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EVALUATION OF MICROSTRUCTURE AND PROPERTIES OF COLD ROLLED CLOSELY ANNEALED STRIPS

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Abstract—This project mainly aims at the study of microstructure and properties of a Cold Rolled Annealed steel coil after undergoing different processes. Cold Rolling is done at temperatures below the crystallization temperature.
Firstly the coil properties and microstructure are observed and tabulated at its initial stage and then this is repeated at its final stage. The properties are then compared accordingly.
The processes involved in this are Cold Rolled Slitting to reduce the width of the coil, Pickling (oxides on the coil are removed using HCL), Rolling (thickness is reduced), Generally4-Hi rollers are used in order to get an accurate thickness. The next process used is Nitrogen Annealing.
It is a heat treatment that alters a material to increase its ductility and to make it more workable. It involves heating material to above its critical temperature, maintaining a suitable temperature, and then cooling. Annealing can induce ductility, soften material, relieve internal stresses, refine the structure by making it homogeneous, and improve cold working properties. The final process is Skin Pass to give an excellent flatness and a perfect finish to rolled steel strip.
The Finished product is tested using a UTM (Ultimate Tensile Machine) to obtain the Tensile Strength Yield Strength, Elongation of the sample. It is access furthur if it meets the customer requirement.
These products are sent to desired destinations. These products are used in different industries that manufacture automobile products, precision tubes, rolled steel products and railways products.
Keywords— Linkage, Mechanical Advantage, spring, overhauling effect, Lead Screw, Square Thread.

I. Introduction

From this paper, we have come across the entire processes, acquired efficient knowledge in the dew coarse, worked with them and found the requirements for the different stages of processes indulged in order to get a finished product as per customer requirement. The process is as follows:-
Firstly, the steel coils a bought to the raw material section from different sources then they are placed accordingly.
Then as per the customer requirement , planning is done to slit the coil's width and hence the coil' are slitted with a single pass by the process of cold rolled slitting
These slitted coil's are moved to the pickling process where the oxides on the coils are removed using Hydrogen Chloride (HCL), and this is performed in various tanks as below :-
Tank 1:
HCL Concentration: 12%, Fe Concentration %: 22 max, Temperature: 50ºC
Tank 2:
HCL Concentration: 2-12 %, Fe Concentration%: 22 max, Temperature: 55-65ºC
Tank 3:
HCL Concentration: 9-18 %, Fe Concentration %: 20 max, Temperature: 60-70ºC
The coils after undergoing Pickling process are rinsed in hot water consisting of four different tanks in series and passed from a hot air drier and finally we obtain a pure coil free from oxides and impurities.
The coils are then shifted to a Four High Rolling process in order to reduce the thickness of the coil as per requirement.
The next step is Annealing. Here Nitrogen Annealing is preferred,Where these coils are maintained at certain high temperature and then cooled until they obtain room temperature, this is done in order to relieve stresses and to improve the softness of the coil.
Finally, the coils are passed through a Skin Pass Mill, where the required surface roughness is correctly maintained and the coil is cut as per required width and then the sample is sent to the quality department where the coil is tested in terms of its Yield Strength and Elongation and hence sent to the required destination.

Effect of Annealing Temperature on the Microstructure, Micro-hardness, Mechanical Behaviour and Impact Toughness of a Low Carbon Steel . Low carbon steel has carbon content of 0.45%. Low carbon steel is the most common form of steel as it's provides material properties that are acceptable for many applications. It is neither externally brittle nor ductile due to its lower carbon content. It has lower tensile strength and malleable. Steel with low carbon steel has properties similar to iron. As the carbon content increases, the metal becomes harder and stronger but less ductile and more difficult to weld. The process heat treatment is carried out first by heating the metal and then cooling it in water, oil and brine water. The purpose of heat treatment is to soften the metal, to change the grain size, to modify the structure of the material and relive the stress set up in the material. The various heat treatment processes are annealing, normalizing, hardening, tempering, and surface hardening. Annealing is to improve ductility and toughness, to reduce hardness and to remove Carbides.

