Investigation of Impact Strength and Hardness in Mold-Vibrated Aluminum Alloy [Al 6063] Casting

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Abstract—

Mould vibration during casting is one of the latest techniques employed in order to get better structure in the solidified casting. Mould vibration during casting results better morphology, surface finish, reduced amount of shrinkage and less chances of hot tear. In this project work, the effect of mould vibration during solidification of Al-6063alloy for different values of wavelengths at a fixed pouring temperature is investigated to understand the modification in microstructure and mechanical properties of casting. The casting has been prepared in Iron EN8 mould. The frequencies are varied from 0Hz, 25Hz, 30HZ, 35HZand 40 Hz during the casting process. A casting has been made without vibration as well to compare the results of castings with vibration. The experimental results show significant improvement in hardness and improvement in impact strength and refinement of grain growth.

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Key words: MOULD VIBRATION,AL-6063 ALLOY

. INTRODUCTION

CASTING:

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting materials are usually metals or various cold setting materials that cure after mixing two or more components together; examples are epoxy, concrete, plaster and clay. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods.

DIFFERENT TYPES OF CASTING PROCESS:

1) Investment casting
2) Permanent mold casting
3) Centrifugal casting
4) Continuous casting
5) Sand casting
6) Die casting
7) Stir casting

VIBRATIONS

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The word comes from Latinvibrationem ("shaking, brandishing") the oscillations may be periodic, such as the motion of a pendulum—or random, such as the movement of a tire on a gravel road. Vibration can be desirable: for example, the motion of a tuning fork, the reed in a woodwind instrument or harmonica, a mobile phone, or the cone of a loudspeaker.

TYPES OF VIBRATIONS

Vibrations are three types there are as follows.

1. **Linear Vibration (or) Longitudinal Vibration:** In this movement will get in longitudinal direction of component.

If all the basic components of a vibratory system – the spring the mass and the damper behave linearly, the resulting vibration is known as linear vibration. Principle of superposition is valid in this case. As shown in fig 1.4(a)

2. **Torsional vibration:** It is angular vibration of an object commonly a shaft along its axis of rotation. Torsional vibration is often a concern in power transmission systems using rotating shafts or couplings where it can cause failures if not controlled. A second effect of torsional vibrations applies to passenger cars. Torsional vibrations can lead to seat vibrations or noise at certain speeds. Both reduce the comfort.

In ideal power generation, or transmission, systems using rotating parts, not only the torques applied or reacted are "smooth" leading to constant speeds, but also the rotating plane where the power is generated (or input) and the plane it is taken out (output) are the same. In reality this is not the case. The torques generated may not be smooth (e.g., internal combustion engines) or the component being driven may not react to the torque smoothly (e.g., reciprocating compressors), and the power generating plane is normally at some distance to the power takeoff plane. Also, the components transmitting the torque can generate non-smooth or alternating torques (e.g., elastic drive belts, worn gears, misaligned shafts). Because no material can be infinitely stiff, these alternating torques applied at some distance on a shaft cause twisting vibration about the axis of rotation. As shown in fig 1.4(b)

1. **Lateral vibration:** Component vibrates in perpendicular direction. Concerned with the rotor part of the pump, the lateral analysis is performed to assess the potential for high vibration, associated degradation, and eventual equipment failure after pump installation. A key deliverable is a Campbell diagram that pictorially identifies which natural frequencies are closest to excitation frequencies.

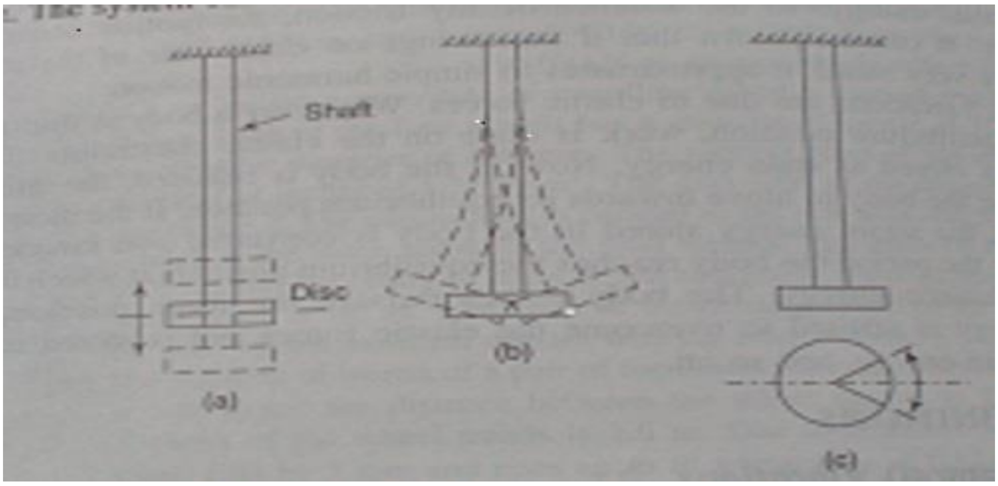


Fig 1.4 Types of Vibrations

DEGASSING

Degassing Methodologies

Process of removing the gasses molten metal is known as degassing. Several methods exist to reduce hydrogen .As seen in allowing the temperature to drop permits for natural outgassing- the first and simplest method to remove hydrogen.

Historically, a number of other techniques that rely on an inert, insoluble purge or collector gas have been employed. The inert gas collects the soluble hydrogen atoms, allowing a hydrogen molecule to form inside the lower pressure of the collector gas bubble. Tablet products were among the first techniques to have been widely utilized to degas the melt.

TYPES OF DEGASSING

1. Rotary Impeller Degassing

Rotary impeller degassing, a technique borrowed from the chemical process industry that improves mixing capability, was introduced into aluminum foundries in the mid-80s. In this technique, purge gas is introduced to melt through a rotating shaft and impeller, or rotor. This provides increased kinetic mixing of the melt with the purge gas. In addition, the action of the rotor creates bubble shear, giving rise to a broader swarm of smaller bubbles over a wider area, which increases surface-area-to- volume ratio. These finer bubbles have a longer residence time in the metal, allowing for a higher capability of collecting the hydrogen atoms present.

Compares the relative degassing efficiency of the three techniques discussed-lance, porous plug refractory and rotating shaft/rotor.

For the operating foundry person, several important variables must be considered in developing a suitable degassing process with rotor .The parameters that must be integrated includes:

1. Initial hydrogen level versus desired final hydrogen level.
2. Available time for melt treatment;
3. Vessel size/volume;
4. The relationship between rotor configuration and rpm, gas volume, surface effects and the time necessary and available to achieve desired degassing

Rotary impeller

2. Adding Flux Injection

Another option for the rotary impeller concept is the introduction of flux injection. Combining both flux injection and with a rotor dispersion creates a one plus one equals two-plus benefit.

