# Effect of The Heat Treatment on The Part of Cage Suspension Gear (PIN) in Mining Operation

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***Abstract*— Investigation were carried out to study the effect of heat treatment on mechanical properties on part (pin) of Cage suspension gear used in mining operation perfoming normalizing and harden temper operation. The Cage suspension gear is basically of low carbon alloy steel in which alloying element is manganese. This low carbon manganese alloy steel was heated to the austenitic temperature 860-950 range performed normalized and quenched operation. Tempered operation done on the quenched steel 550-650 temperature range.**

**This shows that the harden tempered steel having tensile strength(620N/mm$^2$), hardness value(245bhn), toughness value(9.1kgfm/mm$^3$) and microstructure(ferrite and tempered martensite). Normalized steel having tensile strength(500N/mm$^2$), hardness value(180bhn), toughness value(10.7kgfm/mm$^3$) and microstructure(ferrite and pearlite).**

***Index Terms*— ferrite, pearlite and tempered martensite effect on the mechanical properties.**

## I. Introduction

Steel has many practical application in every aspect of life. The steels being divided as low medium and high carbon steel. Low carbon steel has Carbon content of 0.15% to 0.45% low carbon steel is most common form of the steel as it's provides materials properties that are acceptable for many applications. It is neither externally brittle nor ductile due to it's Carbon content. Steel is an alloy of iron and carbon where other elements are present in quantities too small to affect the properties. Steel with low carbon content has the same properties as iron[1]. An alloy steel can be define as one whose characteristic properties due to some element (element are like Ni, Mo and Cr etc.)other than carbon. Although all plain-carbon steels contain moderate amount of Mn (up to about 0.8%) and Si(up to about 0.3%).They combine with oxygen and sulfur to reduce the harmful effect. Purpose of alloying element are added to steels for increasing hardenability, improve strength at ordinary temperatures, improvement in mechanical properties, increases wear resistance, increases corrosion resistance and improvement in the magnetic properties[2]. Manganese is one of the least expensive alloying elements. It also reduces the tendency toward hot shortness. Mn affects on the hardness and strength, but to a lesser degree than Carbon[3]. Basically the experiment done on the part of Cage suspension Gear material[4 ]. This is basically low carbon manganese alloying steel. This is use in mining areas to lift the load from bottom of coal pit to the surface. keeping the other constituent as much as possible to obtain the better mechanical properties. Performed heat treatment operations [5]to determine toughness of the Mn low Carbon steel. It should have adequate toughness and hardness values. That's why this paper based on the properties which are going to change performing various heat treatment operations.

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## II. CHEMICAL COMPOSITION

Chemical composition of cage suspension gear is as fallow:

| element | C | Si | Mn | Ni | Cr | S | P |
|---|---|---|---|---|---|---|---|
| % | 0.22 | 0.15 | 1.30 | 0.10 | 0.20 | 0.05 | 0.05 |

## III. HEAT TREATMENT PROCESS

- Normalizing
- Harden and Tempered

### A. *Normalizing of low carbon steel:*

The normalizing of steel carried out by heating approximate 60℃ above the upper critical temperature line cooling in still air. Purpose of normalizing is to improve machinability, modify structure, improve the hardness. Steels heated 25 min in the furnace at the austenitic range (900℃) then air cooled

### B. *Harden and tempered of steel:*

Steels heated 25 min in the furnace at the austenitic range (900 ℃ )then water cooled. This operation is known as quenching. Due to this it's hardness increases rapidly and toughness decreases.

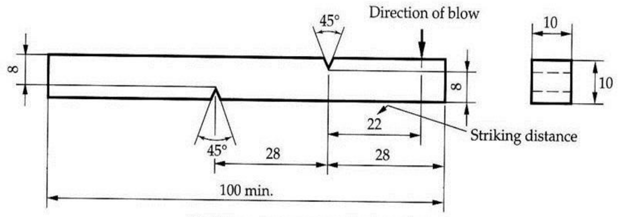
To restore the ductility and toughness it again heated 25 min in the furnace 550-650℃(below critical temp). Hold it again 25 min keeping in the furnace and furnace put it off to restore the toughness and ductility. This operation is known as tempering of steel.[6]

## IV. Experiment Setup

### *A. Toughness:*

The ability of metal to rapidly distribute within itself both the stress and strain caused by a suddenly applied load, or more simply expressed, the ability **[7]**

Toughness test: firstly prepared a izod samples of 10*10*100 mm3 and created a v notch according to the fig.




