ภาคผนวก

ส่วนประกอบของเหล็ก AISI 4140

เหล็กกล้าคาร์บอน (ผลิตภัณฑ์เส้นกลม , บาร์และเหล็กสำหรับตีขึ้นรูป)

AISI TYPE	: 4140
Tensile Strength	: 290,000 – 117,000 psi
Yield strength (0.2% offset)	: 251,000 – 100,000 psi
Elongation (in 2 in.)	: 11 - 23 % (cold drawn with normal draft)
Red. of area	: 42 - 65 % (cold drawn with normal draft)
Hardness , Brinell	: 578 - 235
Impact Strength (Izod) , ft – lb	: 11 -108

ส่วนประกอบทางเคมีของเหล็ก AISI 4140

C : 0.38 – 0.43%

Mn : 0.60-0.90 %

P_{max} : 0.035 %

S_{max} : 0.040 %

Rockwell Test

1. Description :

In this test a hardness value is obtained by determining the depth of penetration of a diamond point or a steel ball into the specimen under certain arbitrarily fixed conditions. A minor load of 10 kgf is first applied which causes an initial penetration, sets the penetrator on the material and holds it in position. A major load which depends on the scale being used is applied increasing the depth of indentation. The major load is removed and, with the minor load still acting, the Rockwell number, which is proportional to the difference in penetration between the major and minor loads is determined; this is usually done by the machine and shows on a dial, digital display, printer, or other device. This is an arbitrary number which increases with increasing hardness. The scales most frequently used are as follows:

Scale Symbol	Penetrator	Major Load,kgf	Minor Load,kgf
B	1/16-in, steel ball	100	10
C	Diamond brale	150	10

Rockwell superficial hardness machines are used for the testing of very thin steel or thin surface layers. Loads of 15, 30, or 45 kgf are applied on a hardened steel ball or diamond penetrator, to cover the same range of hardness values as for the heavier loads. The superficial hardness scales are as follows:

Scale Symbol	Penetrator	Major Load,kgf	Minor Load,kgf
15T	1/16-in. Steel ball	15	3
30T	1/16-in. Steel ball	30	3
45T	1/16-in. Steel ball	45	3
15N	Diamond brale	15	3
30N	Diamond brale	30	3
45N	Diamond brale	45	3

2. Reporting Hardness – In recording hardness values, the hardness number shall always precede the scale symbol, for example : 96 HRB, 40 HRC, 75 HR15N, or 77 HR30T.

3. Test Blocks – Machines should be checked to make certain they are in good order by means of standardized Rockwell test blocks.

4. Detailed Procedure – For detailed requirements of this test, reference shall be made to the latest revision of Test Methods E 18.

Protable Hardness Test

1. Although the use of the standard, stationary Brinell or Rockwell hardness tester is generally preferred, it is not always possible to perform the hardness test using such equipment due to the part size or location. In this even, hardness testing using portable equipment as described in Practice A 833 or Test Method E 110 shall be used.

CHARPY IMPACT TESTING

Summary

1. A Charpy V-notch impact test is a dynamic test in which a notched specimen is struck and broken by a single blow in a specially designed testing machine. The measures test values may be the energy absorbed, the percentage shear facture, the lateral expansion opposite the notch, or a combination thereof.

2. Testing temperatures other than room (ambient) temperature often are specified in product or general requirement specifications (hereinafter referred to as the specification). Although the testing temperature, the two temperatures need not be identical.

Significance and Use

1. Ductile vs. Brittle Behavior – Body-centered-cubic or ferritic alloys exhaibit a significant transition in behavior when unpact tested over a range of temperatures. At temperatures above transition, impact specimens fracture by a ductile (usually microvoid coalescence) mechanism, absorbing relatively large amounts of energy. Within the transition range, the fracture will generally be a mixture of areas of ductile fracture and brittle fracture.

2. The temperature range of the transition from one type of behavior to the other varies according to the material being tested. This transition behavior may be defined in various ways for specification purposes.

The specification may require a minimum test result for absorbed energy, fracture appearance, lateral expansion, or a combination thereof, at a specified test temperature.

The specification may require the determination of the transition temperature at which either the absorbed energy or fuacture appearance attains a specified level when testing is perfotmed over a range of temperatures.

3. Further information on the significance of impact testing appears in Annex A5.

Apparatus

1. Testing Machines :

A Charpy impact machine is one in which a notched specimen is broken by a single blow of a freely swinging pendulum. The pendulum is released from a fixed height. Since the height to which the pendulum is raised prior to its swing, and the mass of the pendulum are known, the energy of the blow is predetermined. A means is provided to indicate the energy absorbed in breaking the specimen.