Successful flux injection requires a properly constituted flux with a morphology that is granular and flows, and that melts only when it finally enters the melt. A carrier gas itself that does the degassing .The rotary degasser provides the kinetic mixing between the flux, carrier gas and the metal to create full-vessel reaction

The flux itself serves two key functions. Properly constituted, the flux can assist not only with hydrogen reduction, but also with partial removal of inclusions from the melt by virtue of the flotation action of the collector gas that is the flux carrier. Proper flux chemistry affects de-wetting for easier separation of solid inclusions from the melt through surface energy effects. Flux application by submerged injection also has the following advantages:

1. A more controlled flux consumption/utilization;

2. Less spillage and waste;

With or without flux injection, any degassing process creates dross. This dross is metal-rich, containing up to 85% aluminum that can be recovered. An appropriate flux composition can treat this dross in its original place, not only reducing the dross volume but also substantially decreasing the metallic content of the dross from 85% to 30% or less.

With any degassing process chosen, the specific purge gas used also affects the resulting dross.

3. Choosing a Purge Gas

There are discernible differences in the kind of purge or collector gas utilized in a degassing process.

Nitrogen: Nitrogen gas is the most commonly employed and is the least expensive. Nitrogen also creates a ‘wet’ dross, one that is rich in metallic aluminum.

Argon: Argon, while significantly more expensive that nitrogen, produces a less metal-rich dross. Argon is more inert, and being heavier, it provides a protective cover over the melt during degassing, precluding further oxidation and hydrogen absorption. It also is easier to keep the argon supply drier and cleaner as fittings and hoses deteriorate.

Active halogens: Active halogens also have been used to assist the inert gas in achieving greater degassing efficiency. In the past, these have included Freon chlorine and sulfur hexafluoride. However, with a small purge gas bubble- as produced by an efficiently operated rotary degasser- the effect of an active halogen on hydrogen reduction may be minimal.

MATERIALS:

ALLOYS MATERIALS

An alloy is a mixture of either pure or fairly pure chemical elements which forms an impure substance (admixture) that retains the characteristics of a metal. An alloy is distinct from an impure metal, such as wrought iron, in that, with an alloy, the added impurities are usually desirable and will typically have some useful benefit.

Alloys are made by mixing two or more elements; at least one of which being a metal. This is usually called the primary metal or the base metal, and the name of this metal may also be the name of the alloy. The other constituents may or may not be metals but, when mixed with the molten base, they will be soluble, dissolving into the mixture.

The term alloy is used to describe a mixture of atoms in which the primary constituent is a metal. The primary metal is called the base, the matrix, or the solvent. The secondary constituents are often called solutes.

Types of Alloys

Alloys are classified as following types

i) According to number of alloying elements

- **Binary alloy**: - If there is a mixture of only two types of atoms, not counting impurities, such as a copper-nickel alloy, then it is called a binary alloy.
- **Ternary alloy**: - . If there are three types of atoms forming the mixture, such as Aluminum, copper and Zinc, then it is called a ternary alloy.
- **Quaternary alloy**: - . If there are four types of atoms forming the mixture, such as Aluminum, copper, Manganese and Zinc, then it is called a Quaternary alloy.
- **Quinary alloy**: - . If there are five types of atoms forming the mixture, such as Aluminum, copper, nickel, manganese and Zinc, and then it is called a Quinary alloy.

ii) According to presence or absence of iron

- **Ferrous Alloys**:-If the alloys that contain Iron as major content then those alloys are called Ferrous alloys
- **Non Ferrous Alloys**:- If the alloys that does not contain Iron as major content then those alloys are called Non Ferrous Alloys

iii) According to process of casting

- **Wrought alloys**:- Wrought alloys are those which are cast as ingot or billet and then mechanically worked by some process such as rolling, extrusion ,or forgings to obtain final form
- **Cast alloys**: - Cast alloys are those which are cast to final or near final form without any mechanical working

iv) According to solubility of atoms in solid state

- **Solid solution alloy**: -A solid solution alloy may be formed in which the atoms of the two metals are said to be soluble in each other in the solid state.
- **Eutectic alloys**:-The Eutectic alloy are the solid alloys which are heterogeneous containing two phases, in which metals may be completely insoluble or partially soluble in the solid state,
- **Intermetallic compound:-** Intermetallic compound is a new chemical compound can be formed in the solid state,

ALUMINIUM ALLOYS

Aluminum alloys are alloys in which aluminum (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat- treatable. About 85% of aluminum is used for wrought produ

Non-heat treatable alloys

These include pure Aluminium, and those based on Aluminium-Manganese, Aluminium-Silicon, and Aluminium-Magnesium. They can be strengthened only by cold work.

Standard Aluminium Grades

Table 3.1: Standard Properties of Aluminium Alloys

Minimum tensile requirements for cast Aluminium alloys

Alloy type		Temper	Tensile strength (min) in ksi (MPa)	Yield strength (min) in ksi (MPa)	Elongation in 2 in %
ANSI	UNS				
201.0	A02010	T7	60.0 (414)	50.0 (345)	3.0
204.0	A02040	T4	45.0 (310)	28.0 (193)	6.0
242.0	A02420	O	23.0 (159)	N/A	N/A
		T61	32.0 (221)	20.0 (138)	N/A
A242.0	A12420	T75	29.0 (200)	N/A	1.0
295.0	A02950	T4	29.0 (200)	13.0 (90)	6.0
		T6	32.0 (221)	20.0 (138)	3.0
		T62	36.0 (248)	28.0 (193)	N/A

		T7	29.0 (200)	16.0 (110)	3.0
319.0	A03190	F	23.0 (159)	13.0 (90)	1.5
		T5	25.0 (172)	N/A	N/A
		T6	31.0 (214)	20.0 (138)	1.5
328.0	A03280	F	25.0 (172)	14.0 (97)	1.0
		T6	34.0 (234)	21.0 (145)	1.0
355.0	A03550	T6	32.0 (221)	20.0 (138)	2.0
		T51	25.0 (172)	18.0 (124)	N/A
		T71	30.0 (207)	22.0 (152)	N/A
C355.0	A33550	T6	36.0 (248)	25.0 (172)	2.5
356.0	A03560	F	19.0 (131)	9.5 (66)	2.0
		T6	30.0 (207)	20.0 (138)	3.0
		T7	31.0 (214)	N/A	N/A
		T51	23.0 (159)	16.0 (110)	N/A
		T71	25.0 (172)	18.0 (124)	3.0