(b) Two-notch square section test piece

Normalized and harden tempered 1.30 Mn low carbon steel toughness value :

| | Normalized 1.3Mn steel | Harden and tempered 1.3Mn steel |
|---|---|---|
| Toughness (kgfm/mm$^3$) | 10.7 | 9.0 |
| | 10.7 | 9.2 |
| average | 10.7 | 9.1 |

### *B. Normalized and harden tempered 1.30 Mn low carbon steel hardness value(brinell hardness value):*

In a simple word hardness can be explain resist to penetrate.

| | Normalized CSG | Harden and tempered CSG |
|---|---|---|
| Brinell hardness number | 180 | 245 |
| | 180 | 245 |
| average | 180 | 245 |

### *C. Micro Structure*

Mechanism of changing microstructure in normalized low carbon steel In the fallowing diagram it can be easily understand It is a hypo eutectoid steel containing 0.22 carbon at c it is fully austenite and f.c.c structure.

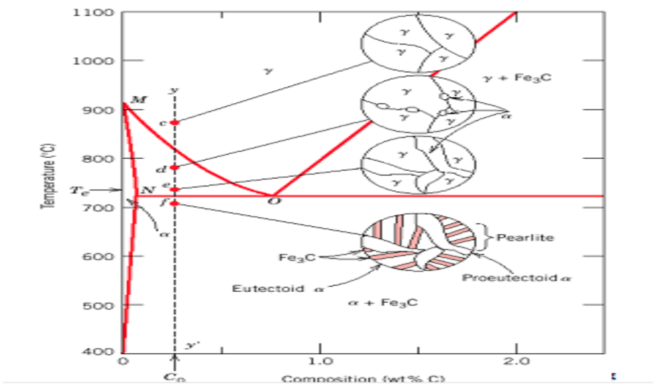



Fig 2 slow cooling of low carbon steel

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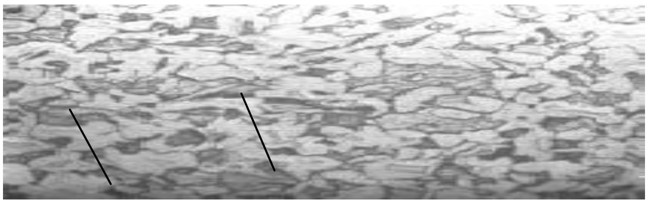
Upon slow cooling nothing happens until the line MO is crossed at point d. this line is known as upper critical temperature line. The allotropic change from f.c.c. to b.c.c. at here ferrite must begin to start at austenite grain boundary shows in figure.

As cooling progresses the amount of ferrite increases at point e.

Finally crossing the line NO and reached point f the remaining austenite change into pearlite (ferrite+ cementite). The NO line known as the lower critical temperature line.[8]

Magnification has been taken at 400X in the microstructure



Ferrite Pearlite

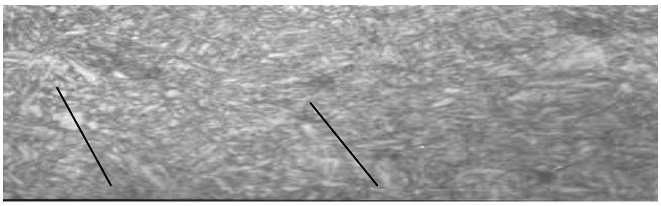
Fig.3 microstructure of 1.3 M normalized steel at 400X

Harden tempered steel:

Heated at 900℃ and cooled it into the water due to sudden and very fast cooling formation of martensite. Formation of martensite increases the hardness of steel decreasing the other mechanical properties.

For restoring the mechanical properties tempered operation performed.

Tempered maternsite and ferrite formation during this operation.



Ferrite tempered martensite

Fig. 4microstructureof 1.3 Mn harden and tempered steel at 400X

### *D. Tensile strength:*

| Heat treated steel | Tensile strength(N/mm$^2$) |
|---|---|
| Harden and tempered steel | 620 |
| Normalized steel | 500 |

## V. RESULT

From the above, the microstructure of normalized steel contain pearlite and ferrite and the microstructure of harden tempered steel contain tempered martensite and ferrite. Due to this normalized steel having toughness value 10.7 kgfm/mm$^3$, hardness value 180 brinell hardness number and tensile strength 500N/mm$^2$ and harden tempered steel having toughness value 9.1 kgfm/mm$^3$, hardness value 245 brinell hardness number and tensile strength 620N/mm$^2$.

## VI. CONCLUSION

As for as result harden tempered steel having good tensile strength and hardness value it is because of its microstructure which contained tempered matensite and ferrite comparison to the normalized steel having pearlite and ferrite microstructure.

The toughness value of normalized steel is more than harden tempered steel. It is because amount of ferrite formation in normalized steel is more than harden tempered steel and ferrite is ductile in nature.

Harden tempered steel shows the good mechanical properties comparison to the normalized steel that’s why it should prefer for the cage suspension gear.

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