

Improvements in Wire Drawing

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Abstract: *This paper presents an overview of different areas that have been utilized to improve the process of wire drawing. The paper revives the various techniques and processes used to improve wire drawing process. The improvement areas include improvisation of wire drawing dies, the raw material to be used both for the process and dies, the nature of wire drawing process and the state of dies. Poly crystal diamond dies and oscillating dies are being used to achieve the improvement in wire drawing. Further treated raw material with higher ductility and processes like electro plastic drawing are being used to improve the wire drawing process.*

Keywords: Annealing, Electro Plastic, Oscillating, Ductility

1. Introduction

The process of obtaining smaller diameter wires from rods of bigger diameter through a die is known as wire drawing. It's usually carried out at room temperature because it's a cold working process. The process of wire drawing is quite simple in operation; a wire is pulled through conical shaped dies made of diamonds/carbide etc. of reducing cross section area, as wire of larger diameter is pulled through conical die, its cross section area gets reduced while its length gets increased while volume of the wire remains constant. One end of wire is prepared so to fit in the die easily by process of hammering or swaging, the prepared tip of the wire is then pulled across the die by a gripper. As such wire of reduced diameter is obtained. This wire is then coiled round a power reel.

Basic requirements of Wire Drawing Process

- The material should be sufficiently ductile as it's subjected to tensile forces.
- Sometimes process of annealing is needed to get the required degree of ductility.
- To make it easy for wire to enter the die, one end of the wire is made pointed by the process of rotary swaging or by hammering.
- The cleaning of the wire is also needed to remove any scales or rust present on surface, usually done by acid pickling.
- The lubrication of wire is also to be done which reduces the friction and thereby the drawing load example snulling, phosphating etc.

Advancements in wire drawing process are made on the basis of improvement in following areas:

- Nature of dies
- Nature of raw material
- State of Dies
- Wire drawing process

Nature of Die

Conventionally [1] metal Dies were used in the wire drawing process. These dies were prone to wear and corrosion. This lead to the use of Poly crystal diamond [2] (PCD) dies. Right materials make all the difference. In wire drawing the reduction in total cost of production can be archived by the use of diamond dies without sacrificing the quality. Diamond dies are more abrasion resistant which allows manufacturer to

maintain longer tolerances as compared to the use of traditional metal dies.

In further advancement of dies Poly crystal diamond (PCD) Dies were developed. These Poly crystal diamond dies have additional favorable properties like;

- 1) PCD have greater flexibility in size and shape as such wider variety of tools can be made.
- 2) PCD have higher thermal conductivity that allows high rate of temperature dissipation at the wire-die interfaces so that interfaces does not get overheated
- 3) PCD have more toughness due to random orientation of natural cleavage planes (as compared to individual crystals), that provides higher toughness and wear resistance than the traditional crystal diamond.

Formation of PCD

Extreme conditions of high pressure and large heat are required to transform the manmade synthetic diamond crystal into the PCD. Here the raw material for the process is large number of small diamond crystals known as diamond grit. The process also requires a special catalyst to allow the efficient diamond bond creation at the points where small diamond crystals are in contact .The high pressure involved in the process together with the presence of catalyst at the diamond crystal contact points leads to the formation of continuous diamond lattice that is due to additional diamond bond formation .The High pressure used is usually applied by using hydraulic and screw mechanisms .Once the required pressure is applied then for the high heating requirement raw material is placed inside a cylindrical graphite heating element . By applying the current to the graphite element its resistance to current leads to the heat generation in the element and the packed raw materials also gets heated up. For past 25 years PCD are in use for wire drawing operations.

Larger dies are made using carbide supported blanks .The grains size of the dies also varies according to the requirement typically smaller grain dies are used for obtaining bright wires, whereas larger grain size dies are used when surface finish is not of much concern . The die life varies with grain size, higher life for coarse grain size and lower life for fine grain size .Most PCD's are thermally stable up to 650°C that is up to 650°C wire drawing continues without degradation mechanism(oxidation&

graphitization) .Therefore to get improved performance in wire drawing right type of PCD blank should be use.

