Determination the notched bar impact work and strength with the influence the specimen temperature

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List of symbol

h	height of fall
h1	lifting height
á	angle of fall
L	Dist. of pendulum axis,length
W	width
H	high
ß	lifting angle
ak	notch bar impact strength in Nm/cm^2
Ak	notch bar impact work in Nm
So	cross-section area of the specimen prior to fracture in cm^2
J	joules
M	meters
Cm	centimeters
mm	mlemater
cm^2	square centimeters
m	mass
g	acceleration of gravity
N	newton
C°	centigrade
An	capacity

Contents

Introduction

Impact resistance:

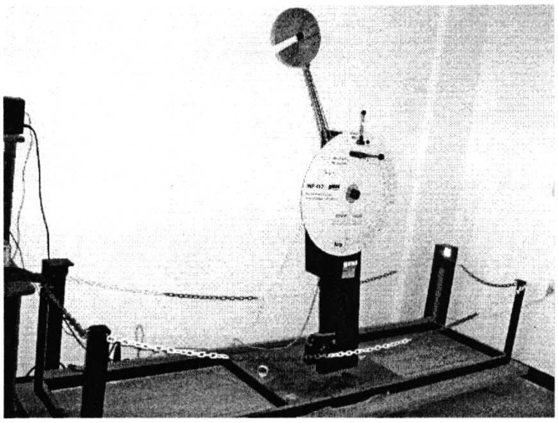
Resistance of a metal to impacts is evaluated in term of impact strength. A metal may possess satisfactory ductility under static loads but may fail under dynamic loads or i mpact. Impact strength is most often determined by the charpy test. It is some time me asured by the izod test. Both types of test use the same type of pendulum testing mach ine. The charpy test specimen is a beam supported at both ends and contains a notch i n the center. The specimen is placed on supports and struck with a pendulum on the si de opposite the notch. The accuracy and location of the notch is of extreme importanc e. there are several types of charpy specimens the V-notch type is the most popular the specimen is standardized in metric dimen-sions. Figure (1) show the impact testing m achine in action.

The impact strength of a metal is determined by measuring the energy absorbed in the fracture. this is equal to the weight of the pendulum time the height at which the pend ulum is released and the height to which the pendulum swings after it has struck the sp ecimen. In conventional terms the impact strength is the foot pounds of energy absorb ed in metric practice, impact resistance is measured two ways

1- The kilogram-meter based on energy absorbed

2-The kilogram-meter per square centimeter of the area of the fractured surface or the cross-sectional area under the notch both terms are used but care must be taken to dete rmine which is appropriate. The SI system measures energy absorbed in joules.

Impact test are often made at different temperatures since steel normally become more brittle or will absorb less energy at lower temperatures. Normally seven specimen are broken at each test temperature and the high and low values are discarded the reported value is the average of the remaining tow specimen. Test temperatures are -60 F (-5 1 C),-50 F (-46), -40 F (-40 C), -20 F (-29 C), -14 F (-25 C), -4 F (-2 0 C), 0 F (-18 C), 14 F (-10 C), 32 F (0 C), 50 F (10 C), 68 F (20 C). all temperatures may not be used however usually five test temperatur es are used so that a transition . At the point of fall-off the transition changes from duc tile to brittle this is know as the transition temperature. The change from ductile to brit tle fracture can also be seen by the surface of the broken bars in the figure. an other m easure of ductility is also utilized and this is the degree of lateral expansion of the bar at the fracture surface the greater the degree of change, the more ductile the fracture. T he fracture surface type is also reported for critical requirements. All these different te st and test specimens are standardized by the American society for testing and materia l. [1]



Figure(1) show the impact testing machine in action

(Chapter 1)

Theory:-

The History and Importance of Impact Testing:

Without uniformity of test results from day to day and from laboratory to laboratory, t he impact test has little meaning. Over the years, researchers have learned that the res ults obtained from an impact test can depend strongly upon the specimen size and the geometry of the notch, anvils, and striker. To a lesser degree, impact test results Also depend upon other variables such as impact velocity, energy lost to the test mach ine, and friction. The goal of those who have written and modified ASTM Standard T est Methods for Notched Bar Impact Testing of Metallic Materials (E 23) has over the years

Been to standardize and control the variables associated with impact testing. This rep ort looks at the history of impact testing, with emphasis on the key advances in unders tanding and application of the impact test, as reflected in the evolution of the test stan dard.