Hardness tests are limited in practical use and do not provide accurate numeric data or scales particularly for modern day metals and materials. The usual method to achieve a hardness value is to measure the depth or area of an indentation left by an indenter of a specific shape, with a specific force applied for a specific time. There are three principal standard test methods for expressing the relationship between hardness and the size of the impression, these being Brinell , Vickers, and Rockwell. For practical and calibration reasons, each of these methods is divided into a range of scales, defined by a combination of applied load and indenter geometry. The main objectives of this study are to investigate the effect of different annealing temperatures on the impact toughness, micro-hardness and mechanical behaviour of low carbon steel.
Material and Procedures
In this study a set of low carbon steel C45specimens have been used, the density is 7.85 gm/cm3, where the chemical

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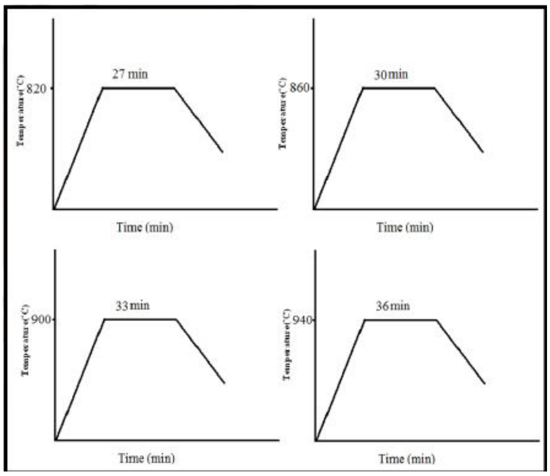
composition is (0.42 C, 0.24Si, 0.69 Mn, 0.019P, 0.016Cr, 0.12Ni, 0.16Cu, 0.12Mo, 0.02Ti, 0.002V, 0.004W).

ANNEALING PROCESS :

Annealing is a heat treatment process by which the material characteristics changes such as hardness and strength of the material, where the annealing conditions are shown in Table 1.

Carbon Steel C45	Annealing Temperature (^oC)	Holding Time (min)
A	820	27
B	860	30
C	900	33
D	940	36

Table 1. Temperatures and holding times for annealing process



Annealing regimes of low carbon steel grade 45

Compression test:

Compression test determining the behaviour of materials under crushing loads. Specimens of 10 mm in diameter and 10mm height (H/D =1) are compressed, and deformation at various loads is recorded where the procedure of compression test was performed in the following steps:

Centered the specimens on a table of compression device.

Move the punch downward to the specimen where uni-axial compressive load is applied using Qusar of 100 KN capacity.

Starting the compressed of specimen using strain rate of $3.96*10^{-}$ /s

Load-Deflection curves were obtained from the true stress- true strain was investigated.

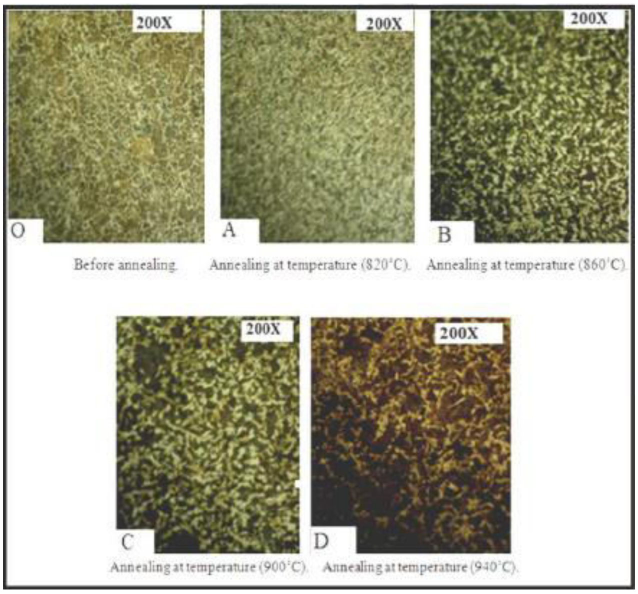
Microstructure:

A specimen of each regime was prepared for the microstructure test using microscope type (Nikon 208) at 200x manufacturing using (98% alcohol ethanol + 2% nitric acid) as etching solution.