The other principal feature of the machine is a fixture designed to support a test specimen as a simple beam at a precise location. The fixture is arranged so that the notched face of the specimen is vertical. The pendulum strikers the other verical face directly opposite the notch. The dimensions of the specimen supports and striking edge shall conform to Fig. 10.

Charpy machines used for testing steel generally have capacities in the 220 to 300 ft.lbf (300 to 400 J) energy range. Sometimes machine should be substantially in excess of the absorbed energy of the specimens (see Test Methods E 23). The linear velocity at the point of impact should be in the range of 16 to 19 ft/s (4.9 to 5.8 m/s).

2. Temperature Media:

For testing at other than room temperature, it is necessary to condition the Charpy specimens in media at controlled temperatures.

Low temperature media usually are chilled fluids (such as water, ice plus water, ice plus water, dry ice plus organic solvents, or liquid nitrogen) or chilled gases.

Elevated temperature media are usually heated liquids such as mineral or silicone oils. Circulating air ovens may be used.

3. Handling Equipment – Tongs, especially adapted to fit the notch in the impact specimen, normally are used for removing the specimens from the medium and placing them on the anvil (refer to Test Methods E 23). In cases where the machine fixture does not provide for automatic centering of the test specimen, the tongs may be precision machined to provide centering.

Sampling and Number of Specimens

1. Sampling:

Test location and orientation should be addressed by the specification. If not,

for wrought products, the test location shall be the same as that for the tensile specimen and the orientation shall be longitudinal with the notch perpendicular to the major surface of the product being tested.

Number of Specimens.

A Charpy impact test consists of all specimens taken from a single test coupon or test location.

When the specification calls for a minimum average test result, three specimens shall be tested.

When the specification requires determination of a transition temperature, eight to twelve specimens are usually needed.

2. Type and Size:

Use a standard full size Charpy V – notch specimen (Type A) as shown in Fig. 11,except as allowed in 2.2

Subsized Specimens.

For flat materials tested in the transverse direction, when the absorbed energy is expected to exceed 80% of full scale, use standard subsize test specimens.

For tubular materials tested in the transverse direction, where the relationship between diameter and wall thickness does not premit a standard full size specimen, use standard subsize test specimens or standard size specimens containing outer diameter (OD) curvature as follows:

(1) Standard size specimens and subsize specimens may contain the original OD surface of the tubular product as shown in Fig. 12. All other dimensions shall comply with the requirements of Fig. 11.

Note 13 – For materials with toughness levels in excess of about 50 ft-lbs, spicimens containing the original OD surface may yield values in excess of those resulting from the use of conventional Charpy specimens.

If a standard full-size specimen cannot be prepared the largest feadible standard subsize specimen shall be prepared. The specimens shall be machined so that the specimen does not include material nearer to the surface than 0.020 in. (0.5 mm).

Tolerances for standard subsize specimens are shown in Fig. 11. Standard

subsize test specimen sizes are: 10 x 7.5 mm, 10 x 6.7 mm, 10 x 5 mm, 10 x 3.3 mm, and 10 x 2.5 mm.

Notch Preparation – The narrow face for standard subsize specimens so that the notch is prependicular to the 10 mm wideface.

3. Notch Preparation – The machining of the notch is critical, as it has been demonstrated that extremely minor variations in notch radius and profile, or tool marks at the bottom of the notch may result in erratic test data, (See Annex A5).

Calibration

1. Accuracy and Sensitivity – Calibrate and adjust Charpy impact machines in accordance with the requirements of Test Method E 23.

Conditioning – Temperature Control

1. When a specific test temperature is required by the specification or purchaser, control the temperature of the heating or cooling medium within 2 F (1 C) because the effect of variations in temperature on Charpy test results can be very great.

Note – For some steels there may not be a need for this restricted temperature, for example, austenitic steels.

Note – Because the temperature of a testing laboratory often varies from 60 to 90 F (15 to 32 C) a test conducted at " room temperature " might be conducted at any temperature in this range.

Procedure

1. Temperature

Condition the specimens to be broken by holding them in the medium at test temperature for at least 5 min in liquid media and 30 min in gaseous media.

Prior to each test, maintain the tongs for handling test specimens at the same temperature as the specimen so as not to affect the temperature at the notch.

2. Positioning and Breaking Specimens:

Carefully center the test specimen in the anvil and release the pendulum to break the specimen.

If the pendulum is not release within 5 s after removing the specimen from the

conditioning medium, do not break the specimen. Return the specimen to the conditioning medium for the period required in 1.1

3. Recovering Specimens – In the event that fracture appearance or lateral expansion must be determined, recover the matched pieces of each broken specimen before breaking the next specimen.

4. Individual Test Values:

Impact energy – Record the impact energy absorbed to the nearest ft.lbf (J).