A356.0	A13560	T6	34.0 (234)	24.0 (165)	3.5
		T61	35.0 (241)	26.0 (179)	1.0
443.0	A04430	F	17.0 (117)	7.0 (48)	3.0
B443.0	A24430	F	17.0 (117)	6.0 (41)	3.0
512.0	A05120	F	17.0 (117)	10.0 (69)	N/A
514.0	A05140	F	22.0 (152)	9.0 (62)	6.0
520.0	A05200	T4	42.0 (290)	22.0 (152)	12.0
535.0	A05350	F	35.0 (241)	18.0 (124)	9.0
705.0	A07050	T5	30.0 (207)	17.0 (117)†	5.0
707.0	A07070	T7	37.0 (255)	30.0 (207)†	1.0
710.0	A07100	T5	32.0 (221)	20.0 (138)	2.0
712.0	A07120	T5	34.0 (234)	25.0 (172)†	4.0
713.0	A07130	T5	32.0 (221)	22.0 (152)	3.0
771.0	A07710	T5	42.0 (290)	38.0 (262)	1.5
		T51	32.0 (221)	27.0 (186)	3.0

		T52	36.0 (248)	30.0 (207)	1.5
		T6	42.0 (290)	35.0 (241)	5.0
		T71	48.0 (331)	45.0 (310)	5.0
850.0	A08500	T5	16.0 (110)	N/A	5.0
851.0	A08510	T5	17.0 (117)	N/A	3.0
852.0	A08520	T5	24.0 (165)	18.0 (124)	N/A
6063.0	A906063	T6	24.1(150)	214.0	12.0

Properties of Aluminum

The natural qualities of aluminum and its alloys are positive deciding factors for designers, manufacturers and industrial users who are always on the lookout for better-performing materials and innovative processes.

- **Lightness -** With a specific mass of 2700 kg/m3, aluminum is the lightest of all ordinary metals, nearly three times as light as steel. Removing weight from products is an effective response to environmental concerns (energy efficiency, smaller carbon footprint) and economics (profitability of production and use). Lightness benefits not only the applications but also operations on the shop floor and working conditions, and means lower expenditures on material handling equipment.
- **Electrical and thermal conductivity -** Unalloyed aluminum has a thermal and electric conductivity about 60% of copper, which accounts for its development as a conductor, in the form of bars and tubes which are used in numerous electrical applications, such as connectors and distribution bars.
- **Corrosion resistance -** aluminum and its alloys provide excellent resistance to atmospheric corrosion in marine, urban and industrial settings. This high resistance extends the life of equipment, significantly reduces maintenance costs and preserves outward appearances. These properties are especially desired in industrial vehicles, street furniture and traffic signals.
- **Suitability for surface treatments -** Aluminum and its alloys lend themselves to a huge variety of surface treatments, which enhances its intrinsic qualities. For example, an anodization of a few micrometers is enough to preserve the optical or decorative properties of the materials, while improving resistance, especially to corrosion and stress.
- **The diversity of the alloys and intermediates -** No less than eight families of aluminum alloys offer properties perfectly suited to their contemplated use, whether it is weldability, corrosion resistance, superior mechanical performance or something else. The numerous ways they can be converted or processed, moreover, gives engineering departments and manufacturers a very broad range of intermediates-rolled (sheets), extruded (profiles), die-cast, forged and molded-able to meet highly specific functional requirements, while simplifying assembly and finishing.

- **Ease of use -** aluminum alloys are used in all the customary processes of forming, bending, and vessel-making, stamping and machining where other metals are used.
- **Recycling -** Aluminum can be recycled indefinitely without losing any of its intrinsic qualities. This is a considerable advantage in modern metallurgical industry. For the past 20 years the proportion of metal consumed that is recycled has grown steadily and today stands at something like 30% of primary metal production.

3.1.1 Applications of Aluminum

- **Aerospace -** The absolute requirement for light structures, made only stronger by environmental regulations, make aluminum and its alloys now more than ever the number one material in the sky. In the last 35 years, newly designed alloys and increasingly innovative conversion and assembly processes have halved the weight of an airplane's structure. Their percentage in aircraft structures sold to airlines companies 70% of what goes into an airframe and are an indispensable part of the programs in the world.
- **Automotive -** Chassis, bodies, engine blocks, radiators, hubcaps... Driven by consumer needs and increasingly tight regulations, the automobile industry has made ample recourse to aluminum. A European car today contains on average 100 kg of aluminum, taking advantage of multiple properties of the materials: lightness (a 100 kg loss of weight reduces fuel consumption by 0.6 liters/100 km and greenhouse gases by 20%), resistance (improved road-handling, absorption of kinetic energy, shorter braking distance) and recycling (95% of the aluminum contained in autos is collected and recycled, and represents over 50% of the vehicle's total end-of-life value.) The automotive use of aluminum is expected to double in the next ten years.
- **Marine -** Marine transport is increasing its use of aluminum by capitalizing on its two leading qualities: lightness and corrosion resistance. Advanced alloys have enabled the design of high-speed ships, by lightening hulls by 40% to 50% over steel. Corrosion resistance, even on the water, makes for more durable hulls, masts and superstructures on pleasure boats and the bridges and superstructures of passenger ships and merchant ships.
- **Rail -** Lighter structures, resistance and durability have made aluminum crucial to rail transport applications. The French SNCF 2-level high-speed train is made of aluminum alloy sheet metal and extrusions, as are many subways and commuter trains throughout the world.
- **Building -** Commonly used in extruded, sheet-rolled or molded form for window frames and other glass supports, for siding and partitions, aluminum is a favorite element of modern architecture. It can be made into complex forms in an extensive range of colors, stands up to the weather and calls for very little maintenance. These features make it especially valued by architects and builders, who use it in public buildings (like hospitals, universities and office buildings), industrial buildings and private houses.
- **Packaging -** Modern packaging is one of the leading consumers of aluminum. Its lightness saves both on the material and the energy it takes to produce it. Its corrosion resistance and impermeability provide the protection and safety required for packaging foods and pharmaceuticals. And its complete recyclability makes it re-usable in the economic cycle. Long in use in the form of foil for flexible packaging, aluminum today has become a commoner sight in rigid and semi-rigid packaging, especially in beverage containers (over 25 billion aluminum cans have been used in greater Europe) but also in preserves, aerosols, bottle caps and lids, etc.
- **Mechanical industry and engineering -** The many features of aluminum and its alloys also account for its growing use in mechanical applications. Makers of machines with moving parts, such as robots, are using an increasing number of aluminium parts to reduce inertia. In terms of heat exchange (liquid-to- liquid or liquid-to-gas), aluminium's thermal conductivity is critical in electronics, seawater desalination, HVAC exchangers and the plastics industry, where using aluminium alloy molds with pronounced mechanical properties (Alumold) can shorten fabrication cycles by up to 30%.
- **Energy distribution -** Aluminium's low density combined with its excellent electrical conductivity make it a crucial material in the distribution of electricity. Universally, and now practically exclusively, used for high-tension wires, aluminium can also be found in conductors (twice as light as copper), telephone cable shields and protectors against electrical and magnetic fields.

