Proto Type Development of Cage Suspension Gear and Test Procedure

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PROTO TYPE DEVELOPMENT OF CAGE SUSPENSION GEAR AND TEST PROCEDURE

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SYNOPSIS

The paper reviews and discusses the meaning of 'proto type' and the difference in technique of mass production vis-a-vis proto type making. It surveys the population of steam, Friction and electric winders in our country. The author discusses the various tests and their procedure required for the development of the proto type of CS Gear. It tells us about the type of steel that is permitted by DGMS and the limits of the permissible imperfections. Finally the author has emphasized on the adoption of ISO 9001-2008 by manufacturers.

PREAMBLE

In every hour of everyday, millions of tons of coal and other minerals as well as thousands of men and large quantities of essential material are being transported through vertical or inclined shafts. If that transport system is to be uninterrupted and safe it is essential to use proved and reliable gear for the attachment of rope to the conveyance.

DGMS Directorate ensures that proven and reliable product is supplied to the industries. It is therefore mandatory to develop a 'PROTO-TYPE' of equipment by manufacturers before they are permitted for regular manufacture and use.

PROTO TYPE DEVELOPMENT OF CAGE SUSPENSION GEAR AND TEST PROCEDURE

The three key words used in this topic are 'PROTO TYPE',
'CAGE SUSPENSION GEAR' and 'TEST PROCEDURE'

PROTO TYPE

Wikipedia says PROTO TYPE means 'an original or model after which anything is copied; the pattern of anything to be engraved, or otherwise copied, cast, or the like; a primary form; exemplar; archetype.

A **prototype** is an original type, form, or instance of something serving as a typical example, basis, or standard for other things of the same category. The word derives from the **Greek**
πρωτΌτυττον *(prototypon)* meaning *"primitive form"*, or πρώτος *(protos)*, meaning *"first"*

In context of an industry 'proto-type' means sample product manufactured on a small scale in order to test product performance and market response. If a prototype is successful, the marketer must determine how to produce it in large quantities in a cost-effective manner. A small group of targeted buyers might be selected to use the prototype on a test basis and participate in fine-tuning the product characteristics.

There are some basic **differences between a prototype and a production design.**

In general, prototype will differ from the final production variant in three fundamental ways:

Materials. Production materials may require manufacturing processes involving higher capital investment than what is practical for prototyping. Instead, engineers or prototyping specialists will attempt to substitute materials with properties that simulate the intended final material.

Processes. Often expensive and time consuming unique tooling is required to fabricate a custom design. Prototypes will often compromise by using more flexible processes.

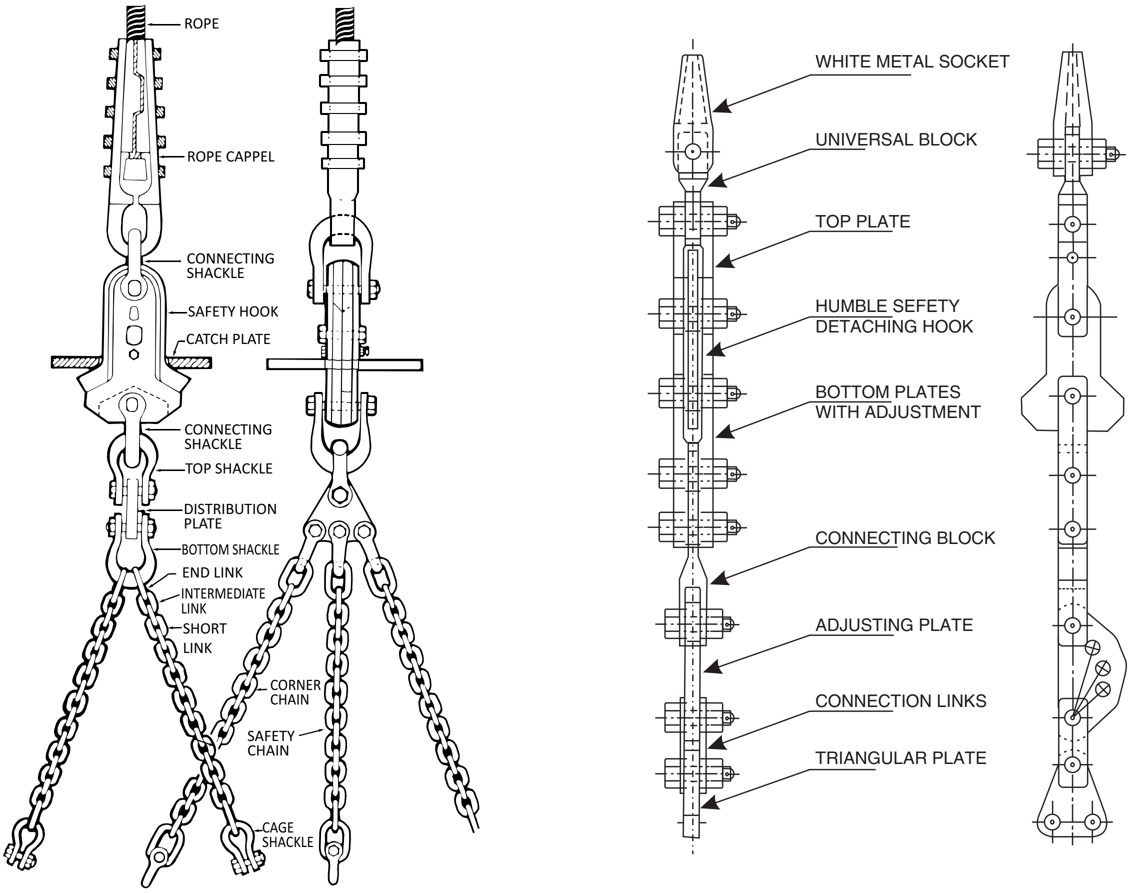
Lower fidelity. Final production designs often require extensive effort to capture high volume manufacturing details. Such detail is generally unwarranted for prototypes as some refinement to the design is to be expected. Often prototypes are built using very limited engineering detail as compared to final production intent.

CAGE SUSPENSION GEAR

It is an equipment used for suspension of cage/ skip for winding in underground mines. It comprises various components including rope cappel (friction wedge rope cappel or white metal rope cappel), safety hook, distribution plate, bridle chains and/ or chase block and link plates.

Two assembly of Cage Suspension Gear, single point as well as Bridle chain Type are illustrated here

CAGE SUSPENSION GEAR



Single Point Type.

Bridle Chain Type.

Fig 1

TESTING

This proto-type CS Gear has to go through a series of test procedure as specified by DGMS Directorate which is discussed later on.

These CS Gears are to be used in conjunction with the winders. A survey report of winder population is given below -

WINDER POPULATION

In our country it is estimated total winder population is about 360 ((Excluding Bharat Gold Mines Ltd. which has 85 nos. winders which are lying closed since about a decade. Normal operation is likely to be resumed shortly) with the following break up:-