Impact Testing:

The earliest publication that we could find on the effects of impact loading on materia ls was a theoretical discussion by Tredgold in 1824 on the ability of cast iron to resist impulsive forces [*1*].In 1849, the British formed a commission to study the use of iron in the railroad industry, which began by considering practical approaches to impact te sting [*2*]. Apparently, failures of structures in the field were leading some researchers to speculate that impact loads affected materials far differently than static loads, so ten sile-strength data (from slowly applied loads) was a poor predictor of performance un der dynamic loads.

In 1857, Rodman devised a drop-weight machine for characterization of gun steels, and over the subsequent 30-year period, his machine was widely used to test railroad steels and for qualification of steel products.

From(1895 to 1922) This period saw the establishment of a number of national and int ernational standards bodies, which took up the causes of developing robust test proced ures and developing consensus standards for many technologies, including impact test ing. One of these standards bodies was The American Society for Testing and Materi als, established in 1898. In 1902, only four years after the founding of ASTM, the AS TM "Committee on the Present State of Knowledge Concerning Impact Tests" publish ed a bibliography on impact tests and impact testing machines in the second volume o f the Proceedings of

By 1905, Charpy had proposed a machine design that is remarkably similar to pres ent designs and the literature contains the first references to "the Charpy test" and "the Charpy method". He continued to guide this work until at least 1914 Based on the inf ormation in this survey, an ASTM subcommittee began to prepare a standard test met hod for pendulum impact testing in 1923. This effort took until 1933, when ASTM pu blished "Tentative Methods of Impact Testing of Metallic Materials," ASTM designati on E

23-33T. (An ASTM specification of "Tentative" indicated that it was subject to annual review and was a work in progress. The tentative designation is no longer used by A STM.) (Other countries also developed their own standards; however, we found it dif ficult to find their records and to track their developments.)

ASTM E 23-33T specified that a pendulum-type machine was to be used in testing a nd "recognized two methods of holding and striking the specimen", that is, the Charpy test and the Izod test (where the specimen is held vertically by a clamp at one end). I t stated that "the Charpy type test may be made on unnotched specimens if indicated b y the characteristics of the material being tested, but the Izod type test is not suitable f or other than notched specimens". Only a V-notch was shown for the Charpy test.

Charpy impact test:

Charpy impact test method for metallic materials is specified by European EN 10045 standard. This specification defines terms, dimension and tolerances of test pieces, typ e of the notch (U or V), test force, verification of impact testing machines etc.

For certain particular metallic materials and applications, Charpy impact test may be t he subject of specific standards and particular requirements. The test consists of breaki ng by one blow from a swinging pendulum, under conditions defined by standard, a te st piece notched in the middle and supported at each end. The energy absorbed is deter mined in joules. This absorbed energy is a measure of the impact strength of the mater ial.

The major factors that affect the results of an Impact Test are:

1-Velocity

2-Specimen

3-Temperature

Velocity:

The velocity at impact does not appear to appreciably affect the results. However, exp eriments conducted with machines that develop velocities above certain critical value

Impact resistance appears to decrease markedly. In general, the critical velocities are much less for annealed steels than for the same steels in the hardened condition.

Specimen:

In some cases it is not possible to obtain a specimen of standard width from the stock t hat is available. Decreasing either the width or the depth of these specimen decreases t he volume of metal subject to distortion, and thereby tends to decrease the energy abs orption when breaking the specimen.

The effect of the notch is to concentrate stresses at the root of the notch, embrittle the material in the vicinity of the notch and , at the same time, raise the elastic limit of the material in this area. When a crack forms at the root of the notch the stress is greatly i ntensified and the crack quickly progresses across the section. Without the notch, man y compositions would simply bend without fracture, and their total capacity to absorb energy could not be detected.

The sharper the notch (i.e. the smaller the included angle) the more pronounced are th e effects noted above. The specimen sizes have been standardized so that results can b e compared with reasonable confidence.

Temperature:

In contrast to the relatively small effect of temperature on the static strength and ductil ity of metals, at least within the atmospheric range, temperature has a very markedly e ffect on the impact resistance of the notched bars. Figure(3) shows the effect of tempe rature on the impact energy absorbed.
[3]

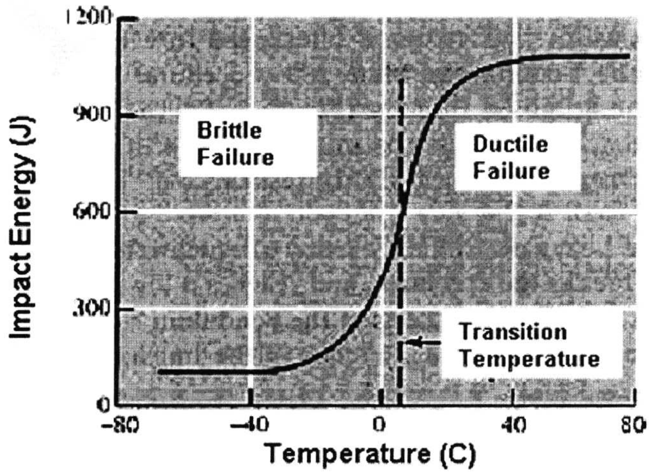


fig.(3)affect temperature of value impact energy

What affects the Charpy Impact Energy?