Sports and leisure - Light and versatile, aluminum is now featured in numerous objects in our daily environment, from mass-marketed electronics (household appliances, refrigerators, radiators, CD coatings, etc.) to sports equipment (hang gliders, ski poles, golf clubs, off-road bikes, scooters) and leisure products (trailers, camping, diving and mountaineering equipment)

ALUMINIUM CASTING ALLOY(Aluminum-6063)
Chemical Composition:

Table 3.2: Chemical Composition of Aluminum-6063

COMPONENT	Si	Cu	Mg	Cr	Ti	Fe	Mn	Al	Zn
%Wt	0.2 to 0.6	Max0.1	0.45 to 0.9	Max 0.1	Max 0.1	Max 0.35	Max 0.1	Max 97.5	Max 0.1

Consequence of exceeding impurity limits. High copper or nickel decreases ductility and Resistance to corrosion. High iron decreases strength and ductility.

Mechanical Properties
Table 3.3: Properties of Aluminum-6063

Material	**Tensile Strength(N/mm^2)**	**Hardness (RHB)**	**Modulus of Elasticity (N/mm^2)**	**Elongatio n (%)**
Aluminium-6063	150	50	71	12

3.1.2 Applications of Aluminum-6063

Mostly used applications are

- Architectural applications
- Extrusions
- Window frames
- Doors
- Shop fittings
- Irrigation tubing

And other applications where High-strength permanent mold or investment castings are required

EXPERIMENTATION SETUP

4.1 MUFFLE FURNACE

A muffle furnace in historical usage is a furnace in which the subject material is isolated from the fuel and all of the products of combustion, including gases and flying ash. After the development of high-temperature electric heating elements and widespread electrification in developed countries, new muffle furnaces quickly moved to electric designs.

Today, a muffle furnace is (usually) a front-loading box-type oven or kiln for high- temperature applications such as fusing glass, creating enamel coatings, ceramics and soldering and brazing articles. They are also used in many research facilities, for example by chemists in order to determine what proportion of a sample is non- combustible and non-volatile (i.e., ash). Some digital controllers allow RS232 interface and permit the operator to program up to 126 segments, such as molybdenum disilicate, can now produce working temperatures up to 1,800 degrees Celsius (3,272 degrees Fahrenheit), which facilitate more sophisticated metallurgical applications.

The term muffle furnace may also be used to describe another oven constructed on many of the same principles as the box type kiln mentioned above, but takes the form of a long, wide, and thin hollow tube used in roll to roll manufacturing processes. Both of the abovementioned furnaces are usually heated to desired temperatures by conduction, convection, or blackbody radiation from electrical resistance heating elements Therefore there is (usually) no combustion involved in the temperature control of the system, which allows for much greater control of temperature uniformity and assures isolation of the material being heated from the byproducts of fuel combustion.

Table 4.1: Specification of Muffle Furnace

Parameter	**Range**
Temperature range	30 to1000^{0}C
Measuring controlling device	3½ digit led
Chamber size	30*10 cm

Fig 4.1: MUFFLE FURANCE

4.2 DIE:

The mold must be accurately created as two halves that can be opened and closed for removal of the metal casting, similar to the basic permanent mold casting process. The mold for die casting is commonly machined from steel and contains all the components of the gating system. Multi-cavity die are employed in manufacturing industry to produce several castings with each cycle. Unit dies which are a combination of smaller dies are also used to manufacture metal castings in industry.

In a die casting production setup, the mold, (or die), is designed so that its mass is far greater than that of the casting. Typically the mold will have 1000 times the mass of the metal casting. In addition to the opening and closing of the mold to prepare for and remove castings, it is very important that there is enough force that can be applied to hold the two halves of the mold together during the injection of the molten metal. Flow of molten metal under such pressures will create a tremendous force acting to separate the die halves during the process. Die casting machines are large and strong, designed to hold the mold together against such forces.

Once the mold has been filled with molten metal, the pressure is maintained until the casting has hardened. The mold is then opened and the casting is removed. Ejector pins built into the mold assist in the removal of the metal casting. In most manufacturing operations, the internal surfaces of the mold are sprayed with a lubricant before every cycle. The lubricant will assist in cooling down the dies as well as preventing the metal casting from sticking to the mold. After the casting has been removed and the lubricant applied to the mold surfaces, the die are clamped together again then the cycle will repeat itself. This project die made with EN8 material.

1) Specification:

Table 4.2: Specification of Die

Material	**Out side Length of the block (mm)**	**Area of the block (mm)**	**Height of the block (mm)**
EN8	100*40*60	15*15	55

Fig 4.2(A) Die after Assembly

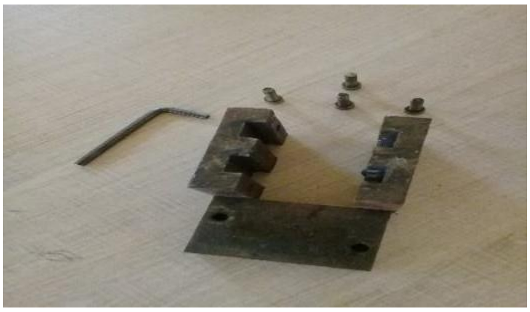


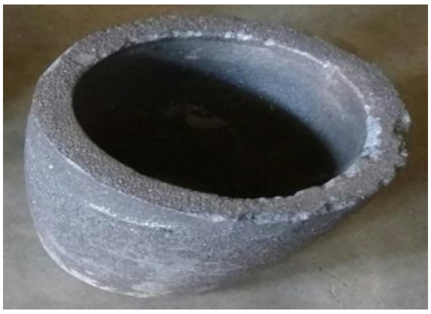
Fig 4.2(B) Die before Assembly

4.3 CRUCILBLE:

A crucible is a container that can withstand very high temperatures and is used for metal, glass, and pigment production as well as a number of modern laboratory processes. While crucibles historically were usually made from clay they can be made from any material that withstands temperatures high enough to melt or otherwise alter its contents. Here we selected crucible which made with Graphite.