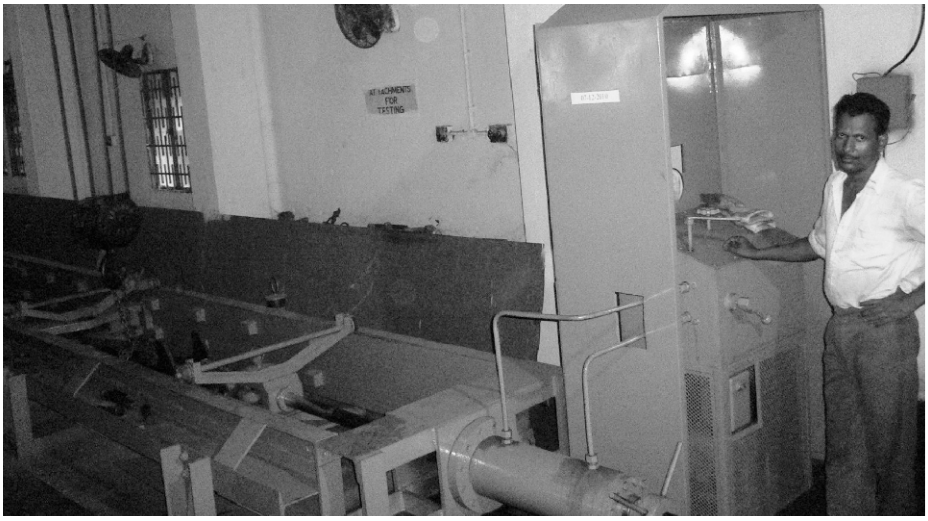
COMPANY'S NAME	NO. OF STEAM WINDERS	NO. OF ELECTRIC DRUM WINDER	NO. OF FRICTION (KOEPE) WINDER	SUB TOTAL
BCCL	31	58	07	96
ECL	118	42		160
CCL		03	03	03
SECL		03		03
WCL		03		03
MCL		04		04
Singareni Collieries Co. Ltd.		04		04
TATA		09	03	09
SAIL		06		06
Uranium Corp. of India		05	06	11
HCL, Khetri		02	01	03
HCL, Kolihan		03	01	04
HZL, Rajpur Dariba		02	01	03
HZL, Zawar		02	04	06
Manganese Ore India Ltd.		08		03
HUTTI Gold Mines		07		07
Indian Metal & Ferro Alloys Ltd,		01		01
Ferro Alloys Corp. Ltd.		03		03
INDIA RESOURCE		03		03
TECHNOMIN		07		07
MAHESHWARI		04		04
DELTA		01		01
TOTAL	***149***	***180***	***23***	***344***
PRESENT TOTAL WINDER POPULATION IN OUR COUNTRY –				**352**

With so many winders working in our country it is quite challenging to take care of the safety of the personnel. To ensure 100% safety following proto-type testing procedure is advised by DGMS Directorate before granting field trial approval to the manufacturer-

1. Proof Load
2. Non Destructive testing by magnetic particle flaw detector and ultrasonic flaw detector
3. Break load.
4. Micro exam and inclusion rating.
5. Hardness at core and surface.
6. Izod-Impact test .
7. Chemical Analysis for elements.

1. PROOF LOAD

Each finished component of suspension gear separately or collectively shall be subjected to tensile proof load as specified in relevant parts of BIS standard and shall satisfactorily withstand the test without any permanent deformation or defect. It is a non-destructive test. It will determine the strength, ductility, resilience, toughness and several other material properties. This is carried out with the help of tensile testing machine.



500 Tone Tensile Testing Machine at CIMFR, Dhanbad

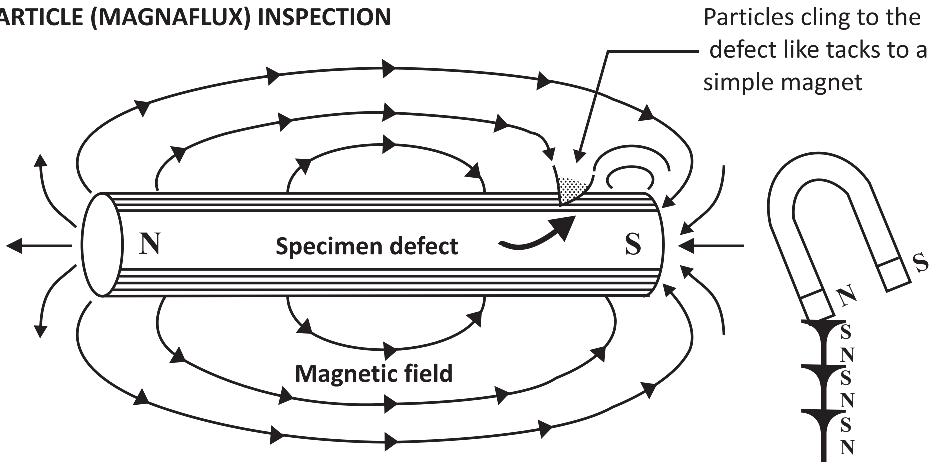
Fig 2

NON-DESTRUCTIVE TESTING

1. As the name implies this test does not damage reduce the service life of the component. Usually these tests do not directly measure the mechanical properties such as tensile strength or hardness, but they are used to locate the defects or flaws in the component. These flaws may reduce the useful life of the component resulting in the premature failure even with a sound design and proper selection of materials.

2. Various methods are used to detect defects in components. The most common types of non destructive test are magnetic particle (Magnaflux) inspection, ultrasonic inspection.
Magnetic particle (Magnaflux) Inspection, eddy current inspection and visual inspection.

MAGNETIC PARTICLE (MAGNAFLUX) INSPECTION



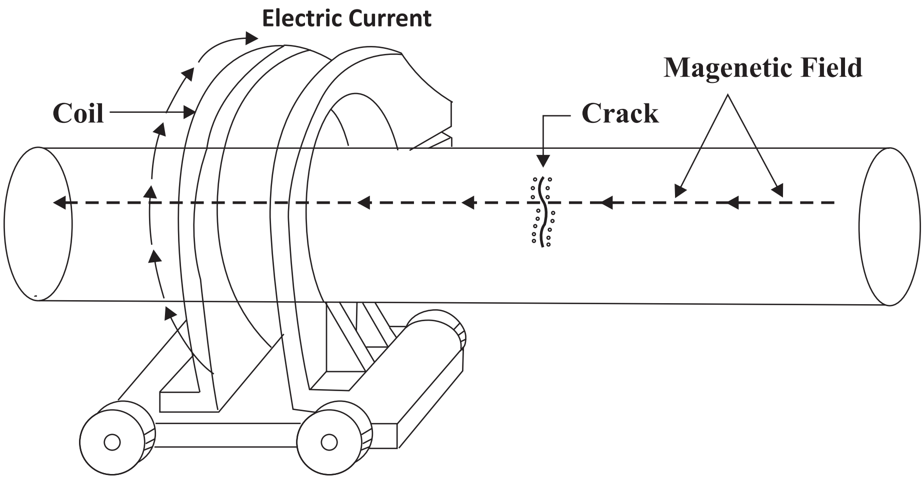
Principle of a magnaflux method

Fig 3

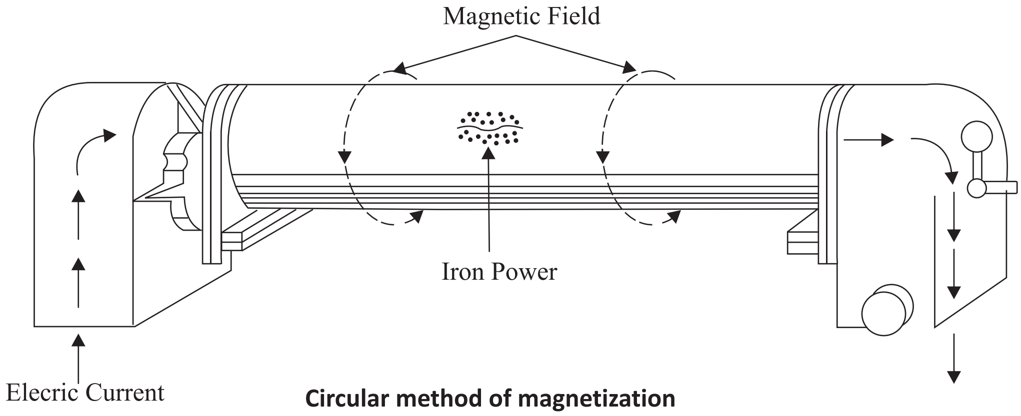
There are several methods of magnetic particle testing (ASTM E 709 or IS 10543 and IS 12147) All these methods are used to detect various kinds of flaws such as welding, castings and forgings of iron and steel in ferromagnetic components.