To understand how the Charpy impact energy is affected by the properties of the material, we need to understand the different contributions which make up the measured energy.

What is the Impact Energy?

The impact energy measured by the Charpy test is the *work* done to fracture the specimen.

On impact, the specimen deforms elastically until yielding takes place (plastic deformation), and a plastic zone develops at the notch. As the test specimen continues to be deformed by the impact, the plastic zone work hardens. This increases the stress and strain in the plastic zone until the specimen fractures.

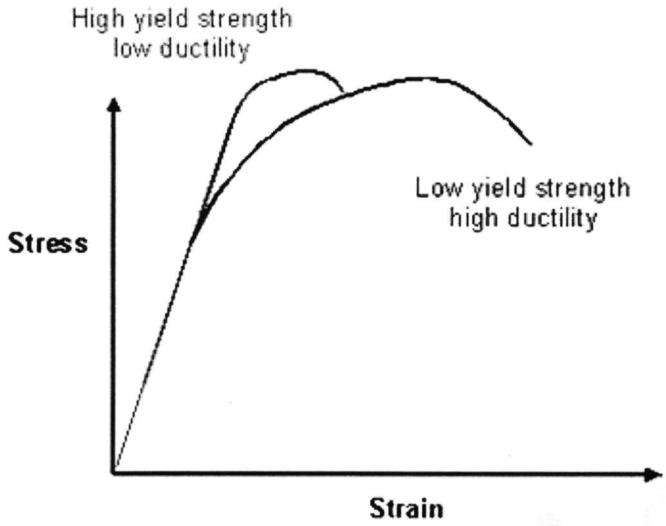
The Charpy impact energy therefore includes the elastic strain energy, the plastic work done during yielding and the work done to create the fracture surface. The elastic energy is usually not a significant fraction of the total energy, which is dominated by the plastic work. The total impact energy depends on the size of the test specimen, and a standard specimen size is used to allow comparison between different materials.

The impact energy is affected by a number of factors, such as:

- **Yield Strength and Ductility.**
- **Notches.**
- **Temperature and Strain Rate.**

Yield Strength and Ductility:

Increasing the yield strength of a metal by processes such as cold work, precipitation strengthening and substitutional or interstitial solution strengthening generally decreases the ductility.This is the plasi ic strain to failure.



figure(4)explaining yield strength and ductility

Increasing the yield strength by these mechanisms therefore decreases the Charpy imp act energy since less plastic work can be done before the strain in the plastic zone is su fficient to fracture the test specimen. An increase in yield strength can also affect the i mpact energy by causing a change in the fracture mechanism.

Temperature and Strain Rate:

Since the Charpy impact energy comprises mostly of the plastic work of yielding of th e specimen, it is affected by factors which change the yield behaviour of the material, such as temperature and strain rate, through their effect on the behaviour of dislocatio ns.

Increasing the yield strength by low temperatures or high strain rates decreases the du ctility, and therefore decreases the Charpy impact energy. The yield strength of body centred cubic (bcc) metals is more sensitive to strain rate and temperature than that of face-centred cubic (fcc) metals. The Charpy impact energy of bcc metals such as fer ritic carbon steel therefore has a stronger dependance on s train rate and temperature t han that of fcc metals such as aluminium, copper and austenitic stainless steel.

How is the Charpy Impact Energy used:

The charpy impact test can be used to assess the relative toughness of different materi als, e.g. steel and aluminium, as a tool for materials selection in design. It may also b e used for quality *control*, to ensure that the material being produced reaches a minimu m specified toughness level. [4]

(Chapter 2)

