Types of extrusion and extrusion equipment

1.1 Introduction

Extrusion is a compressive deformation process in which a block of metal is squeezed through an orifice or die opening in order to obtain a reduction in diameter and increase in length of the metal block. The resultant product will have the desired cross-section. Extrusion involves forming of axisymmetric parts. Dies of circular on non-circular cross-section are used for extrusion. Generally, extrusion involves greater forming forces. Large hydrostatic stress in extrusion helps in the process by enhancing the ductility of the material. Metals like aluminium, which are easily workable, can be extruded at room temperature. Other difficult to work metals are usually hot extruded or warm extruded. Both circular and non circular parts can be obtained by extrusion. Channels, angles, rods, window frames, door frames, tubes, aluminium fins are some of the extruded parts.

Difficult to form materials such as stainless steels, nickel alloys are extruded due to its inherent advantage, namely, no surface cracking due to reaction between the billet and the extrusion container. Extrusion results in better grain structure, better accuracy and surface finish of the components. Less wastage of material in extrusion is another attractive feature of extrusion.

Lead pipes were extruded in late 1700's in England. Later on lead sheathing of electric cables was done by extrusion.

1.2 Types of extrusion:

Extrusion ratio: It is the ratio of area of cross-section of the billet to the area of cross-section of the extrude.

$R = Ao/Af$

Another parameter used in extrusion is shape factor, ratio of perimeter to the cross-section of the part. An extruded rod has the lowest shape factor.

Extrusion is classified in general into four types. They are: Direct extrusion, indirect extrusion, impact extrusion and hydrostatic extrusion.

In extrusion process, the billet is placed in a container, pushed through the die opening using a ram and dummy block. Both ram and billet move.

Direct extrusion:

Direct extrusion, also called forward extrusion, is a process in which is the billet moves along the same direction as the ram and punch do. Sliding of billet is against stationary container wall.Friction between the container and billet is high. As a result, greater forces are required. A dummy block of slightly lower diameter than the billet diameter is used in order to prevent oxidation of the billet in hot extrusion. Hollow sections like tubes can be extruded by direct method, by using hollow billet and a mandrel attached to the dummy block.