The component to be inspected for flaws is magnetized and inspection medium is applied to the component. In the wet method of inspection a liquid containing fine Ferro-magnetic particle suspended in some carrier such as kerosene or petroleum oil is applied on the test piece by dipping or spraying.

Magnetization of the component is done either by using an external magnetic Yoke coil or by passing an electric current through it. A magnetic pole is formed at the crack or flaw, which causes the magnetic powder to concentrate on this area and the flaw, gets easily detected. When the part is magnetized lengthwise (Fig. 4), transverse cracks are easily detected. This is done by passing an electric current, either alternating or direct, through the component. The use of alternating currents limits the test for detection of only those flaws which are open at the surface.



Longitudinal method of magnetization



Circular method of magnetization

Fig 4

Fig 5

ISI 7587 Part I : 2004 specifies that each component shall be examined for cracks after proof load test and visually by means of magnetic crack detection and ultrasonic tests. Permissible imperfections for magnetic particle inspection are given below.

1. Magnetic particle flaw detection shall be carried out as per IS 3703 :

   The type of defects and their limits are given Fig. 6 to Fig. 14.

2. Imperfections in components may be in the form of :

   A) Non-metallic inclusions which are inherent in steels, and

   B) Cracks.

Note - Magnetic particle inspection will reveal these imperfections when they are on or just below the surface.

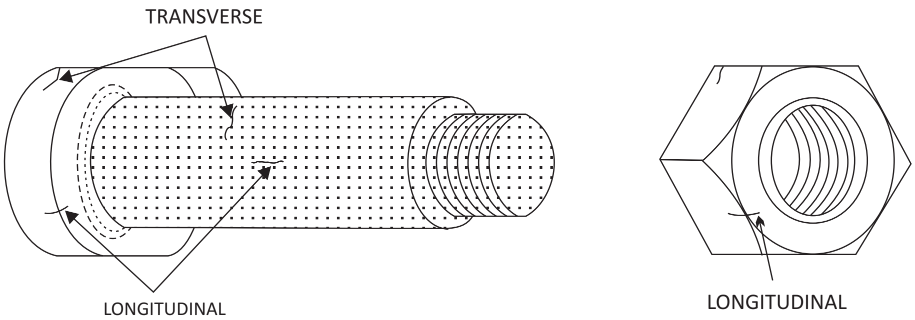
3. Limits of Permissible Imperfections :

   The Limits of Permissible inclusions shall be as given in following Figures. Cracks shall not be permitted.

   A) A Longitudinal imperfection is one which generally runs parallel to the major dimension of the component, a transverse imperfection is one which runs at right angles to the line defined for a longitudinal imperfection.

   B) Record: Imperfections which, although within the permissible limits, are of a large number, unusual pattern or direction, should be recorded on the component certificate.

PIN AND NUT



Part	*Type of Imperfection*	*Permissible Imperfections*
Pin, barrel and Thread	*Shaded Areas* Transverse	None
	Longitudinal	None >32 mm
Pin head and nut	*Unshaded Areas* Transverse	None> 10 mm
	Longitudinal	None >10 mm

Fig 6

SHACKLE BODY

Part	Type of Imperfection	Permissible Imperfections
	Shaded Areas	
Shackle	Transverse	None
body	Longitudinal	None >10 mm
	Unshaded Areas	
Shackle	Transverse	None
body	Longitudinal	None >32 mm

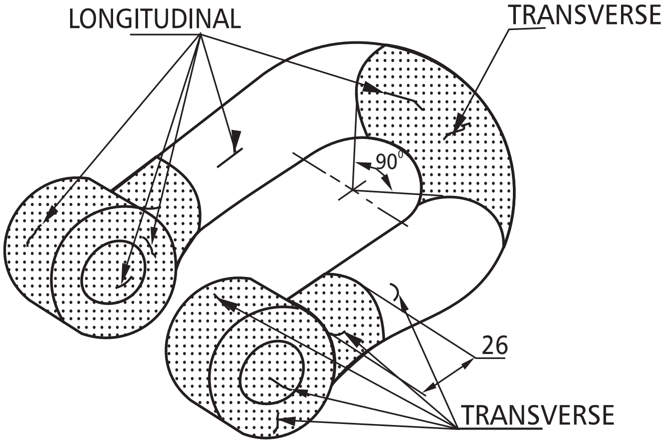
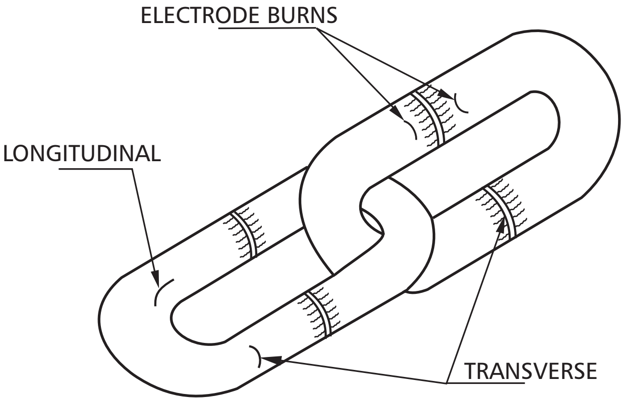


Fig - 7

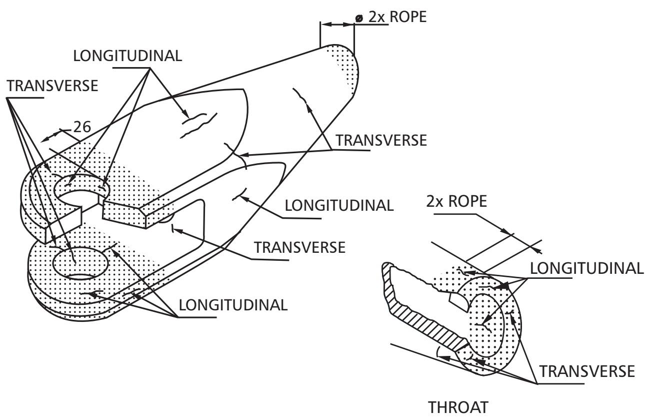
CHAIN LINKS



Part	Type of Imperfection	Permissible Imperfections
	All Area	
Chain Link	Transverse	None
	Longitudinal	None >10 mm
	electrode burns	None

Fig - 8

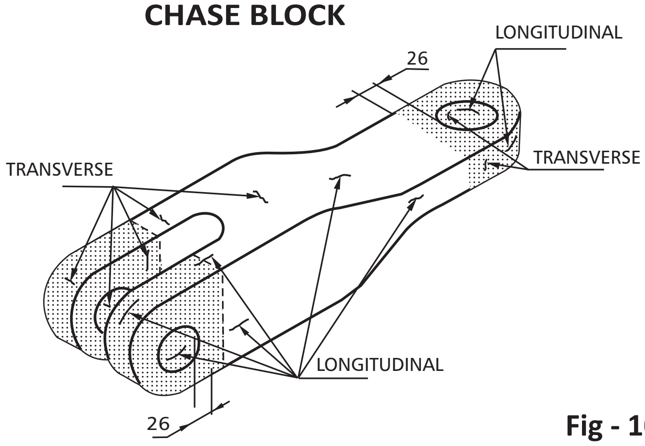
WHITE METAL SOCKET



Part	Type of Imperfection	Permissible Imperfections
	Shaded Areas	
Surfaces and	Transverse	None
throat	Longitudinal	None >10 mm
Holes and	Transverse	None
edges	Longitudinal	None >16 mm
	Unshaded Areas	
Body and	Transverse	None
Edges	Longitudinal	None >32 mm

