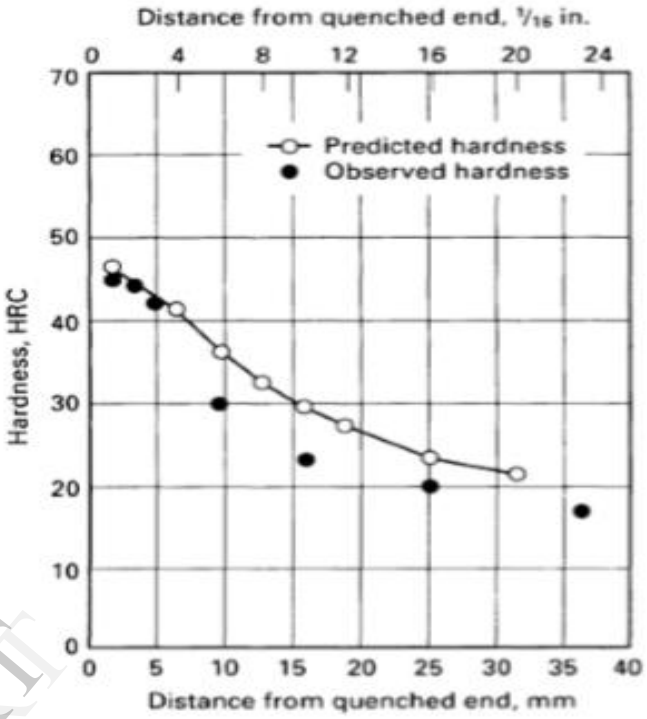

Figure 2: Observed and predicted Jominy curve for the 8620-type steel Composition inputs (0.2% C, 1% Mn, 0.5% Cr, and 0.2% Mo) for the program has manganese slightly above the range for 8620 steel (0.7 to 0.9% Mn).[5]

Figure 2 shows the difference between predicted values and observed values for given grade of sample in Jominy test. From observed values as shown in Figure 2, it can be clearly seen that at 7 mm hardness is 37-38 HRC which is as per our test.

But the curve is decreasing rapidly from there showing low hardness like 30 HRC at 9 mm.

6.1. Effect of percentage of carbon in alloy (%C)

In Ni-Cr-Mo alloy carbon percentage shows main role. As we increase carbon keeping all others alloying element constant hardness increases in greater extent [4]. Even though it shows greater effect on hardenability curve. This can be seen by comparing hardenability curves of Steel grades SAE 8620 and SAE 8640 which varies in carbon percentage shown in figure 3.[3]

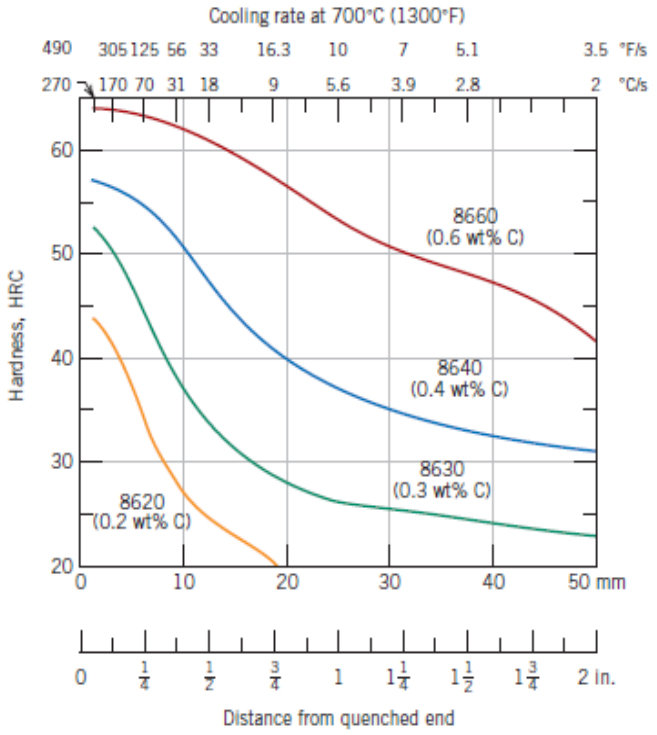

Figure 3: Hardenability curves of Steel grades

6.2. Effect of carburization

From point 6.1, one can say that due to carburizing hardness must be increased. Yes, it is. But not throughout. For given grade case depth is on average 2.1 mm, after that there is sudden drop in hardness profile. It can be seen from graph of case depth V/s hardness for given grade. So, it doesn't affect hardness of core as such. Figure 4 shows the graph for hardness profile for carburized and hardened SAE 8620.

Carburization is necessary as given grade is mainly used for gear application [2][6]. It is also called as carburized / gear steel.