2) *Specifications:*

Table 4.3: Specifications of Crucible



Material	Dimensions(cm)
Graphite	10*10

Fig 4.3: Graphite crucible

4.4 STIRRING COMPONENT:

Whenever we work with alloy casting stirring place vital role, otherwise the ingredients. In the casting may separate each other in order. To avoid this separation, we must need conduct stirring process. In our project we prepared one stirring equipment available material in the market.

The steps involved in preparation of stirring equipment:

1) The motor of exhaust fan which rotates at speed of 250 RPM .

2) We took the steel bowl of cylindrical shape of dimensions more than the crucible dimensions for casting purpose.

3) We made the holes on the steel bowl with diameter suitable for the adjustment of motor.

4) We made a coupling arrangement to motor shaft and a small horizontal strip was arranged at the end of the shaft for mixing purpose.

Fig 4.4 Stirring Equipment

4.5 VIBRATION TABLE

It is the equipment which is used to create vibration in the mould.vibration create longitudinal, lateral and torsional direction in this project we apply vibrations in longidinal direction.

Vibration Table:

Length: 120cm Width:60cm Height:65cm

Main components of vibration table:

Steel springs:

Spring Diameter -30 mm Spring Wire diameter – 6mm Length-150mm

Single phase 0.5Hp electric motor

SAMPLE PREPARATION AND TESTING

SAMPLE PREPARATION

Raw Material Selection

In order to prepare sample we used there following procedure. First we selected the material aluminum 356 alloy as Raw material; because, this material gives better finishing product and good strength. Then we purchased the Al 356 material of 8kg and also degassing agent hexachloroethane (c_2cl_6)in form of chemical powder we purchased it and for stirring purpose we prepared stirring equipment. In production process mould (die) is prepared with standard specimen values.

The aluminum AL-356 bars are cut into small pieces of our required sizes using hand shaker cutter. The cutting process shown in fig below.

Fig 5.1 Cutting Machine Equipment

5.1.1 Casting Sample Preparation (or) Preparation of casting

We prepared samples with help of die that we designed. We prepared casting in the following two way

a) Preparation of Castings without vibrations

b) Preparation of Castings with vibrations. (One set of casting prepared with 5Hz mould vibration and other with 10Hz mould vibration.)

The process takes as follows

The cut pieces are placed into the crucible. Now the crucible is placed in muffle furnace .The temperature starts from room temperature and then increases temperature when temperature falls on steady state. Increases it up to our required temperature. i.e.upto its melting temperature (720^0c).While the crucible is taken out at the temperature of 690^oc and stir the solution with stirrer. After stirring process the crucible is again placed in the furnace and then heated up to 720^0c.

a) At 720^0 the crucible is taken out and add small amount of c_2cl_6(approximately ½ spoon) stir the solution and poor into the die. Leave the die up to 10 minutes to solidification. During pouring and solidification induce mechanical vibrations of known frequencies. This process has taken place without vibration of mould placed. After solidification process the dies is separated and collect the casted object. The process repeated till required number of products obtained.

b) Casting takes place with vibrations:

The above process takes place in making the products with vibrations. The only difference is the die should be place in vibrating table. The die is placed at different frequencies. By changing the frequency values (0 to 10 Hz). This process is repeated till required number of products obtained at required frequencies.

5.1.2 HEAT TREATEMENT PROCESS

After casting we conducted Heat Treatment process there by controlled heating and cooling is used to alter the physical & mechanical properties of metals without affecting any change in the shape of the objects. Heat treatment process is used to increase material strength and also to improve machining, formability & restore ductility. Heat treatment process allows for the improvement in product performance through improvement in material characteristics.

In our production process, we conducted heat treatment like we heated samples temperature to 150^0C and soaked the sample at temperature about 2hr.After that we quenched the sample in water at temperature of 15^0C.

5.1.3 Preparation of Standard Sample

1. *IMPACT TESTING*

3) Preparation of specimen

We cast the rectangular specimen by liquid metal pour into a die ,without vibrations and with vibrations at different known frequencies with dimensions of 15*15*60. After that the specimen is machined to known dimension i.e 10*10*55. The frequencies are 25, 30, 35 and 40 HZ

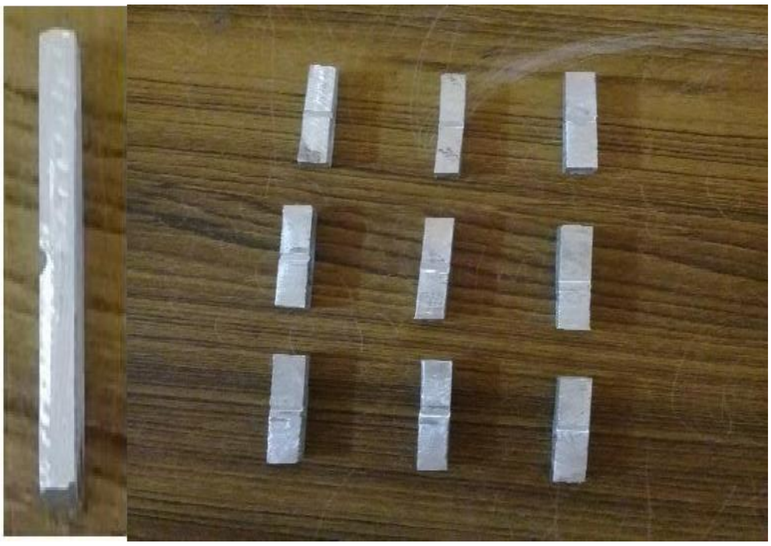


Fig5.2 SPECIMEN FOR IMPACT TEST

2. *HARDNESS*

We selected three different positions in the samples for hardness test. By cutting the total casted specimen into 2 parts

First - top position of casted sample part

Two- bottom position of top casted sample part/Middle position of casted sample part

Bottom sample part

The selected samples are shown in the below figure.

Fig 5.3 Hardness Test Sample Specimen

3. *MICROSTRUCTURE*

Microstructure test is conducted on computerized microscope . The total casted specimen is cut into 2 equal parts. Initially one of the piece is taken for belt grinding, after that taken for polishing on different emery papers grit ,220,320,400,600 and 1/0,2/0,3/0and 4/0. Then specimen taken for disc polishing for fine polishing. Later specimen is washed with etching agent . Make it ready for microstructure test. This gives the directly grain structure .

Fig 5.4 Sample Specimens for Microstructure

MATERIAL TESTING

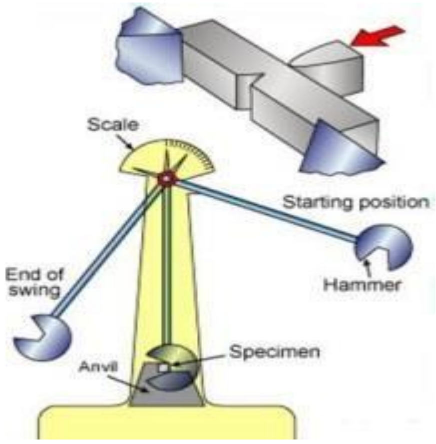
1. IMPACT TEST

The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture.