Fig - 9

CHASE BLOCK



Part	Type of Imperfection	Permissible Imperfections
	Shaded Areas	
Surfaces	Transverse	None
	Longitudinal	None >10 mm
Holes and edges	Transverse	None
	Longitudinal	None >16 mm
	Unshaded Areas	
Body and edges	Transverse	None
	Longitudinal	None >32 mm

Fig - 10

DISTRIBUTION PLATE

Part	Type of Imperfection	Permissible Imperfections
	Shaded Areas	
Plate surfaces	Transverse	None
	Longitudinal	None >10 mm
Plate and edges	Transverse	None
	Longitudinal	None >32 mm
Holes	Transverse	None
	Longitudinal	None >16 mm
	Unshaded Area	
Plate surfaces	Transverse	None
	Longitudinal	None >32 mm
Plate edges	Transverse	None
	Longitudinal	None >64 mm

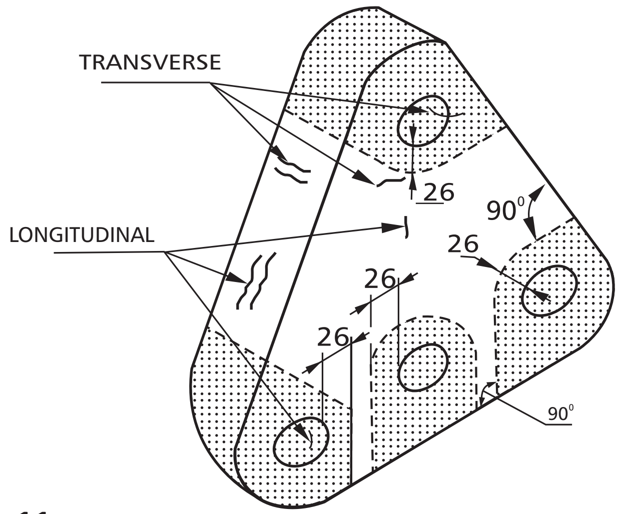


Fig - 11

PLATE AND SLOTTED LINKS

Part	Type of Imperfection	Permissible Imperfections
	Shaded Areas	
Plate surfaces	Transverse	None
	Longitudinal	None >10 mm
Plate edges	Transverse	None
	Longitudinal	None >32 mm
Holes and slot end	Transverse	None
	Longitudinal	None >16 mm
	Unshaded Area	
Surfaces	Transverse	None
	Longitudinal	None >32 mm
Plate edges and slot	Transverse	None
	Longitudinal	None >64 mm
Cantilever Faces	Transverse or Longitudinal	None

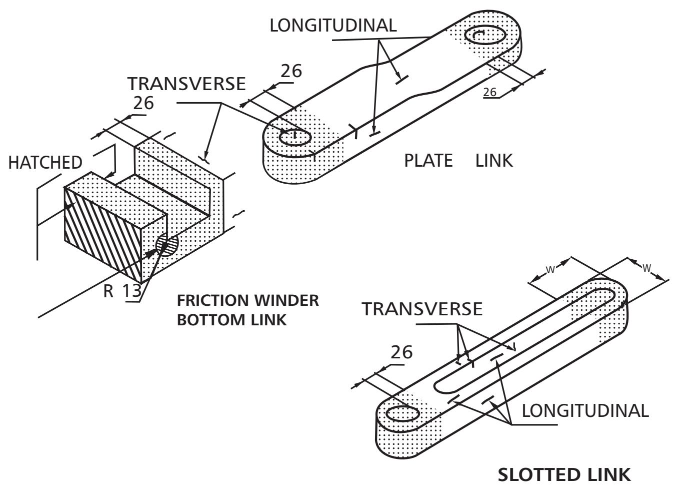
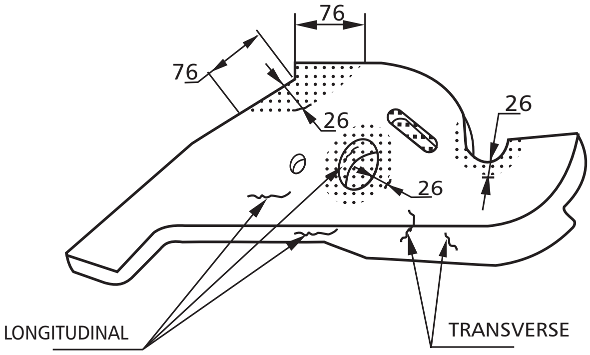
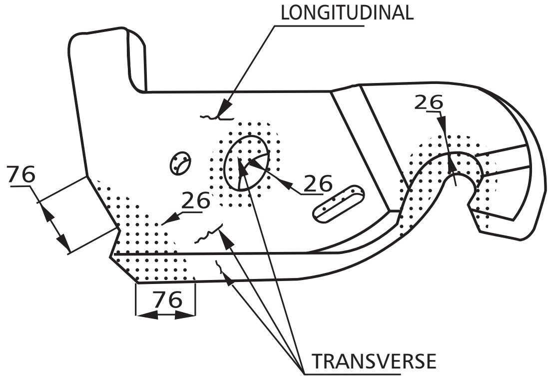


Fig - 12

HUMBLE DETACHING HOOK

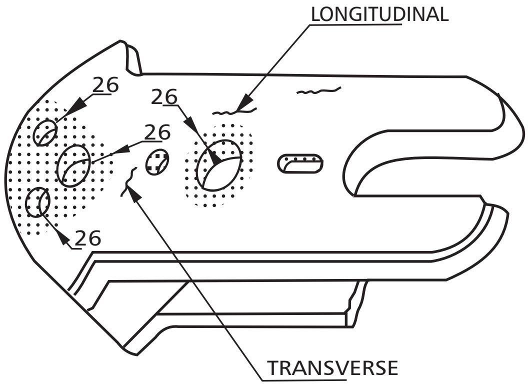


CENTRE PLATE



CENTRE PLATE

Part	*Type of Imperfection*	*Permissible Imperfections*
	Shaded Areas	
Plate surfaces	Transverse	None
	Longitudinal	None >10 mm
Plate edges	Transverse	None
	Longitudinal	None >32 mm
Holes and slots	Transverse	None
	Longitudinal	None >16 mm
	Unshaded Area	
Plate surfaces	Transverse	None
and slots	Longitudinal	None >32 mm
Plate edges	Transverse	None
and slots	Longitudinal	None >64 mm



SIDE PLATE

Fig - 13

FRICTION WEDGE ROPE CAPPEL

Part	*Type of Imperfection*	*Permissible Imperfections*
	Shaded Areas	
Bands, safety	Transverse	None
block & wedges	Longitudinal	None >10 mm
Limbs	Transverse	None
	Longitudinal	None >16 mm
	Unshaded Area	
Wedges	Transverse	None
	Longitudinal	None >32 mm
Limbs	Transverse	None
	Longitudinal	None >64 mm

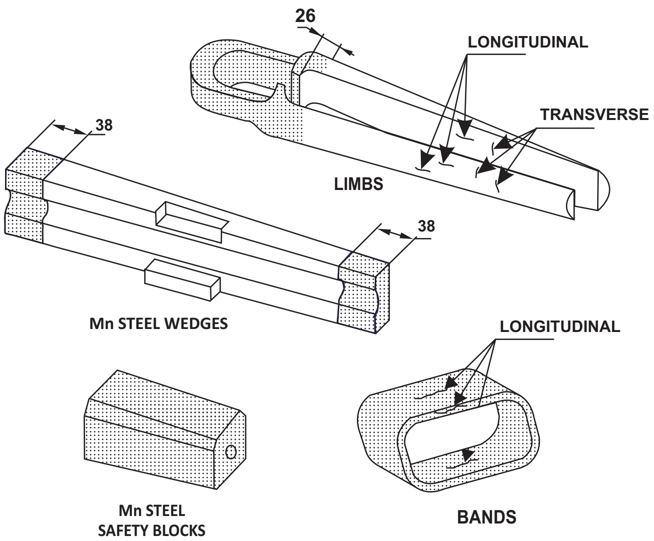


Fig - 14

ELECTROMAGENETIC YOKE

The light weight electromagnetic yoke is the ideal tool for detection of surface or sub surface cracks and flaws in any ferromagnetic material. No other low cost, portable equipment offers such versatility in magnetic particle inspection. Fast and simple to operate, it is widely used with either dry or wet method fluorescent or non fluorescent magnetic powders, in the testing of components and forgings