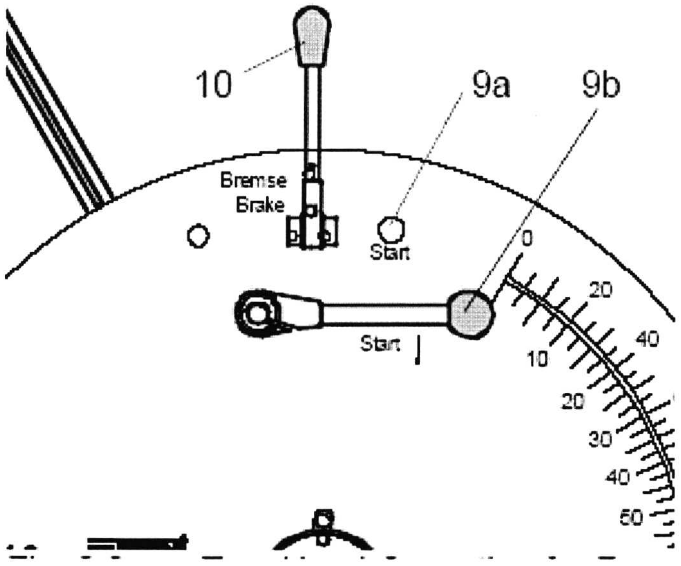
Experimental work& procedures

The Pendulum Impact Tester is fitted to a sturdy base plate (1). This provides the nec essary posi- tional stability. It is, however, recommended to fix the unit to the floor. The dollies (5) in which the specimens are impacted by the hammer (11) are recesse d into the anvil block (4). The hammer has a capacity for work of 150 Nm; by fitting ad ditional weights to the sides of the hammer, a capacity for work of 300 Nm is achieved .

For safety reasons, the release for the hammer is implemented in a two-hand mechani sm. Release is performed by the simultaneous operation of the hand lever (9b) and the start button (9a).
The safety interlock includes the light barrier (2) in the support that prevents release if a person or the safety chain (3) interrupts the beam of light.

After the impact of the hammer on the specimen and the hammer's continued motion past the spe- cimen, the hammer can be retarded with a disc brake using the hand br ake lever (10).

The necessary impact work for the impact on the specimen can be read directly on t he scale (7) using the trailing pointer (8).

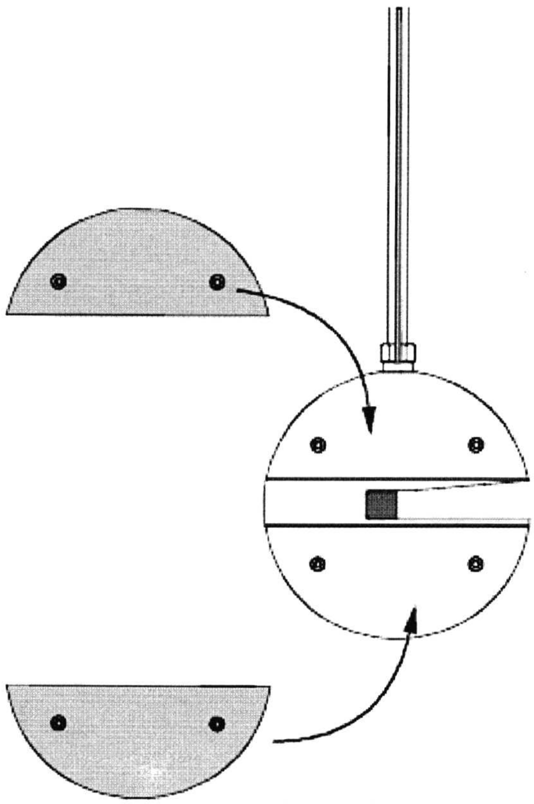


figure(5) two-hand operation for leasing the hammer

Fitting and Removing the additional weights:

The 4 additional weights are fitted as shown in the adjacent figure and fixed in place w ith hex socket head bolts. Removal is performed in the reverse order Capacity for wor k of the Pendulum Impact Tester:

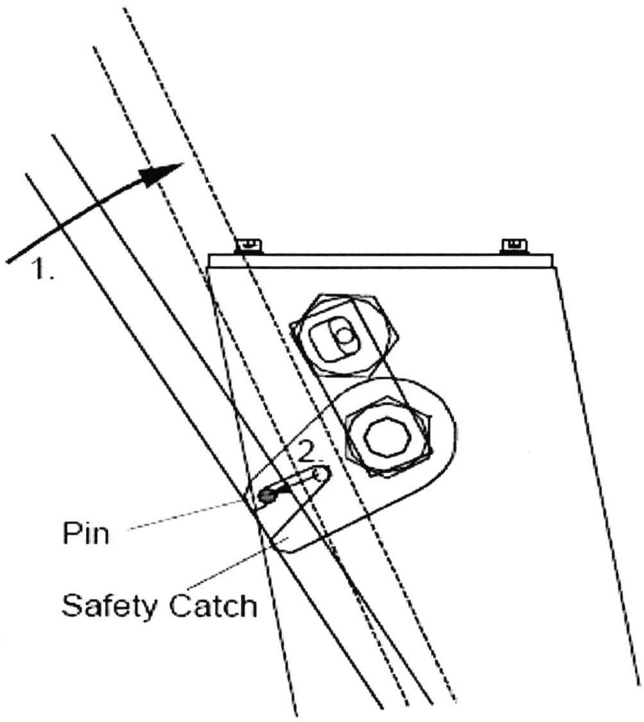
- 150 Nm - **without** additional weights
- 300 Nm - **with** additional weights



figure(6) fitting additional weight

Positioning the Hammer:

At the start of each experiment it is necessary to position the hammer, i.e. place it in its highest position. For this purpose, press up the hammer by hand.
and lock as shown in the adjacent figure. IMPOR- TANT! Under no circumstance let go of the hammer
before it is locked as it will impact the specimen immediately!



Figure(7) Locking the Hammer

Specimens:

The WP 410 basic unit is supplied with an assort- ment of ISO V specimens made of d ifferent mate- rials. The specimens can be reordered from G.U.N.T. Please ask yo ur distributor.shown by figure(8)

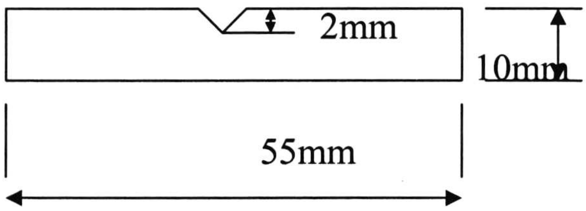


Fig.(8) standart speciment of charpy impact V-notch

Measuring Principle:

The notched bar impact bending test is performed using a pendulum impact tester in ac cordance with DIN 51222; during this test a pendulum hammer falls from a maximu m height (height of fall h). At its lowest point, the hammer meets the rear of a notc hed specimen. On driving or dragging the specimen through the dolly, part of the pendulum energy is absorbed by deformation and fracture. The necessary notched ba r impact work Ak can be read directly on the gauge (height h1). The shape of the notc hed bar impact specimens is also defi- ned by the DIN 50115 standard. As the magnit ude of the notched bar impact work is dependent on the shape of the specimen, the l ater must always be defined, e.g. Ak(ISO-V) = 10 J.

$A_k = m \times g\,(h - h_1)$ as show in figure(8)

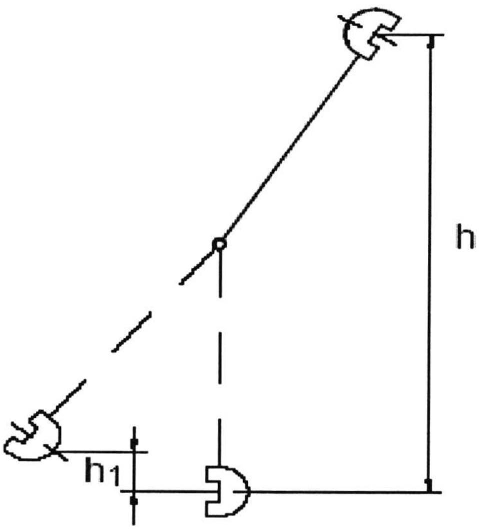
The quotient of the notched bar impact work and the nominal cross-section (that is the remaining area of the specimen at the base of the notch) is the notched bar impac t strength:

ak=Ak/so

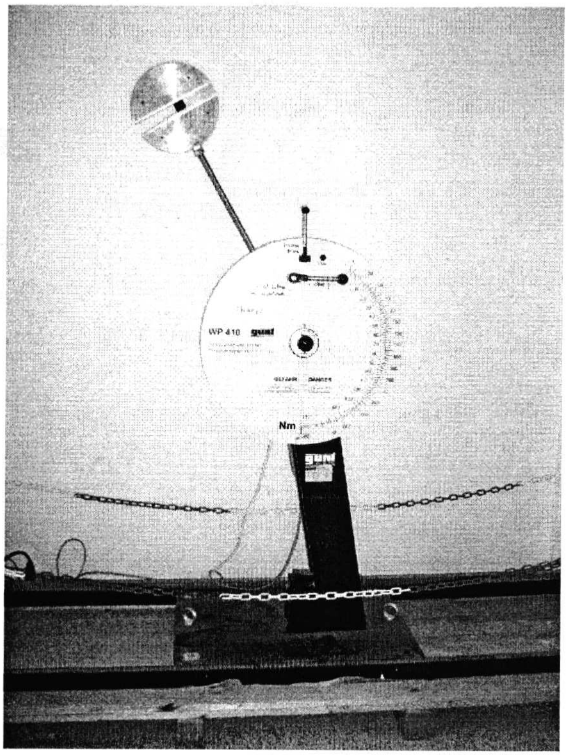
Here:

ak: Notched bar impact strength in Nm/cm^2
Ak: Notched bar impact work in Nm
S0:
Cross-sectional area of the speci men prior to fracture in cm^2