Hardening test:

A digital micro hardness tester model HWDM-3 is used to investigate the hardness of low carbon steel specimens at 300 gmf load; five readings were taken from which the average was determined.

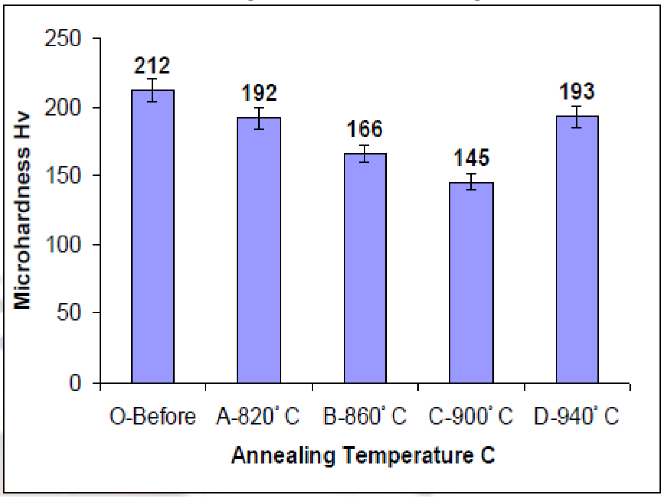
Effect of annealing temperature on the microstructure of low carbon steel C45. It can be seen from Fig.2 that the grain size becomes larger as the annealing temperature increase this due to lower cooling rate. This will resulted in changing the mechanical characteristics of low carbon steel grade C45 according to hall-pitch equation.



micro structure of carbon steel C45 before and after annealing at 200x.

Effect of annealing temperature on the micro hardness of low carbon steel C45

From the histogram of the next figure it can be seen that the micro hardness decrease as the annealing temperature increase except at 940˚C it return back to increase, the maximum decrease was 31.6 % that achieved at 900˚C. This can be attributed to the coarse grains as shown in Figure.



Micro-hardness Hv

Fig.3: Effect of annealing temperature on the micro-hardness of low carbon steel C45.

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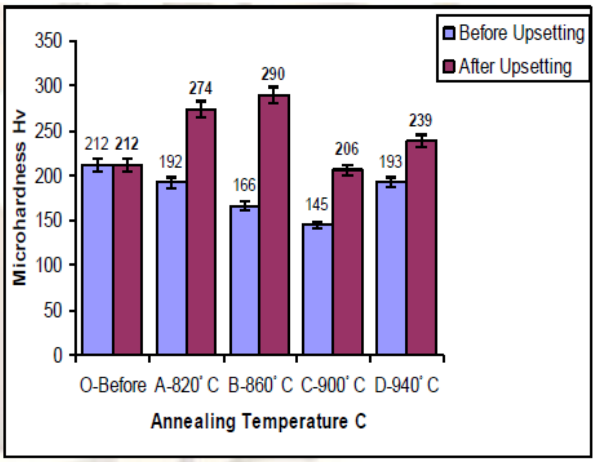
It is that the micro-hardness affected by the plastic deformation, the micro-hardness increased after upsetting process the maximum is 75 % that attained after 860 ˚C annealed temperature.



Micro hardness Hv Before Upsetting After Upsetting. Effect of upsetting process on the micro-hardness of low carbon steel C45 and its regimes.

Effect of annealing temperature on the mechanical behaviour of low carbon steel C45:

It can be seen from the figure that as the annealing temperature increase to 900 ˚C the mechanical behaviour decrease, but at 940 ˚C the mechanical characteristics enhanced, this finding is consistent with the micro-hardness results.