Fracture appearance:

Determine the percentage of shear fracture area by any of the following methods:

(1) Measure the length and width of the brittle portion of the fracture surface, as shown in Fig. 13 and determine the percent shear area from either Table 7 or Table 8 depending on the units of measurement.

(2) Compare the appearance of the fracture of the specimen with a fracture appearance chart as shown in Fig. 14.

(3) Magnify the fracture surface and compare it to a precalibrated overlay chart or measure the percent shear fracture area by means of a planimeter.

(4) Photograph the fractured surface at a suitable magnification and measure the percent shear fracture area by means of a planimeter.

Determine the individual fracture surface appearance values to the nearest 5% shear and record the value.

Lateral Expansion:

Lateral expansion is the increase in specimen width, measured in thousandths of an inch (mils), on the compression side, opposite the notch of the fractured Charpy V-notch specimen as shown in Fig. 15.

Examine each specimen half to ascertain that the protrusions have not been damaged by contacting the anvil, machine mounting surface, and so forth. Discard such samples since they may cause erroneous readings.

Check the sides of the specimens perpendicular to the notch to ensure that

no burrs were formed on the sides during impact testing. If burrs exist, remove them carefully by rubbing on emery cloth or similar abrasive surface, making sure that the protrusions being measured are not rubbed during the removal of the burr.

Measure tha amount of expansion on each side of each half relative to the plane defined by the undeformed portion of the side of the specimen using a gage similar to that shown in Fig. 16 and Fig. 17.

Since the fracture path seldom bisects the point of maximum expansion on both sides of a specimen, the sum of the larger values measured for each side is the value of the test. Arrange the halves of one specimen so that compression sides are facing each other. Using the gage, measure the protrusion on each half specimen, ensuring that the same side of the specimen is measured. Measure the two broken halves individually. Repeat the procedure to measure the protrusions on the opposite side of the specimen halves. The larger of the two values for each side is the expansion of that side of the specimen.

Measure the individual lateral expansion values to the nearest mil (0.025 mm) and record the values.

Interpretation of Test Result

1. When the acceptance criterion of any impact test is specified to be a minimum average value at a given temperature, the test result shall be the average (arithmetic mean) of the individual test values of three specimens from one test location.

When a minimum average test result is specified:

The test result is acceptable when all of the below are met:

(1) The test result equals or exceeds the specified minimum average (given in the specification),

(2) The individual test value for not more than one specimen measures less than the specified minimum average, and

(3) The individual test value for any specimen measures not less than two – thirds of the specified minimum average.

If the acceptance requirements of 1.1.1 are not met, perform one retest of three additional specimens from the same test location. Each individual test value of the retested specimens shall be equal to or greater than the specified minumum average value.

2. Test Specifying a Minimum Transition Temperature:

Definition of Transition Temperature – For specification purposes, the transion temperature is the temperature at which the designated material test value equals or exceeds a specified minimum test value.

Determination of Transition Temperature:

Break one specimen at each of a series of temperatures above and below the anticipated transition temperature to the nearest 1 F (0.5 C).

Plot the individual test results (ft.lbf or percent shear) as the ordinate versus the corresponding test temperature as the abscissa and construct a best – fit curve through the plotted data points.

If transition temperature is specified as the temperature at which a test value is achieved, determine the temperature at which the plotted curve intersects the specified test value by graphical interpolation (extrapolation is not permitted). If the tabulated test results clearly indicate a transition temperature lower than specified, it is not necessary to plot the data. Record this transion temperature to the nearest 5 F (3 C). If the tabulated test results clearly indicate a transition temperature lower than specified, it is not necerest to plot the data. Report the lowest test temperature for which test value exceeds the specified value.

Accept the test result if the determinde transition temperature is equal to or lower than the specified value.

If the determined transition temperature is higher than the specified value, but not more than 20 F (12 C) higher than the specified value, test sufficient samples in accordance with Section 25 to plot two additional curves. Accept the test results if the temperature determined from both additional tests are equal to or lower than the specified value.

3. When subsize specimens are permitted or necessary, or both, modify the specified test reqirement according to Table 9 or test temperature according to ASME Boiler and Pressure Vessel Code, Table UG – 84.2, or both. Greater energies or lower test temperatures may be agreed upon by purchaser and supplier.

Records

1. The test record should contain the following information as appropriate:

Full description of material tested (that is, specification number, grade, class

or type, size, heat number).

Specimen orientation with respect to the material axis.

Specimen size.

Test temperature and individual test value for each specimen broken, including initial and retests.

Test results.

Transition temperature and criterion for its determination, including initial tests and retests.

Report

1. The specification should designate the information to be reported.

Keywords

1. bend test; Brinell hardness; charpy impact test; elongation; FATT (Fracture Appearance Trainsition Temperature); hardness test; portable hardness; reduction of area; Rockwell hardness; tensile strength; tension test; yield strength.