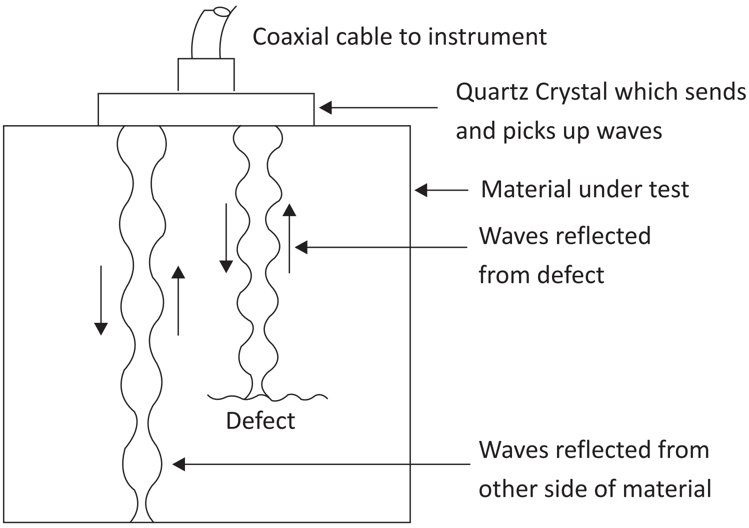
Fig - 15

Ultrasonic Inspection

The principle of ultrasonic testing involves a measure of the time required by ultrasonic vibrations to penetrate the material of interest, reflect from the opposite side or from an internal discontinuity and return to the point where the waves were introduced. The behavior of waves through such a cycle of travel with regard to time is approximately recorded on a cathode-ray oscilloscope (CRO) screen. By visual observation of this wave pattern on CRO screen, presence of defects and their location can be detected.

Ultrasonic testing is a very fast method of testing for defects because the time of travel of ultrasonic waves is of the order of microseconds for the usual size of the component. It is also a very sensitive method and reveals very fine flaws and discontinuities.

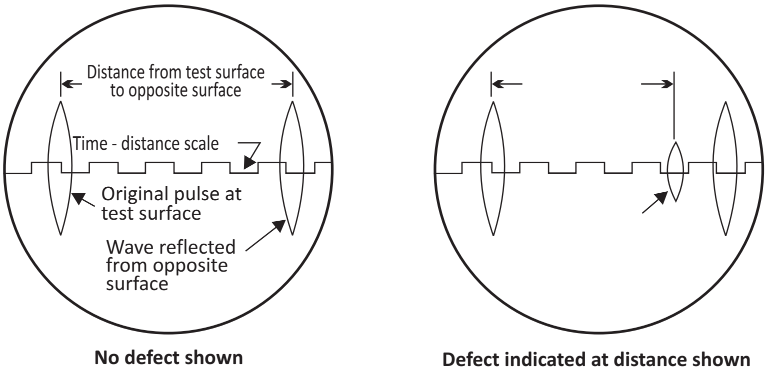
In the pulse echo method, a pulse generator produces ultrasonic waves and these waves are passed into the component through a quartz crystal as shown in the following figure



Detection of defects by ultrasonic waves.

Fig - 16

For a better contact of the transducer with the metal surface, couplent like thin oil or glycerin is used. As soon as the wave comes across a discontinuity, it gets reflected back. This is indicated as a pattern or 'pip' on the CRO. The wave reflected by the surface of the test piece and the wave reflected by the opposite side of the test piece are also indicated as 'pips' on the CRO, defining the time of initial pulse and the reflected pulse from the opposite side. If there is a flaw in the specimen a smaller pip will be seen between the two i.e. one from the top and other from the bottom as shown below



Ocsilloscope screen of ultrasonic tester

Fig - 17

Fig - 18

Since the distance between the pips on the OCR represent elapsed time of the reflected pulse, the distance to a flaw can be accurately measured.

Ultrasonic inspection method can be used as a quality control test for detecting internal defects such as cracks, porosity and laminations in metallic and non-metallic components during and after production.

3. BREAK-LOAD

It is the destructive tensile load to which the components are subjected to in the finished condition. In the breaking load the factor of safety should not be less than 10 and for threaded component not less than 15.