The notched bar impact strength is also heavily dependent on the shape of the spe cimen. This means that values obtained from specimens of different geometry are n ot directly comparable.



figure(9)



Procedure:

The project that we have mode for two different metals contains(steel-60),(á brass).fo ur specimen for each one we have made the experiment in a special case.
First we take about steel.
Concerning the steel specimens which contains(steel-60),is four specimen each one w as in a different case for instance.

1- Steel-60 normal that is in a room temperature.
2- Steel-60 but we have made annealing in 650 c°.
3- Steel-60 but we have made annealing in 870 c°.
4- Steel-60 but we have made normalizing for it in 870 c°.

Is four specimen each one was in a different case for instance.

1- α-brass normal we did not make any heat treatment.
2- α -brass when we made annealing for it in 400 C°.
3- α -brass when we made annealing for it in 500 C°.
4- α -brass when made annealing for it in 600 C°.

2

as showing by table(1)

Specimen	Condition
steel-60	room temperature
steel-60	normalizing 870C°
steel-60	annealing 870C°
steel-60	annealing 650C°
α –Brass	room temperature
α –Brass	annealing 600 C°
α –Brass	annealing500 C°
α –Brass	annealing400 C°

Table(1) type of specimen and condition

Equipment

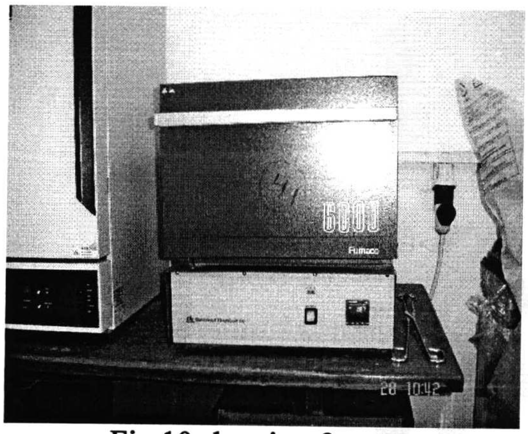


Fig.10 showing furnace

Fig.11 showing vernier

Fig(12) thermo couple

(Chapter 3)

Result & discussion

Specimen	Condition	Notched bar impact Av(J)
steel-60	room temperature	314.96
steel-60	normalizing 870C°	317.77
steel-60	annealing 870C°	96.43
steel-60	annealing 650C°	104.54
α –Brass	room temperature	74.17
α –Brass	annealing 600 C°	168.81
α –Brass	annealing500 C°	189.39
α –Brass	annealing400 C°	23.67

Table(2)type of specimen and condition and notch bar impact

The projrct that we have made for two different metals condition(α-Brass),(steel-60) for specimen for each one.we have made the experiment in a special case. explaining before

We realized from the data that the value notched bar impact(Av)j, Impact value (ak)j/cm , lifting angle(ß°), lifting height(h1)m, have changes according to the case.

For instance in room temperature we see (Av) is less than all the other case, and this is near in reality because no treatment is made for it.

The most (Av)in stee-60 in 870c° normalizing is in this is suitable according to knowledge.

Normalizing: When normalizing is done for steel some changes occur in the metal. Some of the changes the occur in the properties are:

1- Producing a harder and stronger steel .
2- Improving the machinability.
3- Modifying and refine the grain structure.
4- Obtaining a relatively good ductility without reducing the hardness and strength . [5]

As shown diagram normalizing for steel.figure(13)