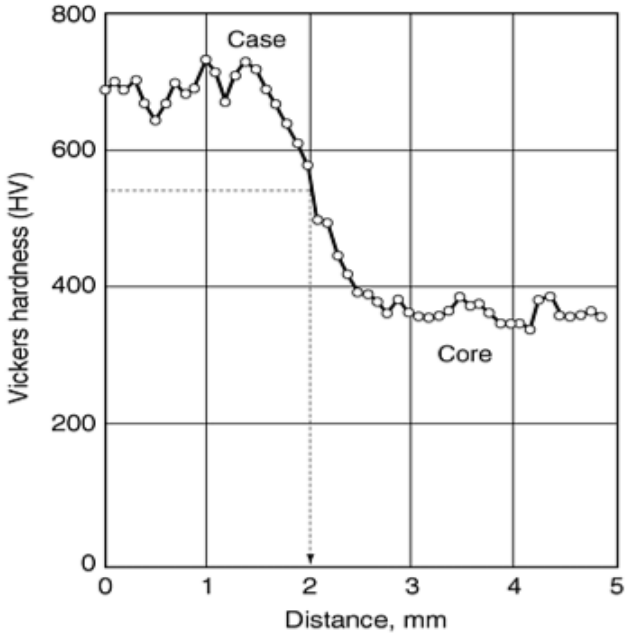

Figure 4: Vickers traverse showing the hardness profile results from a carburized and hardened SAE 8620

6.3. Quenching media:

It is too important as it determines cooling rate, which determines the hardness of the material [7]. There may be problems like CCR of medium is not sufficient to get required phases. But, alloying addition of Ni, Cr and Mo shifts the Time-Temperature-Transformation diagram to right side. The oil quenching is sufficient to get a required phase that is martensite. Also it is necessary for less distortion during quenching.

6.4. Specimen size

Figure 5 shows upper and lower limits for hardness during quenching. From this figure 5, it is clearly seen that as specimen diameter increases hardness values at same point decreases. So for getting HRC 32 hardness at core i.e. at center the specimen size must be less than 28 mm dia.

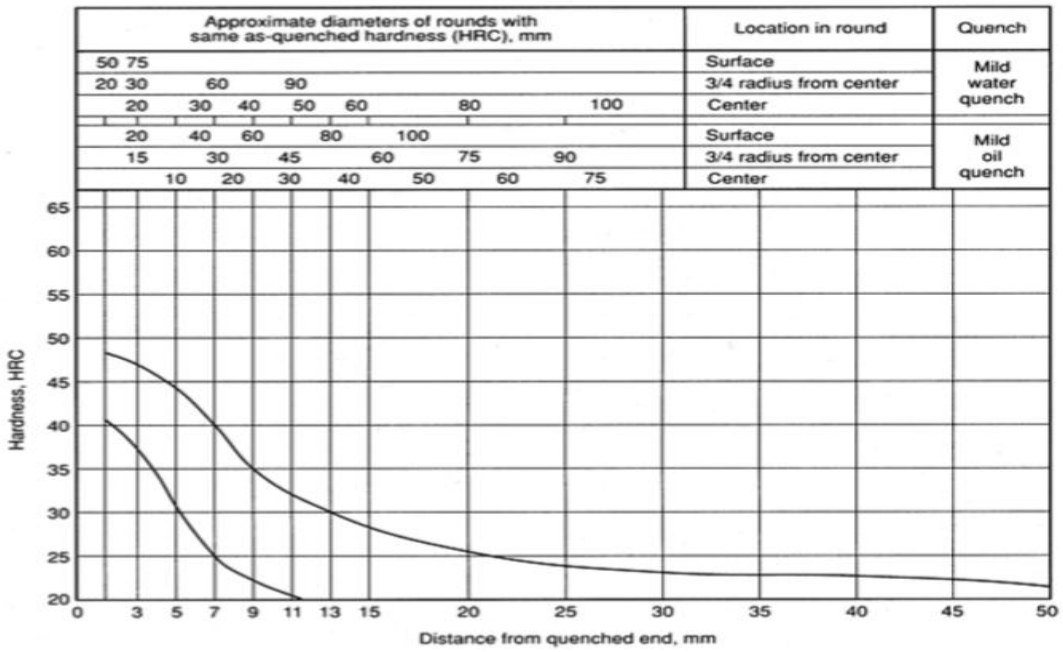

Figure 5: Heat-treating temperatures recommended by SAE Normalize (for forged or rolled specimens only): 925 °C (1700 °F) Austenitize: 925 °C [6]

So, specimen size is also critical factor. During quenching it is 25.4 mm, so for getting required result after quenching specimen/part size must be considerable. Core hardness for this grade ranges from 20 to 40 HRC. So for getting required value within this large range get final quench from lower temperature to get through hardness .

7. CONCLUSION AND DISCUSSION

From this we can conclude that various parameters must be taken into account to get appropriate hardness value. Carbon percentage in steel which is used for such application can be considered for quality selection of material. One should study the effect of through process on required properties. Quenching media and product size are important parameters in this study. Other parameters like, steel making process may be customized for the composition. Also, sample size can be optimized in accordance to get required hardness.

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