Abstract — The study summarizes increasing the quality of flute rollers used in goods packaging industry by hardening the flute rollers using heat treatment process and more particularly to the method of, first quenching the steel and secondly hardening the steel by tempering.

Keywords — Nitriding, Martensite, Austenite, Corrugated Boxes, En-9, En-19, C, Si, Mn, Cr, V.

I. BACKGROUND HISTORY

Corrugated boxes are widely used for packaging in the food industry and all other packaging need of various industrial products. China started to introduce and use corrugated box as the external packing box from the early 1930s. At that time 80% of the external packing boxes in use were wooden boxes, with cartons accounting for only about 20%. By the end of 1940s and the beginning of 1950s, the percentage of boxes in use increased to 80%. With the development of packaging materials and machine industries, 90% packing boxes in use nowadays are corrugated boxes. [1]

II. INTRODUCTION

Corrugated box is a container [2] most extensively applied in goods packaging and transporting and various industrial products. The high strength composite corrugated box replaces wooden box, not only its appearance and printing has been improved, but more importantly, it satisfies the environmental protection requirement, at a remarkably reduced cost [3]. It contributes directly to maintain the sensitive earth temperature from being heat up, by saving the trees. The materials used for manufacturing these boxes are organic and no harmful chemicals used in the process of making these packaging types.so in no way we are harming the environment.

The packaging have three or more layers of cardboard in the corrugated boxes and can pack your products in a more compact manner to prevent any movement during long journey. The layers actually resist shocks and jerks during transportation as it provides cushion effect protection to the goods. The final outer layer is the fluting medium that maintains the whole durability of the box. It can resist extreme heat and pressure. The Fluting in the corrugated box is provided by the flute rollers and, life of these flute rollers is 1 year to 2.5 years approximately.

Daniel Howard Prutton, US Patent no.3,141801 [4] invention relates in general to the method of hardening SAE D-5 steel. In the art of hardening steel it has long been customary to provide a hardening by heating to a suitable temperature and quenching with water subsequently, the steel was case hardened, as by nitriding to achieve an even harder surface. Nitriding is a slow process taking from 40 to 100 hours in the usual case at elevated temperatures which are supposedly below the lower transformation point of the steel. However, it has been found that with tool steels which are capable of being hardened to a considerable degree, this normal process of hardening the entire steel and then case hardening the surface to obtain increased hardness has the effect of softening the core somewhat. In a particular case the core softened about 7 to 10 points on the Rockwell C scale which is sufficient to make a core that has decreased compression strength. When such a steel is used in a die subject to considerable compressive stress, the die core collapsed or crushed, and the surface form is fragmented and breaks off, thus ending the useful life of the die.

Lee et al. (2006) investigated effects of the surface temperature and cooling rate on the residual stresses in flame hardening of 12 Cr steel. As both the surface temperature and cooling rate is increase at temperature above T_{eq}, the increment of the tensile stress was evident. It was furthermore, found that the cracks were nucleated and propagated across the prior austenite.[5]

XUE et al. (2010) Influence of Pre-Transformed Martensite on Work-Hardening behaviour of SUS 304 Metastable Austenitic Steel. Result shows the Pre-transformed martensite in the microstructure remarkably affects the deformation behaviour of the steel, and the strength increases and the elongation decreases. [6]

Ravindra Babu (2016) investigates the heat treatment effect on dry sliding wear behavior of as cast, grain refined and modified gravity cast A356 by using Taguchi’s method. Grain refinement
resulted in fine grain structure but reduction in size of primary aluminium grains. [7]

S.A Tukur (2014) investigates the effect of Tempering Temperature on Mechanical Properties of Medium Carbon Steel. Untempered martensitic steels, are very hard and are too brittle to be useful for most applications. Samples were subjected to annealing, hardening at at four different temperatures: 250°C, 350°C, 450°C, 550°C. The brittleness is caused by a predominance of martensite. [8]

Rufin Rasheed (2015) investigation the effect of heat treatment on Al 6061- Al2O3 Composite & Analysis of Corrosion Behaviour. Hardness of the composite material increased with increase in content of the reinforcing material in the metal matrix. +Heat treatment helped to improve the hardness and decreased the elongation. [9]

In todays practice, mechanical surface treatments have been widely applied particularly in the automobile industry and failure of these components depends upon factors like fatigue. So to improve the fatigue strength of metallic components suitable surface hardening process should be used. [10]

Those work [4-10] however mainly focussed on the surface hardening of various components but did not link the rollers to surface hardening. The study investigates the effect by hardening the flute rollers using heat treatment process and more particularly to the method of, first quenching the steel and secondly case hardening the steel by tempering.