VOLUME: 09 ISSUE: 04 | APRIL - 2025 SJIF RATING: 8.586 ISSN: 2582-3930

4) Measurement of Impact Test:

Charpy impact test is practical for the assessment of brittle fracture of metals and is also used as an indicator to determine suitable service temperatures. The Charpy test sample has 10x10x55 mm 3 dimensions, a 45^0 V notch of 2 mm depth and a 0.25 mm root radius will be hit by a pendulum at the opposite end of the notch . To perform the test, the pendulum set at a certain height is released and impact the specimen at the opposite end of the notch to produce a fractured sample. The absorbed energy required to produce two fresh fracture surfaces will be recorded in the unit of Joule. Since this energy depends on the fracture area (excluding the notch area), thus standard specimens are required for a direct comparison of the absorbed energy.



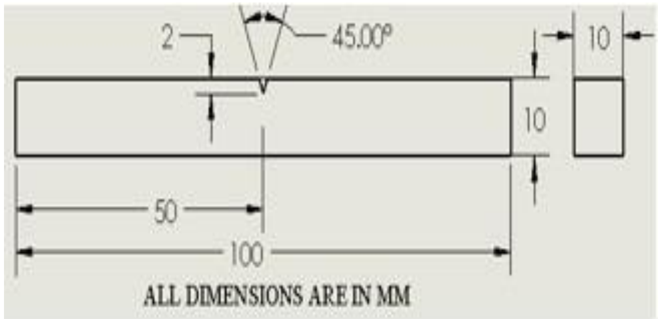


Fig6.1 : Impact Test Equipment **Fig6.2 : Specimen Dimensions PROCEDURE**

As the pendulum is raised to a specific position, the potential energy (mgh) equal to approximately 300J is stored. The potential energy is converted into the kinetic energy after releasing the pendulum. During specimen impact, some of the kinetic energy is absorbed during specimen fracture and the rest of the energy is used to swing the pendulum to the other side of the machine . The greater of the high of the pendulum swings to the other side of the machine, the less energy absorbed during the fracture surface. This means the material fractures in a brittle manner. On the other hand, if the absorbed energy is high, ductile fracture will result and the specimen has high toughness. The impact test values are tabulated in the table no 7.1 and 7.2.

2. HARDNESS TEST

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

5) Measurement of Hardness:

Hardness is not an intrinsic material property dictated by precise definitions in terms of fundamental units of mass, length and time. A hardness property value is the result of a defined measurement procedure. Hardness of materials has probably long been assessed by resistance to scratching or cutting. An example would be material B scratches material C, but not material A. Alternatively, material A scratches material B slightly and scratches material C heavily. Relative hardness of minerals can be assessed by reference to the Mohr's Scale that ranks the ability of materials to resist scratching by another material. Similar methods of relative hardness assessment are still commonly used today. An example is the file test where a file tempered to a desired hardness is rubbed on the test material surface. If the file slides without biting or marking the surface, the test material would be considered harder than the file. If the file bites or marks the surface, the test material would be considered softer than the file. The above relative 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.

Hardness Test Methods:

1. Rockwell Hardness Test
2. Rockwell Superficial Hardness Test
3. Brinell Hardness Test
4. Vickers Hardness Test
5. Micro hardness Test

a) ROCK WELL HARDNESS TEST

The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, HRB, HRC, etc., where the last letter is the respective Rockwell scale. In this project we conducted hardness test on Rockwell hardness B-scale. We conducted hardness test as per ASTM standard the values are tabulated in the table

Measurement of Hardness:

Rockwell hardness test was done for measuring hardness of casted sample as per ASTM. The values are tabulated in table- and Rockwell hardness testing machine is shown in fig 6.3

Fig 6.3 : Rockwell hardness testing machine

b) PROCEDURE

We conducted hardness test on Rockwell hardness testing machine. For aluminum we have to choose ball indenter to measure hardness. We fix the ball indenter to the fixers. As for this we cut the specimens into 2 equal pieces for both vibrations and without vibrations. Load the specian in hardness test equipment and conduct the hardness test a per the standerds. For each pieces taken different hardness values at different locations. And take the average values of those values which are obtained. The values are tabulated in table no 7.3 and 7.4. We plot the graph for those values. As shown in graph 7.2.

3. MICROSTURCTURE

Microstructure is the small scale structure of a material, defined as the structure of a prepared surface of material as revealed by a microscope above 25× magnification. The microstructure of a material (such as metals, polymers, ceramics or composites) can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior or wear resistance. These properties in turn govern the application of these materials in industrial practice. Microstructure at scales smaller than can be viewed with optical microscopes is often called nanostructure, while the structure in which individual atoms are arranged is known as crystal structure. The nanostructure of biological specimens is referred to as ultrastructure.

Microstructure and characterization

To quantify microstructural features, both morphological and material property must be characterized. Image processing is a robust technique for determination of morphological features such as volume fraction, void, crystal orientations. To acquire micrographs, optical as well as electron microscopy are commonly used. To determine material property, Nano indentation is a robust technique for determination of properties in micron and submicron level for which conventional testing are not feasible. Conventional mechanical testing such as tensile testing or dynamic mechanical analysis (DMA) can only return macroscopic properties without any indication of microstructural properties. However, Nano indentation can be used for determination of local microstructural properties of homogeneous as well as heterogeneous materials.

Optical Microscope

When a polished flat sample reveals traces of its microstructure, it is normal to capture the image using macrophotography. More sophisticated microstructure examination involves higher powered instruments: optical microscopy, electron microscopy, X-ray diffraction and so on, some involving preparation of the material sample (cutting, microtome, polishing, etching, vapor-deposition etc.). The methods are known collectively as metallography as applied to metals and alloys, and can be used in modified form for any other material, such as ceramics, glasses, composites, and polymers.

Two kinds of optical microscope are generally used to examine flat, polished and etched specimens: a reflection microscope and an inverted microscope. Recording the image is achieved using a digital camera working through the eyepiece.