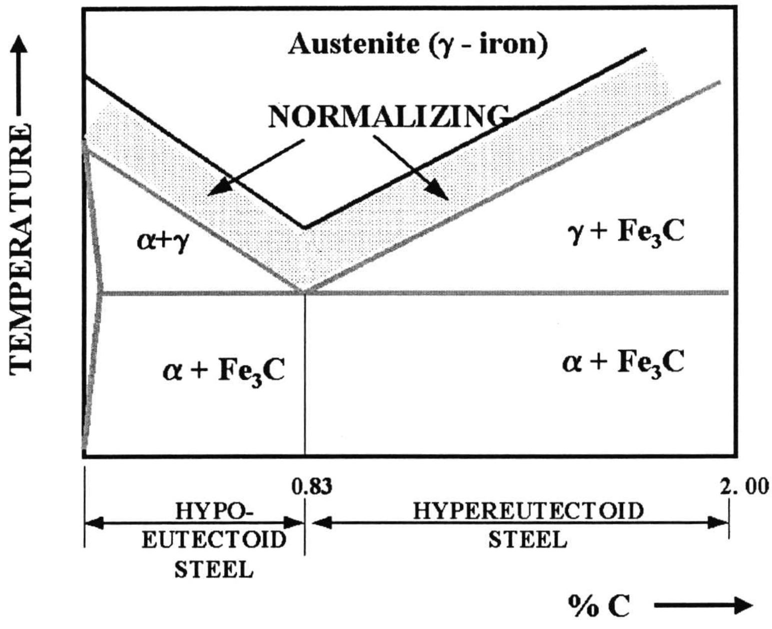


Fig.(13) diagram normalizing

In the same way (ak) for normalizing is more than all the others because (ak) depends on (Av) and cross-section area of the specimen(so)cm^2.

One of the other cases which we have made annealing
At first sub-critical annealing for it in 650 c°, when we make annealing for it we notic e that it doesn't reach 723 c°, below lower critical temperature(LCT) and this become different in structure because recrystalization occurs and this %c judges over the chan ges if %0.83C there its
Hypo eutectoid steel Structure(Fe3C+á)but if carbon percent is more than %0.83-2 C t hat is hyper eutectoid steel, therefore the grain faces spheroidizing. The composition i s semintite+pearlite. The sementite makes a web round the pearlite which is brittle,
Then in this case when we have made full annealing for it, its temperature is 870 C° o ver lower critical temperature about upper critical temperature (UCT)therefore in this case some changes happen in the specimen, same properties of annealing.

1-Improved ductility

2-Removal of residual stresses that result from cold-working or machining

3-Improved machinability

4-Grain refinement

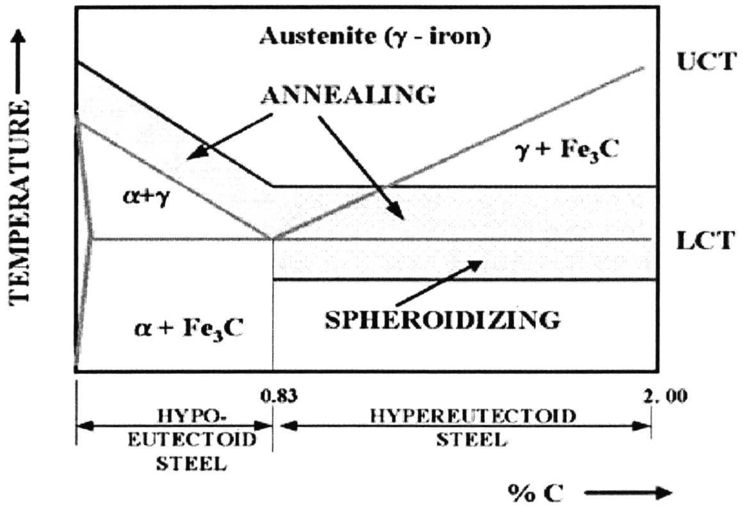
It passes some operations which are

(1) recovery (stress-relief),

(2) recrystallization,

(3) grain growth stages. [6]

When we make full annealing we notice that hardness, yield strength and tensilewii be come less. The diagram annealing showing by figure(14)



Fig(14) diagram annealing

The result that we have get are close to reality as it appears infigure(15) we see how ever (h1) is more the (ak)will be less and vice versa. This depends on the rate of carbo n if %C is lea than 0.83 and this is the hypo eutectoid, If the rate of carbon is more tha n is%0.83-2 this is hyper eutectoid steel when we made normalizing some changes in the properties of the metal happened Which are written before.

We see from the result in normalizing that we have got the greatest(Av) so our experi ment is near in reality. [7]