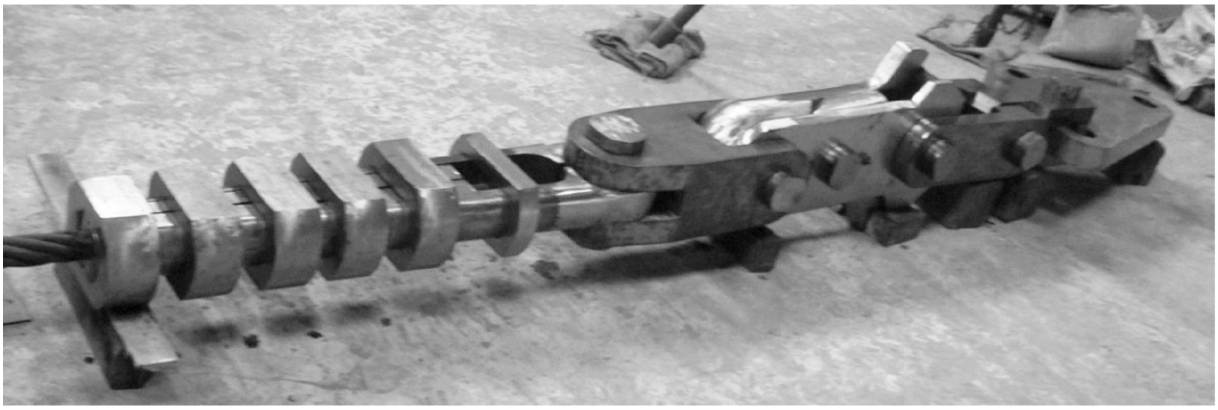


Fig - 19

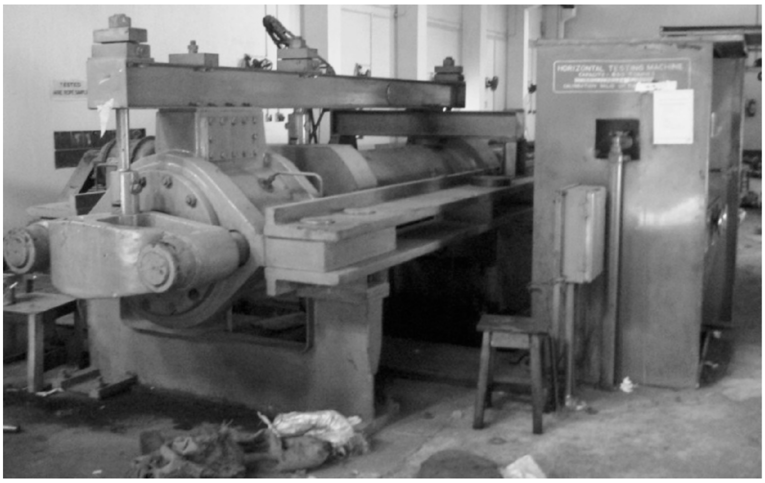


Fig - 20

4. MICRO EXAM

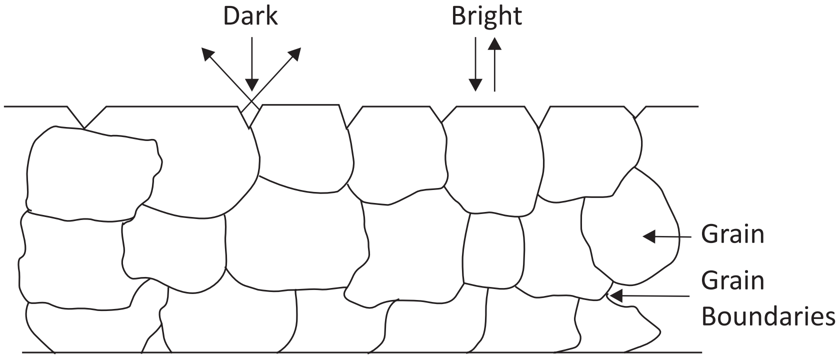
Microscopic examination involves study of prepared metal surfaces using higher magnifications (>60 x). Due to use of higher magnifications, it reveals large number of structural details of the metals or alloys under examination. Structural details such as grain size; the size, shape and distribution of secondary phases and non metallic inclusions; and segregation and other heterogeneous conditions are revealed by microscopy. Study of micro structural details also reveals the history of mechanical and heat treatments given to the metal or alloy. All of them influence the mechanical properties and deformation behavior of metals. When these and other constitutional features are determined by the metallographic examination, it is then possible to predict the likely behavior of the metal for a particular service condition with reasonable accuracy.

For microscopic examination, the specimen surface must be prepared properly. Improper preparation is likely to remove inclusions in steels ultimately producing a structure, at least on the surface, entirely different from the original structure of the metal. Obviously, interpretations based on such faulty structures will be erroneous and unreliable.

The sample is grinded, polished and examined under the microscope in an un etched condition. Non-metallic inclusion rating for type A, B, C and D as per IS: 4163:1982 should not exceed 1.5. (IS 7587:2000 Part I)

Then the specimen is polished and etched. Etching is a process done on polished surface so that the structural details are revealed by the microscope. In most of the cases, the process consists of subjecting the polished surface to the action of a suitable chemical reagent under controlled conditions. The sample is etched in 1% Nital solution

Nital (**Nit**ric acid + **Al**cohol) Nitric acid (conc.) (Sp. Gr. 1.42**)**.....2 to 5 ml Ethyl or methyl alcohol (absolute).....100 ml.



Correlation of etched surface with the microscopical appearance of a single phase alloy or pure metal.

Now, the sample should reveal normalized structure with distributing pearlite resembling to the 20C15 plain low carbon steel. Magnification is usually done as 400x.

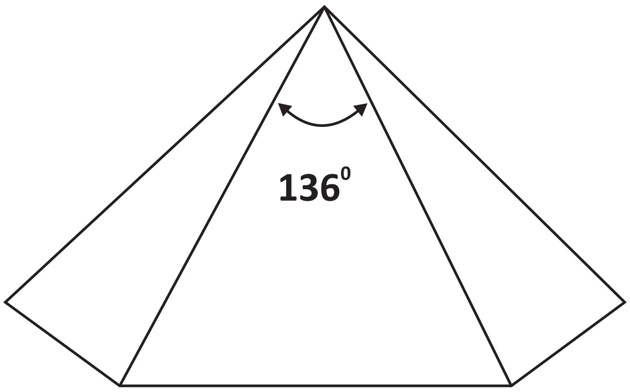
Fig - 21

5. HARDNESS AT CORE AND SURFACE

Hardness of metals and alloys is a complex property and depends upon other properties such as grain size, yield strength, tensile strength, ductility, work hardening co-efficient, resistance to abrasion etc. Various methods are used for the measurement of hardness and each method is based on a different principle. In all these methods, hardness is reported by a certain characteristic number.

In our country Vickers Hardness Test method as per IS: 1501:2002 is adopted. Vickers hardness tester works on the same principle as the Brinell Hardness tester and the way of expressing hardness is also similar (ASTM E 92 or IS 1501).

Vickers indenter is made of diamond in the form of a square based pyramid with an included angle of 136^0 between the opposite faces. This 136^0angle is chosen because it corresponds to the most desirable ratio of indentation diameter to ball diameter of 0.375 in the Brinell hardness test. Loads to be applied are in the range of 1 to 120 kgs. The load selected for a given test piece should be as large as possible, with due consideration for the dimensions of the test piece (Particularly the thickness), the relative hardness of the material and the purpose of the test. For case hardened components 1 and 2.5 kg loads are suitable whereas for most of the other materials, loads from 10 to 40 kg are suitable. The hardness tester is semi-automatic operation in which after the specimen surface is brought close to the indenter, the preset load is applied for some definite time and the load is removed automatically. The loads are slowly applied to avoid errors due to inertia effects. The time of load application and load duration can be controlled and is between 10 and 30 sec.



Vickers diamond Prayamid

Fig - 22

HEAT TREATMENT

ISI 7587 Part I : 2004 specifies the following values of Hardness of various materials
To obtain an optimum and specified hardness the materials have to be HEAT TREATED

Material	Hardness HV
20C15	200 to 230
20Ni2Cr2Mo2	250 o 280
Bridle Chain	270 to 330

The effects of heat treatment are inter-allied with the metallurgy of metals and it is only possible to touch briefly upon this subject in its application to materials for suspension gear.

It is of the utmost importance that the selected steel from which components of suspension gear are to be manufactured should be subjected to correct heat treatment. The object of heat treatment is to refine the grain structure and thus obtain the required mechanical properties and also to relieve internal stresses set up during manufacture. As an alloy steel is heated or cooled, structural changes take place due to molecular re-arrangement in the alloy constituents.

For practical purpose steel used for suspension gear may be regarded as iron carbon alloys and the variation of the microstructure with temperature is as indicated in the iron-carbide equilibrium diagram, Fig. 23. This diagram shows the range of temperatures to which steels of varying carbon content are heated for normalizing and quenched for hardening.