Nature of raw material

Improving the ductility of the raw material used for wire drawing serves as most important factor to economically increase the productivity. Various processes and methods are available or have been discovered to increase the ductility of wire materials.

Annealing: Since wire drawing is cold working operation. Therefore when stock is cold drawn its ductility goes on decreasing with increased cold working, there comes a point beyond which a specimen or stock will crack. In order to apply more amount of cold work to the stock, the stock is annealed as such its earlier (pre cold worked) stage is restored. Annealing involves heating a material above its recrystallization temperature, the allowing it to cool slowly. In annealing process there is migration of atoms present in lattices and decrease in number of dislocations that results changes in ductility and hardness because of slow cooling course grain size is obtained that relieves internal stress, that cause reduction in hardness and increase in ductility. After each wire drawing operation stock can be subject to the annealing process, so as to increase its ductility as such it can be subjected to further drawing.

State of dies

Conventional dies used in drawing process were fixed, that is there was no relative motion between the dies and stock which resulted in the higher friction between die and stock which in turn leads to higher wear of dies and higher amount of drawing force. Now a day's roller dies [4] are being used instead of conventional fixed dies to convert shear friction into the rolling friction that results in the reduction of drawing force.

Improvement in wire drawing operation by the introduction oscillating dies

The force required to draw the wires through dies can be reduced to large extent by using oscillating dies. Reduction in drawing force results in the increase of drawing capacity or formability. Different techniques can be utilized to excite the dies. The dies are usually excited in longitudinal direction though radial excitation can be occasionally applied. Further direction of die vibration is also having effect on drawing process that is if die vibration is parallel to the drawing direction, it will have greater effect on the friction between die and wire and if the die vibration is perpendicular to the drawing direction then influence will be more on forming properties of work piece. Since there is generation of standing wave longitudinal oscillating dies at their natural frequency, there is the greater possibility to locate a die at nodal or anti nodal points. With ultra-sonically oscillating die the static forming forces get reduced. There are two reasons which lead to the reduction in static forming forces.

- Due to reduction of friction between die and the wire.
- Due to absorption of sonic energy by the dislocations.

Improvement in the Wire drawing process

Conventional wire drawing processes were carried out at room temperatures with the aid of simple dies. Now a day's

electro plastic manufacturing process has been introduced. Electro plastic manufacturing process is a new energy efficient, ecofriendly and versatile metal forming process used to manufacture the metals or the alloys that are difficult to process by any other conventional metal forming process. It has been found that deforming forces required during a forming process are reduced due to the application of electric current. When electric current is applied to the metal undergoing deforming process its deformation resistance decreases drastically while its plasticity increases significantly. This effect of electric current on plastic flow is known as electro plastic effect.

Electro plastic drawing:

In electro plastic drawing process the electric pulse is applied either to the drawing dies or to the stock by means of conventional contacts. It has been found that the application of electric current reduces the drawing forces. Here electric pulses that are high intensity electric shocks are used, that cause the generation of drift electrons. These drift electrons aid dislocations to overcome resistance from obstacles and the lattice resistances and there by resulting the load drop. The reason for electro plastic process is dynamic recrystallization. The reduction in drawing force depends on current density, pulse direction and pulse frequency. The recent studies by "TANG and Co-works" showed, by the use of electro plastic drawing during cold drawing operation, the forming resistance of steel wires is reduced by more than 10%.

It cause lesser martensite formation during forming of steel, hence greater ductility is obtained. With reference to magnesium alloy drawing forces is reduced by 25%. At lower temperatures, the process of dynamic recrystallization occurs within a short span of time, thereby enhancing the plasticity.

2. Conclusion

With the passage of time conventional wire drawing process has been improved to a large extent both in terms of raw material and the set up required. Treated raw material [annealed] with improved properties like ductility is being used for drawing process. Similarly oscillating dies has replaced the static conventional dies. Also use of PCD dies has improved the efficiency.

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