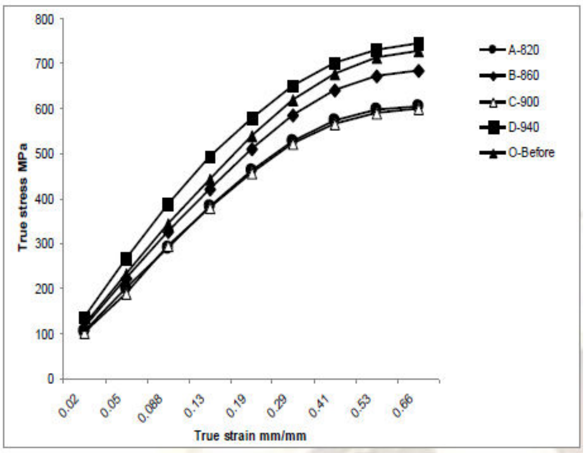
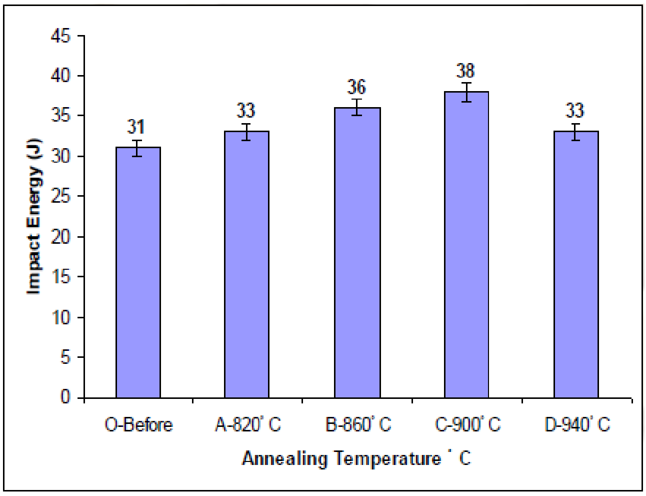


Fig.5: Effect of annealing temperature on the mechanical behavior of low carbon steel C45.

It can be seen from the histogram of Fig. 6 that the impact toughness in general increase as the annealing temperature increase, the maximum is 22.5 % that achieved at 820˚C. This indicates that the annealed steel will sustain further plastic deformation during the forming processes, however the formability of low carbon steel C45 will be enhanced.



Impact Energy (J)

Figure : Effect of annealing temperature on the impact energy of low carbon steel C45 and its regimes

Conclusions:

The following points can be concluded:
The impact toughness in general increase as the annealing temperature increase, the maximum is 22.5 % that achieved at 820˚C.
Micro hardness is increased after upsetting process the maximum is 75 % that attained at 860 ˚C.
The micro-hardness decrease as the annealing temperature increases except at 940˚C it returns back to increase, the maximum decrease was 31.6 % that achieved at 900˚C.
The grain size becomes larger as the annealing temperature increase.
ANALYSIS OF ANNEALING AND COLD ROLLING MECHANICAL PROPERTIES OF COIL NO:
124371D

Purpose:
To examine impact of the cold rolling reduction and annealing on mechanical properties of coil no:

Methodology:
Testing the steel strip of coil no: was based on combination of cold rolling, recrystallization annealing using bell furnace, mechanical properties testing and metallographic analysis.

Findings:
It was confirmed that by different reduction percentage and different annealing temperatures there will change in mechanical properties of same raw material.

Implications:
The experiment should be supplemented by different modes of annealing temperatures, a steel strip with various reductions and a spectrometer.

Practical implications:
The results may be utilized for optimization of terms of heat treatment in a cold rolled mill.

PROLOGUE

Cold rolling will affect the structure and material properties of steel because there will be no recrystallization can occur. Gradual extensions of grains in the direction of rolling occur due to affect of rolling deformation of other structural phases has been developed, such as attachment, pearlitic blocks , etc. A deformation is structural and crystallographic texture arises, which causes in mechanical properties.