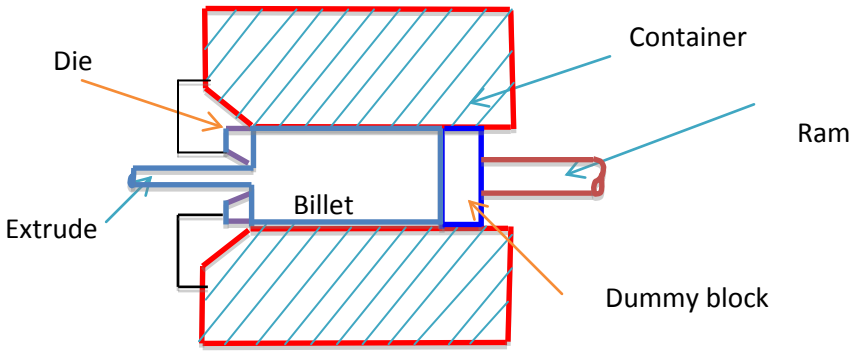

Fig. 1.2.1: Direct extrusion process

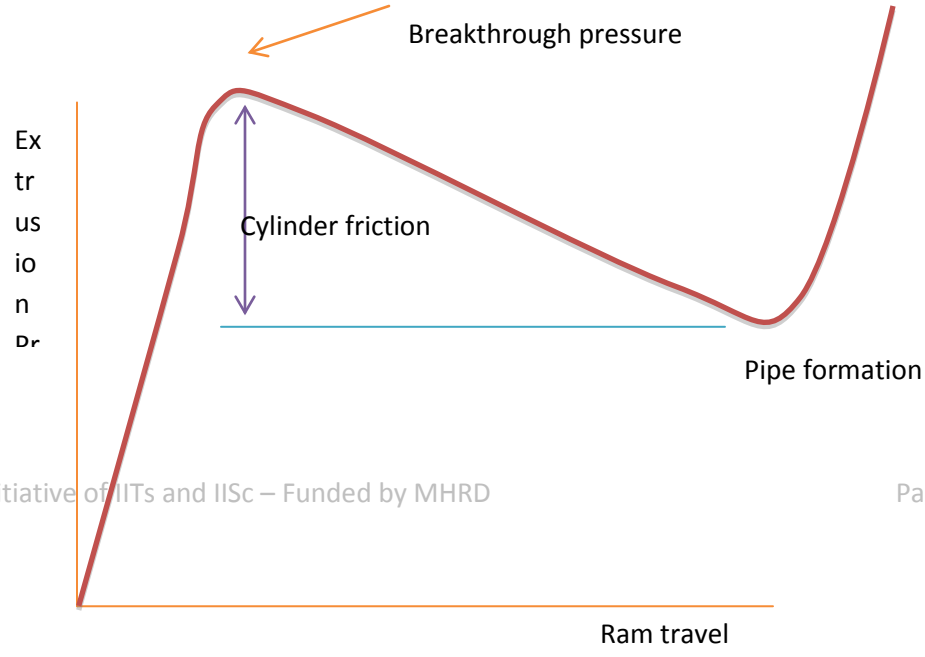

Fig. 1.2.2: Variation of extrusion force with ram travel in direct extrusion

Extrusion force, which is the force required for extrusion, in direct extrusion, varies with ram travel as shown in figure above. Initially the billet gets compressed to the size of container, before getting extruded. Also, initially static friction exists between billet and container. As a result the extrusion pressure or force increases steeply as shown. Once the billet starts getting extruded, it length inside the container is reduced. Friction between billet and container now starts reducing. Therefore, extrusion pressure reduces. The highest pressure at which extrusion starts is called breakthrough pressure. At the end of the extrusion, the small amount of material left in the container gets pulled into the die, making the billet hollow at centre. This is called pipe. Beyond pipe formation, the extrusion pressure rapidly increases, as the small size billet present offers higher resistance. As the length of the billet is increased, the corresponding extrusion pressure is also higher because of friction between container and billet. Therefore, billet lengths beyond 5 times the diameter are not preferred in direct extrusion.

Direct extrusion can be employed for extruding solid circular or non-circular sections, hollow sections such as tubes or cups.

Indirect extrusion:

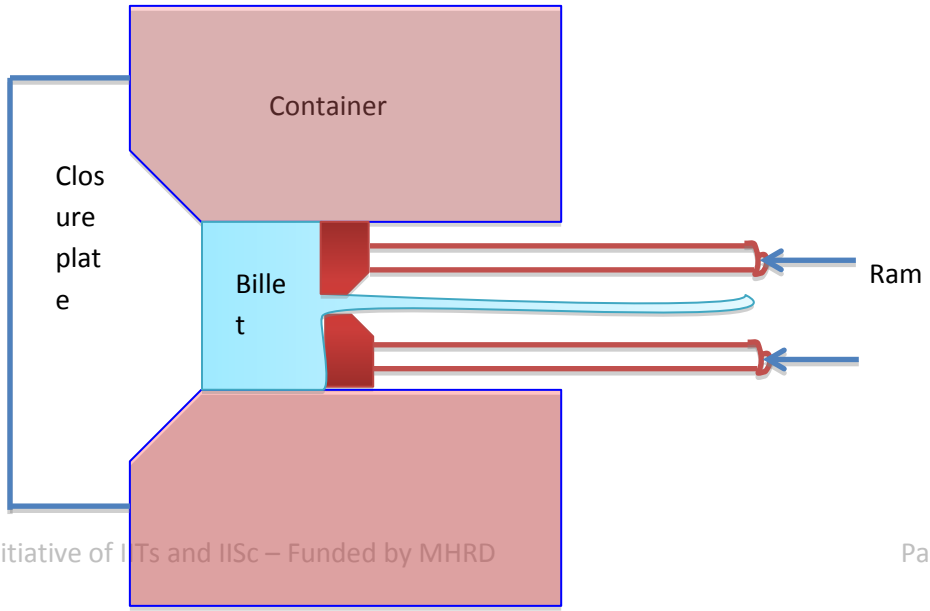

Fig. 1.2.3: Indirect extrusion

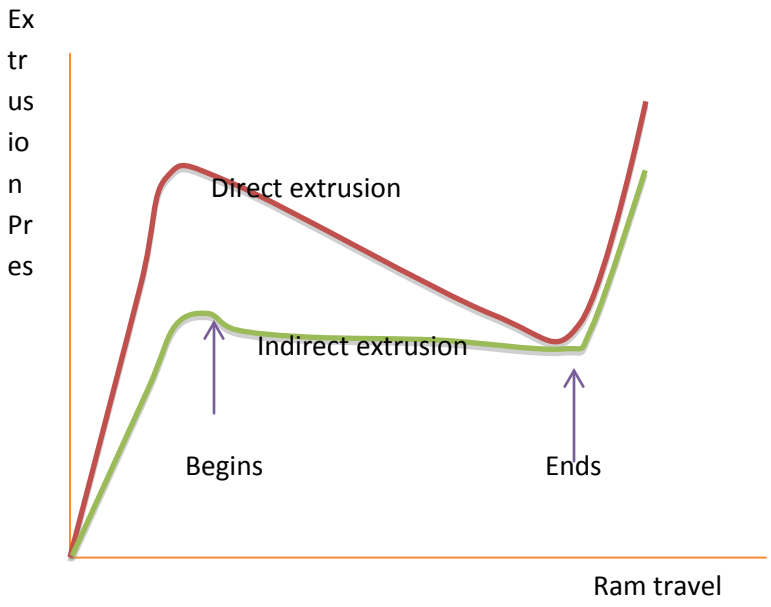

Fig. 1.2.4: Extrusion pressure versus ram travel for indirect and direct extrusion

Indirect extrusion (backward extrusion) is a process in which punch moves opposite to that of the billet. Here there is no relative motion between container and billet. Hence, there is less friction and hence reduced forces are required for indirect extrusion. For extruding solid pieces, hollow punch is required. In hollow extrusion, the material gets forced through the annular space between the solid punch and the container. The variation of extrusion pressure in indirect extrusion is shown above. As seen, extrusion pressure for indirect extrusion is lower than that for direct extrusion. Many components are manufactured by combining direct and indirect extrusions. Indirect extrusion can not be used for extruding long extrudes.

Hydrostatic extrusion:

In hydrostatic extrusion the container is filled with a fluid. Extrusion pressure is transmitted through the fluid to the billet. Friction is eliminated in this process because of there is no contact between billet and container wall. Brittle materials can be extruded by this process. Highly brittle materials can be extruded into a pressure chamber. Greater reductions are possible by this method. Pressure involved in the process may be as high as 1700 MPa. Pressure is limited by the strength of the container, punch and die materials. Vegetable oils such as castor oil are used. Normally this process is carried out at room temperature. A couple of disadvantages of the process are: leakage of pressurized oil and uncontrolled speed of extrusion at exit, due to release of stored energy by the oil. This may result in shock in the machinery. This problem is overcome by making the punch come into contact with the billet and reducing the quantity of oil through less clearance between billet and container. Hydrostatic extrusion is employed for making aluminium or copper wires-especially for reducing their diameters. Ceramics can be extruded by this process. Cladding is another application of the process. Extrusion ratios from 20 (for steels) to as high as 200 (for aluminium) can be achieved in this process.