Fig 6.4 Computer Based Metrological Microscope

In this project, we used computerized inverted metallurgical microscope with image analysis software. The viewed microstructure is printed in figure 7.1to 7.5

RESULTS AND DISCUSSIONS

7.1 IMPACT TEST RESULTS

Table 7.1:Impact Test Results

Material at different frequencies	Area of the specimen at the notch (mm^2)	Energy absorbed (J)		Energy absorbed to break the specimen(J)	Specific impact power (J/mm^2)
		initial	final		
With out vibrations	80	300	50	250	3.125
		300	50	250	
With vibrations at 25 HZ	80	300	46	254	3.175
		300	46	254	
With vibrations at 30 HZ	80	300	52	248	3.189
		300	52	248	
With vibrations at 35 HZ	80	300	28	272	3.405
		300	28	272	
With vibrations at 40 HZ	80	300	67	233	2.912
		300	67	233	

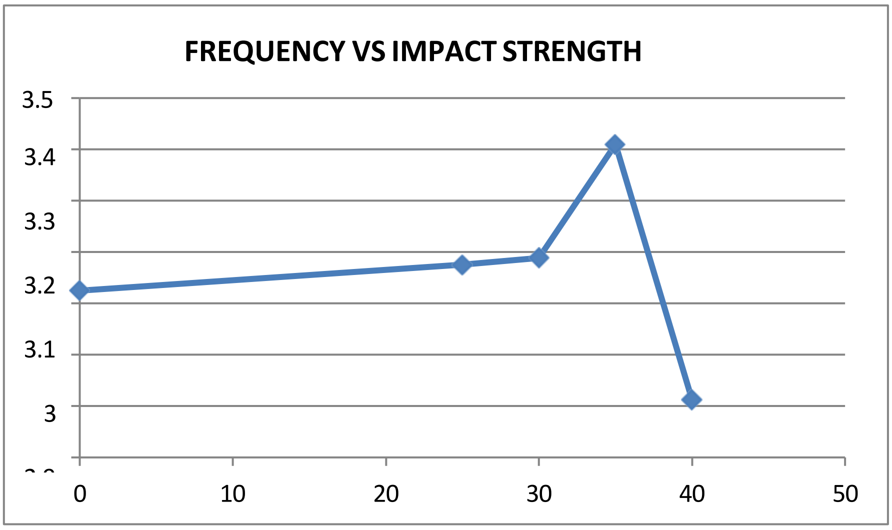
7.1.1 Discussions of Impact Test Result:

Impact strength of the cast samples are shown in the table 7.1. it is clear that the impact strength of the casting increases from a frequency of 0-35 Hertz and beyond that(40HZ) there is a reduce in the impact strength of the specimen. We can observed that the material has high impact strength at a frequency of 35HZ. The variation is shown in the graph 7.1.

Table 7.2: Impact Test Results

Frequency(Hz)	Specific Impact strenght
0	3.125
25	3.175
30	3.189
35	**3.405**
40	2.125

Graph7.1: Frequency Vs specific Impact strength



7.2 HARDNESS TEST

7.2.1 Hardness Test Results

TABLE 7.3: MEASUREMENT OF HAREDNESS.

TYPE	NO OF SPECIMENS	HARDNESS(RHB) NO OF TRALIS			AVERAGE (RHB)
		1	2	3	
Without	1	44	45	46	45

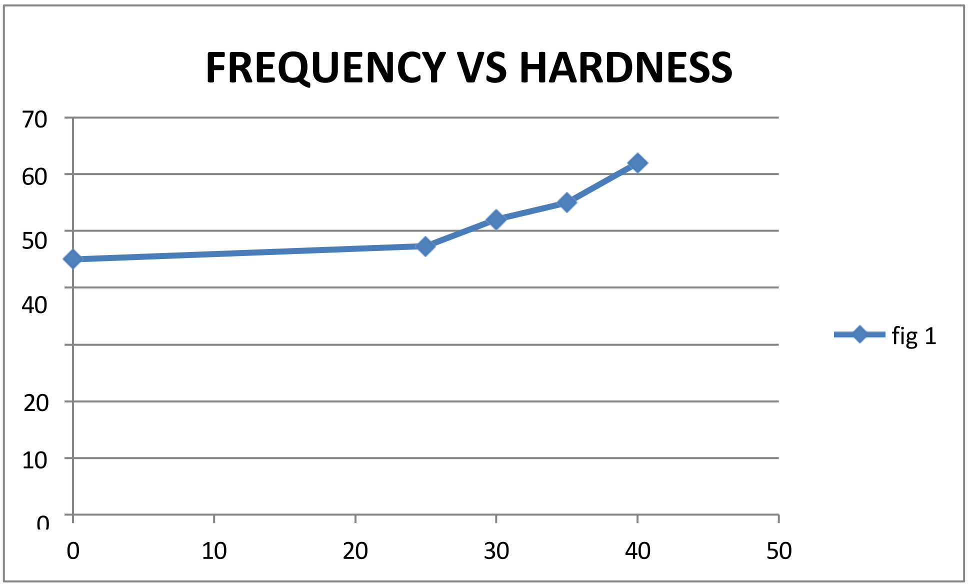
vibrations	2	47	44	44	45
With vibrations at 25 HZ	1	53	49	42	48
	2	47	47	48	47
With vibrations at 30 HZ	1	53	55	48	52
	2	57	53	48	54
With vibrations at 35 HZ	1	55	57	53	55
	2	59	53	53	55
With vibrations at 40 HZ	1	61	62	63	62
	2	62	65	59	62

7.2.2 Discussions of Hardness Test Results

Hardness of the cast samples are shown in table 7.3&7.4. It is clear that hardness of casting increases with the increase in vibration frequency because vibration causes refinement of grains. The highest hardness is obtained at the bottom of each and every sample, because highest cooling rate and vibration intensity at the bottom of sample, it is evident from the microstructure. More cooling action promotes creation of fine grain and at the same the vibration procedure fine grains. That means more grain boundary more hardness. So we may be concluded that due to combined effect of cooling rate and intensity of vibration, there are remarkable changes of hardness in the cast product. The variation of hardness is plotted on graph 7.2,

Frequency(Hz)	Hardness(RHB)
0	45
25	47.8
30	53
35	55
40	**62**

Graph 7.2:Frequency Vs Hardness

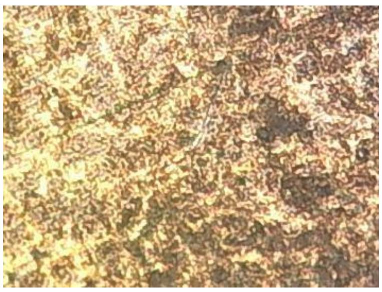


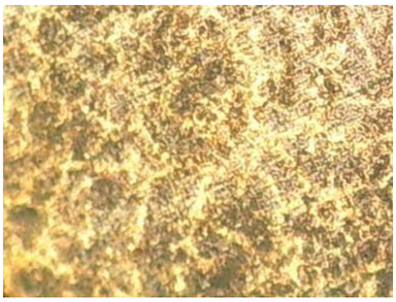
7.3 MICROSTRCTURE

7.3.1 MICROSTRCTURE RESULTS

By increasing the frequency of vibrations the grain refinement increases. This can be seen in following figures.