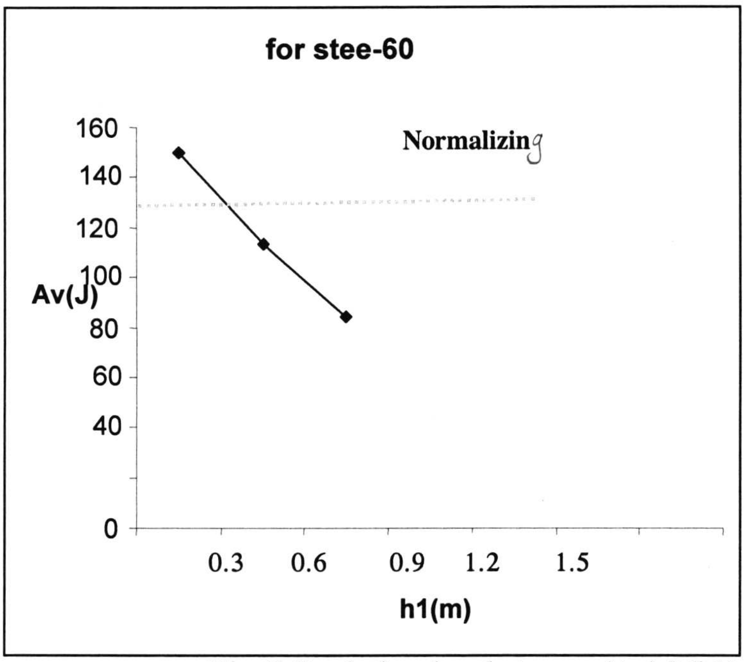


Fig.(15) relationshep between (Av)&(h1)

The second time we used α -brass.

We realized from the data the value of impact work changes according to the specime n condition for instance, notched bar impact(Av)j for α -brass 400 C° is less than all th e others. then room temperature comes as a second. After that α -brass 600 comes as a third, and α -brass 500 C° comes as a fourth.

The reason of this is the difference of temperature in the pieces and heating them, The n cooling rate that all of them except the room temperature in a furnace have been coo led, but as it appears in the results we notice few differences in the value of notched b ar impact(Av)j, Impact value (ak)j/cm^2 , because of some defects including.

1-Mistakes in measurements.

2-Mistakes in the instrument.

We also noticed the reason of changing the value result from the operation that we ma de fpr the metal which is annealing, and this shows some phenomena in the metals as i t was mentioned before.

These properties show when work is done on the metal we see that a change in value notched bar impact(Av)j, Impact value (ak)j/cm^2, lifting angle(ß°), lifting height(h1) m, has happened.

The aim of our project in this will see itself.

In the same way the greater angle=124.7 ° which α -brass annealing at 400 C°. The sm allest angle=0 ° which is á-brass at temperature 500 C°,600 C°.

We see the greater h1=1.297m which of α -brass is 400 C° and the smallest h1=0.193 m which in α -brass is 600 C°.

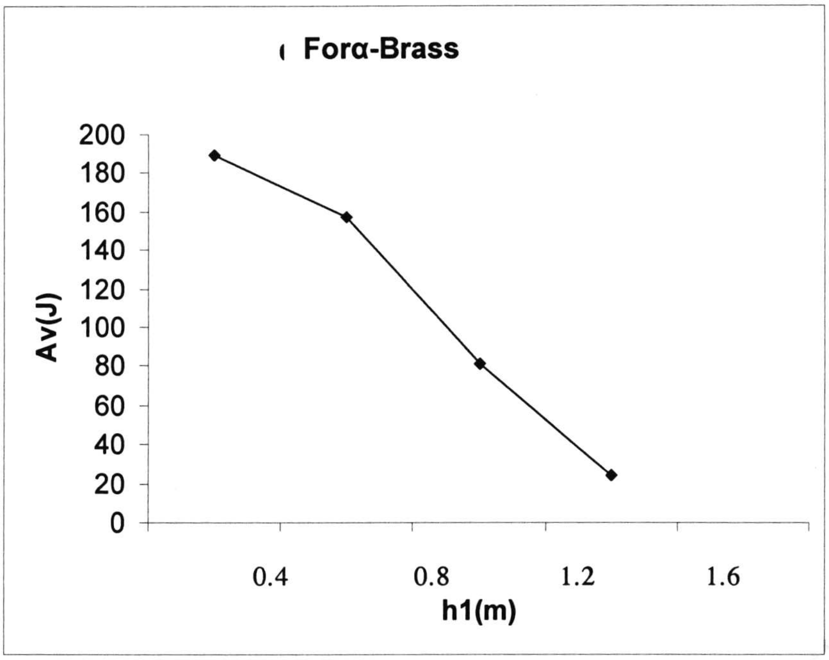


Fig.16 relationship between(Av,h1)

Conclusions:-

In this project we conclude these information :-

1-The Annealing is affected on the value of (h1,ß,ak,Av).

2-The normalizing is affected too on the value of (h1, ß ,ak,Av).

3- We conclude however value of Av increased the value of h1 decreased.

4- We conclude the maximum value of impact work (Av) in normalizing for steel-60.

5- Minimum value of impact work (Av) in steel-60 in the normal room temperature.

6- The normalizing is more affected than annealing on the specimen and it become mo re ductility.

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