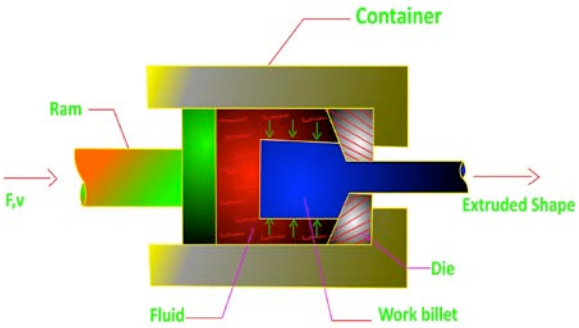

Fig. 1.2.5: Hydrostatic extrusion

Impact extrusion: Hollow sections such as cups, toothpaste containers are made by impact extrusion. It is a variation of indirect extrusion. The punch is made to strike the slug at high speed by impact load. Tubes of small wall thickness can be produced. Usually metals like copper, aluminium, lead are impact extruded.

Tube extrusion:

Employing hollow billet and a mandrel at the end of the ram, hollow sections such as tubes can be extruded to closer tolerences. The mandrel extends upto the entrance of the die. Clearance between the mandrel and die wall decides the wall thickness of the tube. The mandrel is made to travel alongwith the ram in order to make concentric tubes by extrusion.

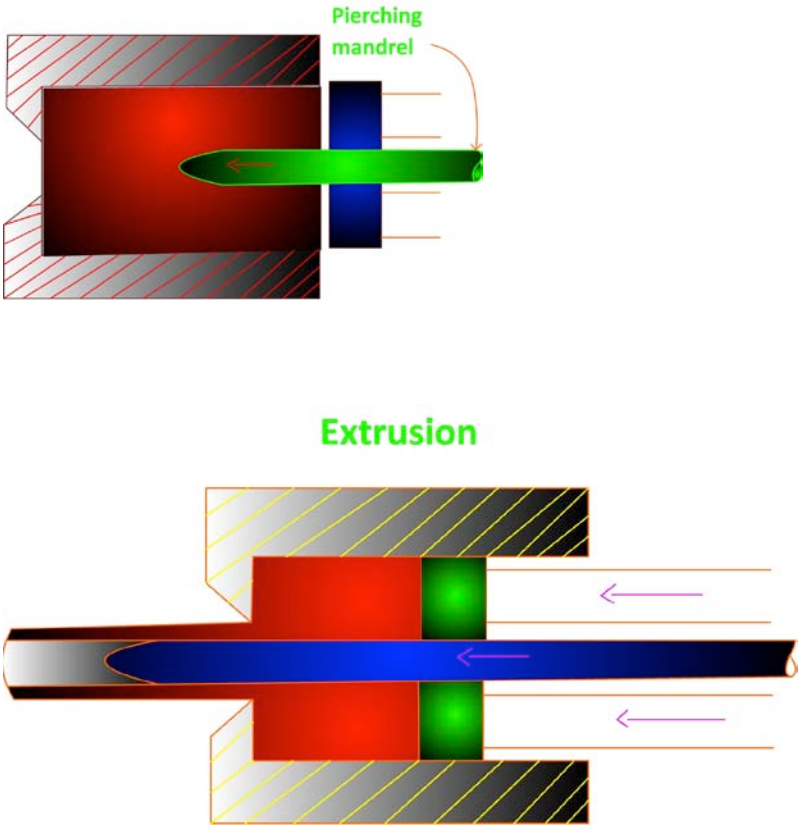

Fig. 1.2.6: Extrusion of tubes – piercing and extrusion

Tubes can also be made using solid billet and using a piercing mandrel to produce the hollow. The piercing mandrel is made to move independently with the help of hydraulic press. It moves along with the ram coaxially. First the ram upsets the billet, keeping the mandrel withdrawn. Next the mandrel pierces the billet and ejects a plug of material from central. Then the ram and mandrel together are moved in and extrude the billet.