As this occurrence is most harmful heat treatment is done after cold rolling for removal of such properties. These factors effect the microstructure after annealing and the total reduction in cold rolling, conditions of annealing (temperature , time). In the field of processing of metals more new progressive types of material has currently been used generally high rolling of material before annealing, the less initial temperature of recrystallization. at very low temperatures the time required for finishing of annealing is significantly higher and required spheroidising of carbides cannot be attained. strength properties of material will increase with increase in temperature of annealing, where as plastic properties also increase. considerably lowering the strength or hardness values occurs at temperatures which are near to 600C.the aim of this work was to investigate impact of three different cold reduction sizes in combination with three modes of recrystallization annealing on mechanical properties of steel coil no:

METALLOGRAPHIC ANALYSIS:

Samples of microstructure by metallurgical microscope were taken from middle parts of rolled coils(in perpendicular section, i.e; rolling direction).now the structure was evaluated with selected samples after annealing. The microstructure was created absolutely by ferrite, not all ferrite grains were approximately equal in all directions. The below figures are the microstructure of rolled samples and annealed samples. All samples have fundamentally structured by ferrite and very low content of pearlite,

RESULTS OBTAINED

Annealing mode 1is featured by gentle increase of strength properties with rising strain up to the value of39 ,after reaching the value a comparative abrupt drop follows, which is caused by the sequence of recrystallization. Plastic properties were comparatively less influenced by the deformation and they were worse than in case of other annealing modes. Annealing mode 2 exhibits the most convoluted course of mechanical properties because slow rise of YS and TS is followed by these properties after previous strains 33% to58%. The reason is uneven coarsening of re-crystallized grains. For a strain above 60% a rise of described properties occurs again.

Strength properties achieved by this mode of annealing are lower most ones and, on the divergent, plastic properties (mainly after deformations around 33%) the best ones, which is not astonishing with regard to high annealing temperature. Particular curves in all graphs replicate the relation between plastic and strength properties. Formability rises and vice versa strength and plastic properties fall with increase in temperature of recrystallization annealing.

OBSERVATIONS:

RAW MATERIAL: COIL NO: 124371D for 4mm coil.
•Tensile strength: 0.360 KN/mm2
•Elongation: 26%
•YS/UTS ratio: 7.380 N
•Yield stress: 0.245 KN/mm2

PROPERTIES OF ROLLED PRODUCTS:
•Tensile strength: 0.633 KN/mm2
•Elongation : 10 %
•Yield load : 31.560 KN
•Yield stress: 0.627 KN/mm2

PROPERTIES OF ANNEALED PRODUCTS:
•Tensile strength: 0.290 KN/mm^2
•Elongation : 35%
•Yield load : 7.380 KN
Yield stress: 0.212 KN/mm^2

ANALYSIS OF COLD ROLLING AND ANNEALING ON MECHANICAL PROPERTIES OF STEEL EVALUATION:

The initial material taken from semi-continuous picking from hot rolled strip with thickness 6mm.chemical composition of steel was as follows:99.61%Fe-0.044%c-0.214%mn-0.012%si-0.010%p-0.014%al-0.0003%b-0.013%cr-0.10%ni-0.006%cu-0.002%mo-0.003%co-0.004%nb-0.001%ti-0.001%v-0.016%.samples in the form of strips with dimensions 6x21x300mm were rolled in several passes with total thickness reduction33to58% by using hydraulically pre stressed mill(a four high mill with work rolls of 50cm diameter).

Now annealing is done with one of three lower mentioned modes followed. It was carried out in a laboratory muffle furnace in the protective atmosphere. parameters of particular annealing modes are already shown. They may be described in a following system:
The rate of temperature increase up to an intermediate dwell// temperature of the intermediate dwell//time of intermediate dwell.

Mode1-160ºC/h//640ºC//2h
Mode2-160ºC/h//675ºC//2h

Description of applied annealing modes:

The annealed samples under went the tensile test to room temperature and the brinell hardness test. The gained results-hardness HB, yield stress YS(KN/mm2),tensile strength TS(KN/mm2) and their ratio, as well as elongation were summarized in graphs. the found out points were plotted in a coordinate system and the corresponding curves were constructed.

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