III. MATERIALS USED

1. EN9 is an un-alloyed medium carbon steel with chemical composition (in mass percent %) C 0.50, Si 0.25, Mn 0.70, S 0.05, P 0.05 by chemical analysis method.as shown in fig1. It is supplied at the hardness obtained after hot rolling or cold drawing, with a hardness normally within the range of 180 to 230 HB. EN9 is available from stock in bar and can be cut to our requirements. The dia of the roller used in paper corrugated machine is 180 mm, heater roller at 7KW and drive is bush mounted by simple spur gear and fixed speed by AC motor with the speed of machine at 70ft/min. The life of the rollers at 8 hours shift without any heat treatment of rollers is 1 year approximately.

2. EN19 is a high quality, high tensile alloy steel. Its chemical composition (in mass percent %) is C 0.40, Si 0.25, Mn 0.70, Cr 1.20 , Mo 0.30. usually gives good ductility and shock resisting properties combined with resistance to wear. The dia of the roller used in paper corrugated machine is 225 mm and heater roller is 12 KW and drive is given by variable speed AC drive. The speed of the machine is 159ft/min. The life of the rollers with rollers hardened and grounded by Nitriding is 1.5 years approximately.

IV. FIGURES

![EN-9 STEEL](image)

Fig. 1(a) showing chemical composition of EN-9 steel

![EN-19 STEEL](image)

Fig. 1(b) showing chemical composition of EN-9 steel

C is the most important element in the majority of steel, affecting hardness and strength by heat treatment. The ductility and weldability decreases with increasing carbon content.

Si is a principal deoxidiser in steel, used in silicon manganese, corrosion and heat resisting steels.

Mn contributes to strength and hardness with variable carbon content. It is an austenite forming element in some steels and has a significant effect on hardenability.

Cr is added to steel to increase corrosion and oxidation resistance. It also increases hardenability and combined with high carbon improves wear and abrasion resistance

V helps improve fatigue stress and wear resistance when used with other alloying elements.

IV. EXPERIMENTAL ANALYSIS

A) Chemical Analysis

We took two bars each of EN-9 and EN-19 steel. Circular specimens of dia 7 cm with length 7 cm were cut from these steel bars and turning and facing operation is done to get the required size of dia 6.5 cm and length 6.5 cm and tested them for chemical analyses to find the chemical composition of these three material. Spectrometer was used during chemical analysis.

B) Material Testing

Then we tested the hardness of these raw materials EN 9 and EN19 on Rockwell hardness tester. The hardness of the EN-9 was +10 Rockwell C and EN-19 was 20 Rockwell C. The hardness was measured
with a Rockwell hardness tester. The applied load was 5.0 kg with a duration of 10 s.

C) Heat Treatment

1. Then flute teeth of section B with depth of 3.65 mm were made on gear hobbing machine on these three samples of steel. A normalizing treatment was given to the rollers to relieve the residual stresses in the specimen generated during the rolling and machining.

2. Both the specimens were austenitized at 900 ºF for 1 hour then quenched in oil. The specimens are reheated to 400 ºF in another furnace for 30 minutes and then removed and allowed to cool at room temperature. Martensite in the as-quenched state, in addition to being very hard, is so brittle that it cannot be used for most applications. The ductility and toughness of steel are enhanced and the internal stresses are relieved, through the tempering process.

VI. CONCLUSIONS

The investigation reveals that a) The process of hardening the high manganese, high carbon steel (EN-9) capable of being hardened and tempered by heating the steel up to 900ºC to obtain a tempered hardened case of 0.15 to 0.20 inch deep. Fig.2(a) shows surface hardness was +10 Rockwell C before tempering which was increased to +20 Rockwell C after tempering thereof, increasing the quality of rollers.

b) The process of hardening the high chromium steel (EN-19) capable of being hardened and tempered by heating the steel up to 900ºC to obtain a tempered hardened case of 0.15 to 0.20 inch deep. Fig. 2(b) shows surface hardness increases sharply from +28 Rockwell C to +41 Rockwell C after tempering thereof, increasing the quality of rollers.

VII. REFERENCES