Plug rolling and Mannesmann processes are also the other methods of producing seamless tubes.

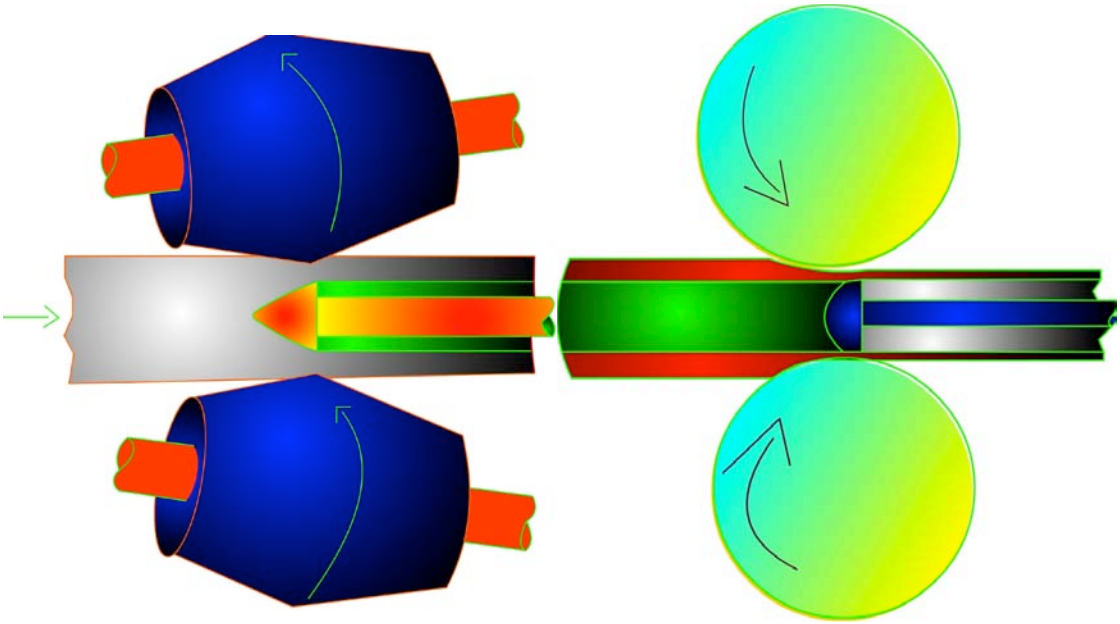

Fig. 1.2. 7: Mannesmann process and plug rolling process

Port hole extrusion is another method of producing tubes and hollow sections in aluminium, magnesium etc. In this method, a die with a number of ports and a central mandrel supported by a bridge is used. The billet is squeezed through the ports and flows in separate streams. After the die section the extruded streams are joined together by welding in the welding chamber.

1.3 Cold and hot extrusion:

Cold extrusion could produce parts with good surface finish, high strength due to strain hardening, improved accuracy, high rate of production. However, the process requires higher pressure and tools are subjected to higher stresses. Proper lubrication is necessary for preventing seizure of tool and workpiece. Phosphate coated billets are lubricated with soap.

Hot extrusion can be employed for higher extrusion ratios. Inhomogeneous deformation can occur due to die wall chilling of the billet. Metal may get oxidized. The oxide layer can increase friction as well as the material flow. Glass is used as lubricant for hot extrusion. Molybdenum disulfide or graphite are the solid lubricants used in hot extrusion. Canned extrusion using thin walled cans made of copper or tin is usually used for extruding highly reactive metals and metal powders.

1.4Extrusion presses:

Hydraulic presses of vertical or horizontal type are used for extrusion. Vertical presses are of capacity ranging from 3 to 20 MN. Horizontal presses occupy less space, but the billets get nonuniformly cooled. Horizontal presses upto 50 MN capacity are being used. Tubular extrusions are mostly done in vertical presses, while horizontal presses are used for bar extrusion.

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