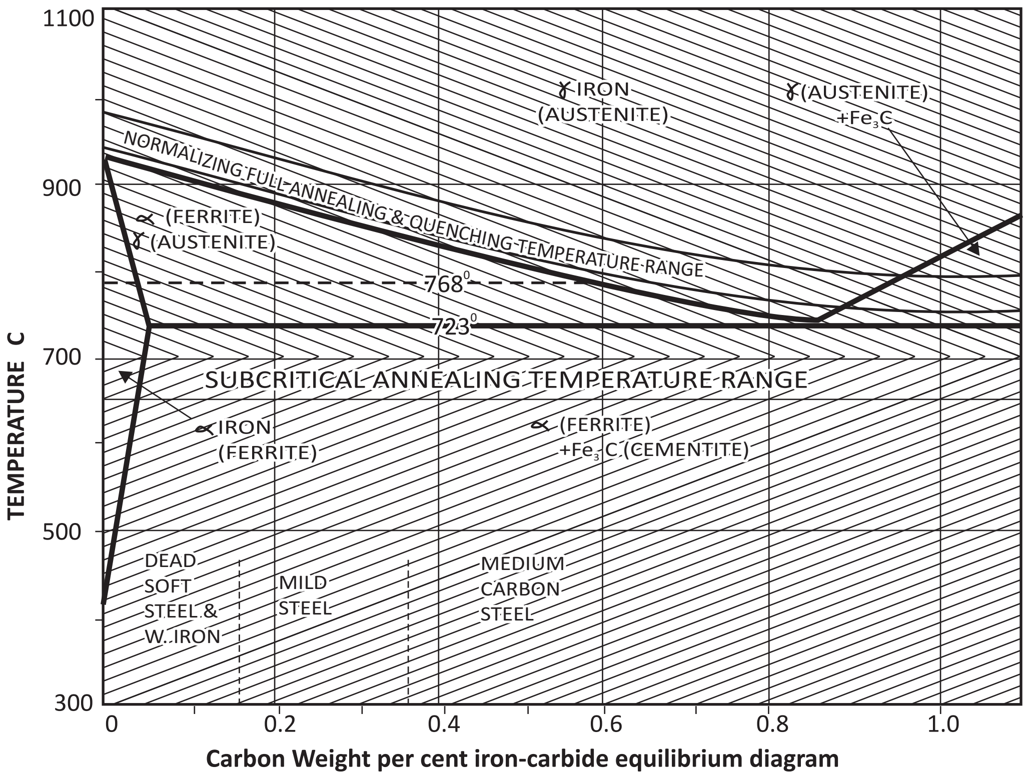


Fig - 23

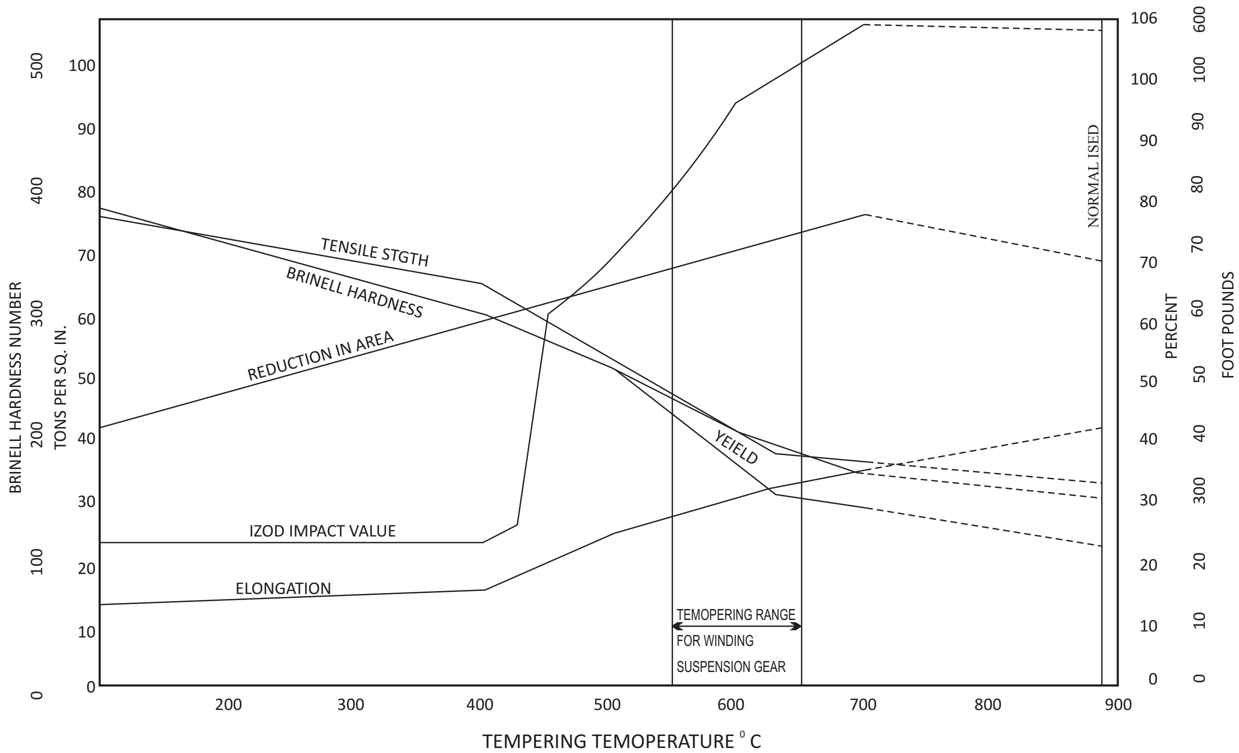
The forms of heat treatment generally applied are ; - i) sub-critical annealing, ii) normalizing and iii) hardening and tempering.

Fig. 23 Shows that the sub-critical temperature for all iron-carbon alloys is 723^0C and the heat treatment range lies between 650^0 and 700^0C.
In normalizing, the component is soaked in the furnace for a time depending upon the cross-section and at a temperature depending upon its carbon or alloy content, and then removed from the furnace and allowed to cool in still air. This treatment produces a tough, strong and relatively hard material. The normalizing temperature for carbon and alloy steels is about 890^0C depending upon their chemical composition.

Hardening and tempering has the effect of improving the mechanical properties of the material beyond those obtained by normalizing. The tempering temperature will vary according to the chemical composition but for steels as used for suspension gear this is usually between 550^0 to 650^0C. The quenching is by either water or oil.

Heat Treatment Furnace

Fig - 24



Curves showing variation mechanised properties of 1.5% manganese steel
BS 2272 Part 2 : 1956 water quenched from 890°C and tempered

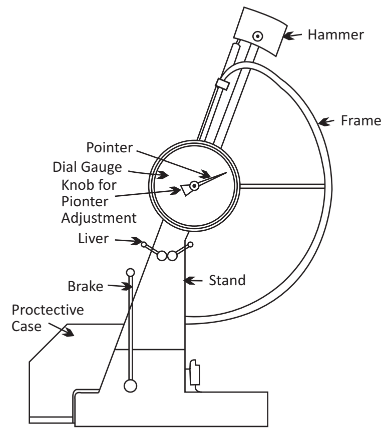
Fig - 25

ISI : 7517 Part I 2004 specifies normalizing, hardening and tempering temperature as indicated below ;

Designation of Steel	Normalizing Temperature ^{0} C	Hardening Temperature ^{0} C	Tempering Temperature	Quenching Agent
(1)	(2)	(3)	(4)	(5)
20C15	860-900	860-900	550-660	Water or Oil
20Ni2Cr2Mo2	*	820-850	*	Water
* Suitable temperature may be adopted so as to obtain the optimum properties				

6. IZOD - IMPACT TEST OF TEST PIECE FROM SAME MATERIAL AND SAME HEAT TREATMENT BATCH.

Impact test measures the strength of a material under dynamic loading. Often in actual service, most of the structural components are subjected to dynamic loading. Hence, knowledge of tensile strength alone will not be of sufficient use as a design parameter. In impact test, the material is subjected to sudden (impact) load. For this purpose, in general, a hammer is made to swing from a fixed height and strike the standard impact specimen. Impact strength of a material is defined as the capability of the material to absorb energy without failure under impact loading. The Izod specimen may have either square or round cross-section



Block diagram of impace testing machine

Fig - 26

Impact test specimens

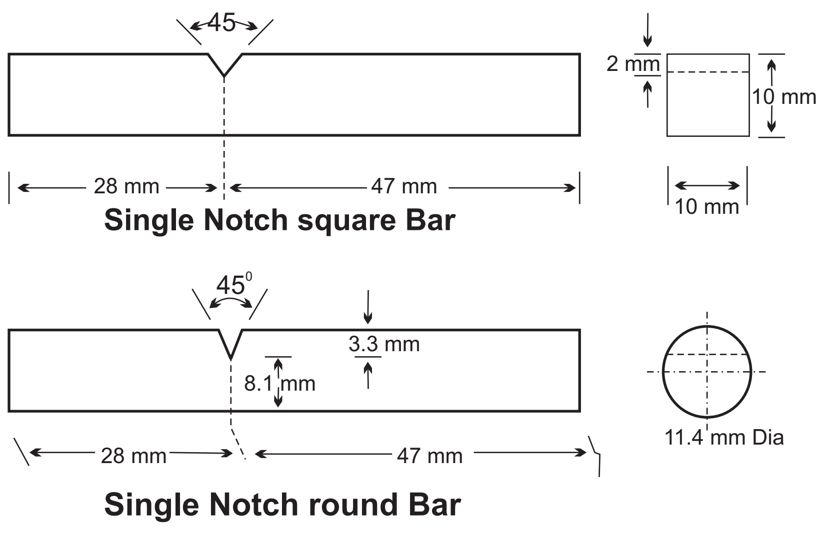
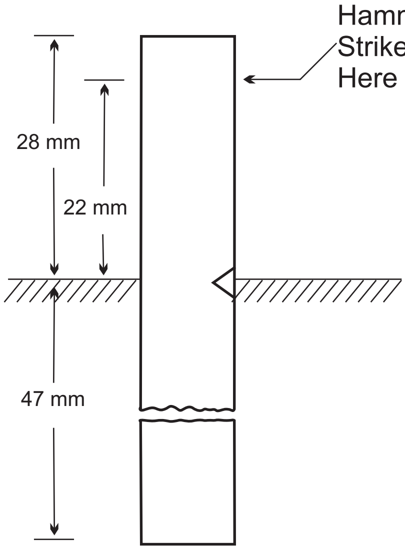


Fig - 27

The specimen has a V-shape notch. The depth of notch is 2 mm and included angle is 45°. In this test, a hammer strikes the specimen which is fixed in vertical position. The notch faces the hammer.