Fig 7.1: microstructure without vibration

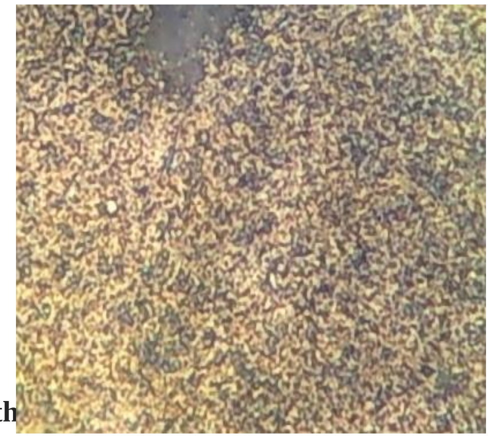


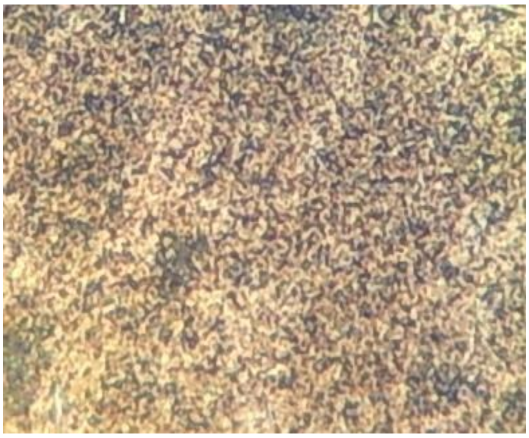


Top part of the cast **Bottom part of the cast**

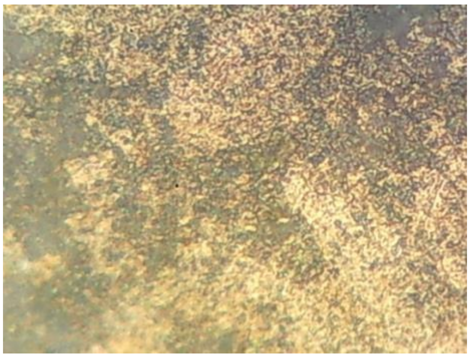
Fig 7.2: microstructure with frequency at 25HZ

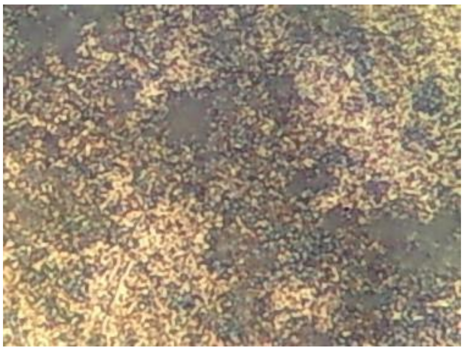
Top part of th





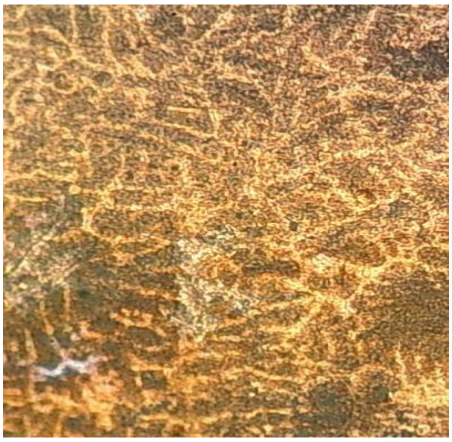
microstructure with frequency at 30HZ

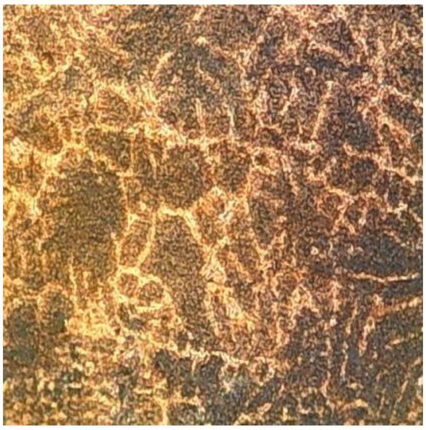




Top part of the cast **Bottom part of the cast**

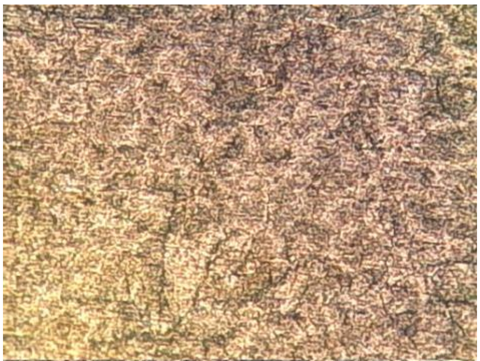
Fig 7.4: microstructure with frequency at 35HZ

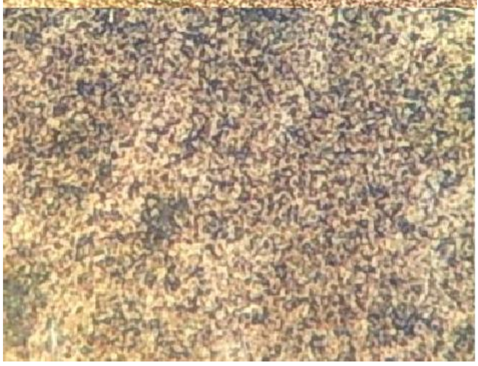




Top part of the cast **Bottom part of the cast**

Fig 7.5: microstructure with frequency at 40HZ





Top part of the cast **Bottom part of the cast**

Discussion on microstructure test

The microstructure test results (images) saying that refinement of grains can observed on increasing of vibration. i.e, at unvibrated condition the grains are small. By increasing the vibrations the grains are refined, that are can observe in the micro test images.

CONCLUSION:

Based on the experimental results there are three main conclusions we can say

I. By increasing the mould vibrations of the casting the Hardness increases

II. Mould vibration during casting provides good impact strength and best impact strength at 35 HZ

III. The vibration in the casting procedure gives refinement of grains .

FUTURESCOPE:

In this project we just examined the vibration frequency increases or by introducing the mould vibrations the casting strength increases.

This project we can extend optimization of process parameters those are pouring temperature, mould vibration time, mould vibration frequency. By varying these properties using we optimizing tool we can select best input parameters to get a sound casting.

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