## 4.2 Metallic glasses

**Definition:** ***Metallic glasses*** are the amorphous metallic solids which have high strength, good magnetic properties and better corrosion resistance and will possess both the properties of metals and glasses.

*Examples: Alloys of Fe, Ni, Al, Mn, Cu, Cr and Co mixed with metalloids such as Si, Ge, As, B, C, P and N.*

## CONCEPT BEHIND THE FORMATION OF METALLIC GLASSES

Generally, liquids can be made into glassy state by increasing the rate of cooling. In a similar manner the metals can also be made into glassy state by increasing the rate to cooling to a very high level [2 x $10^6$ °C per second]. At that state the atoms will not be able to arrange orderly because of its rapid cooling rate.

Thus, the atoms will not be allowed to go to crystalline state, rather it goes to amorphous state and it will form a new type of material. These new types of materials which are made by rapid cooling technique (i.e., the temperature decreases suddenly with respect to time) are called ***metallic glasses.***

The cooling rate for the formation of metallic glasses varies from material to material. **Glass Transition Temperature**

*The temperature at which the metals [alloys] in the molten form transforms into glasses i.e., liquids to solids is known as* ***glass transition temperature (Tg).***

It was found that the glass transition temperature for metallic alloys varies from 20°C to 300°C.

## PREPERATION OF METALLIC GLASSES

### Principle

**"*Quenching"*** *is* a technique used to form metallic glasses**,** Q*uenching* means rapid cooling. Actually, atoms of any materials move freely in a liquid state. Atoms can be arranged *regularly* when a liquid is cooled *slowly*. Instead, when a liquid is *quenched*, there will be an *irregular pattern, which results in the formation of metallic glasses.*

**Technique**

The process involved in the formation of metallic glasses is melt spinning technique. This technique is illustrated in Fig.

**Experimental Setup**

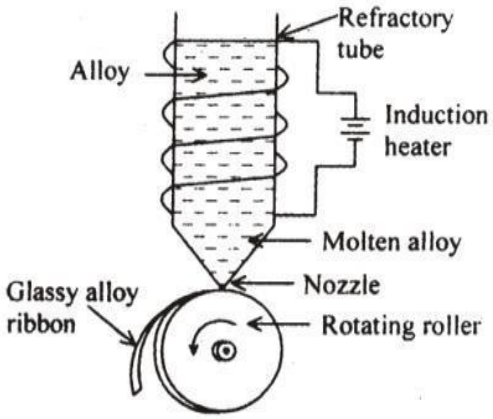


Fig:4.2.1- Melt spinning technique

The setup consists of a refractory tube with fine nozzle at the bottom. The refractory tube is placed over the rotating roller made up of copper. An induction heater is wounded over the refractory tube in order to heat the alloy inside the refractory tube as shown in fig 4.2.1

**Preparation**

The alloy is put into the refractory tube and the induction heater is switched ON. This heats the alloy and hence the super-heated molten alloy is ejected through the nozzle of the refractory tube onto the rotating roller and is made to cool suddenly. The ejection rate may be increased by increasing the gas pressure inside the refractory tube. Thus due to rapid quenching a glassy alloy ribbon called metallic glass is formed over the rotating roller.

Metallic glasses of various thicknesses can be formed by increasing (or) decreasing the diameter and speed of the roller.

**TYPES OF METALLIC GLASSES**

Metallic glasses are of two types viz,

**(i)Metal-metalloid glasses**

*Examples:* Metals : Metalloids

Fe, Co, Ni: Ge, Si, B, C

**(ii)Metal – Metal glasses**

*Examples:* Metals : Metals

Ni : Niobium

Mg : Zn

Cu : Zr

**PROPERTIES OF METALLIC GLASSES**

Since the atoms in the metallic glasses are disordered, they have some peculiar properties as follows:

**(i)Structural Properties**

**a.**Metallic glasses have tetrahedral closely packed(TCP) structure rather than hexagonal closely packed (HCP) structure.

**b.**They do not have any crystal defects such as grain boundaries, dislocations etc.

**(ii) Mechanical Properties**

a.The metallic glasses are very strong in nature.

b.They have high corrosion resistance.

c.They possess malleability, ductility etc.

**(iii) Magnetic Properties**

**a.**Metallic glasses can be easily magnetized and demagnetized.

**b**.They have very narrow hysteresis loop as shown in fig .In Fig the hysteresis loop of the metal alloy in crystalline phase is also given for reference.

**c.**They exhibit very low hysteresis loss and hence transformer core loss is very less.

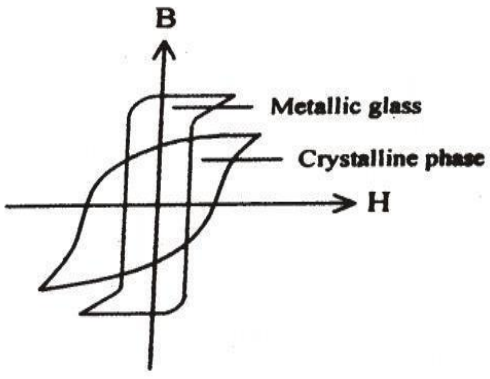


Fig:4.2.2- Hysteresis loop

**(iv) Electrical Properties**

**a**.Metallic glasses have high electrical resistance .

**b**.The electrical resistance for metal glasses will not vary with temperature.

**c**.They possess very low eddy current losses.

**APPLICATIONS OF METALLIC GLASSES**

*Since the metallic glasses possess low magnetic loss, high permeability, saturation magnetization and low coercivity, ***these materials are used in cores of high power transformers.***

*As the metallic glasses are malleable and ductile, it can be used in simple filament winding to reinforce pressure vessels.

*Since the metallic glasses are very strong/hard they are used to make different kinds of springs.

*As the mettalic glasses are similar to the soft magnetic alloys, they are used in leads of tape recorder, cores of transformers and magnetic shields.

*Because of their high resistivity, they are used to make computer memories, magneto-resistance sensors etc.

*Since they have high corrosion resistance, they are used in reactor vessels, surgical clips, marine cables etc.

*Since some metallic glasses can behave as super conductors, they are used in the production of high magnetic fields.

*Since the mettalic glasses are not affected by irradiation, they are used in nuclear reactors.