Mounting of Izod impact specimen

Fig - 28

Impact strength of a material is governed by many factors such as temperature, heat treatment, chemical composition and grain size. Temperature has marked influence on impact strength. As temperature comes down, impact strength also decreases. There is sudden drop in impact strength when a material is cooled below a particular temperature. The temperature at which an otherwise ductile metal changes to brittle is known as transition temperature. Fortunately, the deleterious effect of carbon is counteracted by manganese.

Grain size also affects transition temperature significantly. Heat treatment also affects impact strength. A tempered martensitic structure provides the best combination of tensile strength and impact strength.

7. CHEMICAL ANALYSIS

Use of 1.5% Mn Steel - A Historical perspective

The mechanical properties of mild steel are superior to those of wrought iron and a considerable improvement in the quality of welds has been achieved by electrical butt welding.

The ultimate tensile and yield strength of steels can be increased by an increase in the carbon content and the application of the correct heat treatment, but neither will alleviate the effect of embrittlement by strain-age hardening in service.

On the recommendation of the Safety in Mines Research Establishment, an alloy steel containing 1.5% manganese, BS 291:1927, was used for colliery haulage draw gear. It was found that this steel was less susceptible to strain-age embrittlement, maintained a good impact value below zero temperature and its properties were less likely to be affected by incorrect heat treatment or rough treatment in service.

Following its successful application to haulage draw bar gear, it was recommended in 1936 as being suitable for conveyance suspension gear which has been proved by its subsequent satisfactory performance in service. This steel, produced by the open-hearth process has a chemical composition (Table I) which shows that it is a low carbon manganese steel having as alloying elements carbon and manganese. The residual elements of nickel and chromium are not considered to have any effect on the properties. Phosphorous of Sulphur are kept as low as possible.

Its mechanical properties (Table II) show that in both the normalized and hardened and tempered states it is ductile steel having moderately high tensile and yield strengths with very good Izod impact values.

TABLE I Chemical Composition of 1.5 per cent Manganese Steel (to B. S. 2772: Part 2:1956)

Element	Per Cent	
	Min.	Max.
Carbon	0.10	0.15
Silicon	0.10	0.35
Manganese	1.30	1.70
Nickel (residual)	---	0.30
Chromium (residual)	---	0.20
Sulphur	---	0.050
Phosphorus	---	0.050

Bars, Billets and Forgings			Plates	
Property	Normalized or Normalized and Tempered	Hardened and Tempered	Normalized or Normalized and Tempered	Hardened and Tempered

TABLE II Mechanical Properties of 1.5 per cent Manganese Steel (to B. S. 2772: Part 2:1956)

	Limits of Ruling Section			
	6 in	4 in	6 in	4 in
Tensile strength tons/sq. in. (Min)	30	35	28	32
Yield stress tons/sq. in (min)	18	22	17	21
Elongation per cent (min)	30	28	30	28
Izod impact value ft/lb (min)	60	60	45	50

To correlate the properties of this and other alloy steels into one specification for the requirements of the mining industry, B.S.2772: Part 2: 1956 was published and superseded B.S. 291. 1927. From this specification it will be seen that three wrought steels are listed as being suitable for the manufacture of conveyance suspension gear components : i) 1.5 per cent manganese steel, ii) .25/.30 carbon steel and iii) 50/70 ton tensile steel-SAE : 8620.

In general, 1.5 per cent manganese steel need only be normalized, which is a simple heat treatment, and this is less likely than the other steels to be affected by incorrect heat treatment. Quenching and tempering is sometimes carried out on load bearing pins or other components and even on the complete suspension gear when demanded by particular conditions.

The Safety in Mines Research Establishment has stated that, in general, material for suspension gear has failed where the notch bar impact values have been lower than 40 ft/lb and it is generally accepted that 60 ft/lb is desirable. This value can be obtained from 1.5 per cent manganese steel in the normalized condition but with the other two steels it is necessary a to harden and temper.

The impact value of 1.5 per cent manganese steel is retained down to minus 40^{0}C which makes it very suitable for use in downcast shafts under severe winter conditions.

This British legacy has translated into the use of 20 Mn2 Steel in our Indian Mines. ISI 5517:2004 has laid down the following specifications for 20C15 which is more or less in line with BS 2772:1956 Part II

Chemical Composition of 20C15 as per IS; 5517: 2004.

Steel Designation	Constituent, Percentage				
	C	Mn	Si	S Max	P Max
20C15	0.16 to to 0.24	1.30 to 1.70	0.10 to .035	0.035	0.035

Recommended Hardening and Tempering of 20C15 as per IS; 5517: 2004.

Designation	Hot Working Temperature	Nominalizing Temperature	Hardening Temperature	Quenching Medium	Tempering Temperature
20C15	1 200 to 850^{0}C	860 to 900^{0}C	860 to 900^{0}C	Water or Oil^{0}C	550 to 660^{0}C

Mechanical Properties of Steels Hardened and Tempering of 20C15 as per IS; 5517: 2004.

Steel Designation	Tensile Strength Mpa	0.2 Percent Proof Stress MPa, Min	Elongation 5.65/A Percent, Min	Izod Impact Joules, Min	Limiting Ruling Section mm
20C15	600 to 750	440	18	48	30
	700 to 850	500	16	48	15

CHEMICAL ANALYSIS is done as per as per IS 228: 1988. Steel should conform to 20C15 IS; 5517: 2004.

DGMS grants field trial permission after the PROTO TYPE has passed all the above seven tests. If the equipment works satisfactorily for one year the DGMS grants regular approval for the supply of equipment to the industries. This approval has to be re validated every three years. After getting the proto type approval if the manufacturer does not get any order during the next six years the field trial permission becomes null and void.

ISO 9001

DGMS has advised the CS gear manufacturers to adopt ISO 9001 in 2007. It will be a win-win situation for manufacturer and statutory authority. Mines will be assured of quality product with in-time delivery at competitive prices due to increased productivity of manufacturers. Statutory authority will have access of documents and records at all stages of manufacturing process.

ACKNOWLEDGEMENT

Performance of the winders and its associate components are a crucial factor affecting the efficiency of a mine and the safety of the personnel. This work shop will promote awareness among the operating engineers and it will also provide an ideal platform to have intensive deliberations for non destructive testing on winding engine components and other associated installations. I am sure every stake holder will benefit from the discussions. It is a praise worthy effort on the part of DGMS Directorate and TATA Steel organization. I am thankful to Sri G. Nagraj Venkatesh, Director of Mines Safety (Mech) HQ and Sri Soumendu K Majhi of TATA Steel for giving me the opportunity to present the paper on 'PROTO TYPE DEVELOPMENT OF CAGE SUSPENSION GEAR AND TEST PROCEDURE'.

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