Research & Analysis Journals

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

INTRODUCTION TO NUCLEAR FUEL COMPLEX

md azmath, md jalal uddin

asst prof mech dept snits college

CHAPTER-1

INTRODUCTION:

The Nuclear Fuel Complex (NFC) established in the year 1971 in a major industrial unit of department of Atomic Energy, Government of India. The Hyderabad site was selected, recognizing the presence of many science and technology institutions, the industrial infrastructure available and also the advantages of central location with excellent communication links with all parts of country.

The complex is responsible for the supply of nuclear fuel bundles and core components for all the Nuclear Power Reactors in India. It is a unique facility where natural and enriched uranium fuel, zirconium alloy cladding and reactor core components are manufactured under one roof starting from the raw material.

➢ MISSION AND VISION:

India is pursuing a three stage nuclear power program linking the fuel cycles of Pressurized Heavy Water Reactors (PHWR) and Liquid Metal Cooled Fast Breeder Reactors (LMFBR).

From the very inception of the nuclear power program in India the mid-1960s, great emphasis has been given towards self-reliance and indigenization in fabrication of nuclear fuels.

Since 1971, the Nuclear Fuel Complex (NFC) of Hyderabad is playing a key role in this program and has been supplying natural and enriched Uranium Oxide fuels and Zirconium alloy core components for all the power reactors in India.

NFC is the only facility in the world wherein under the same roof; both Uranium Oxide fuels and Zirconium alloy components are fabricated starting from the basic raw materials namely Magnesium-di-uranate, Uranium ore concentrate and Zircon sand respectively.

So far, assemblies for the BWRs and a variety of Zirconium alloy components for power and research reactors in India including pressure tubes and calandria tubes for PHWRs.

In addition, NFC has manufactured and supplied stainless steel core components for the Fast Breeder Reaction materials for both nuclear and non-nuclear applications.

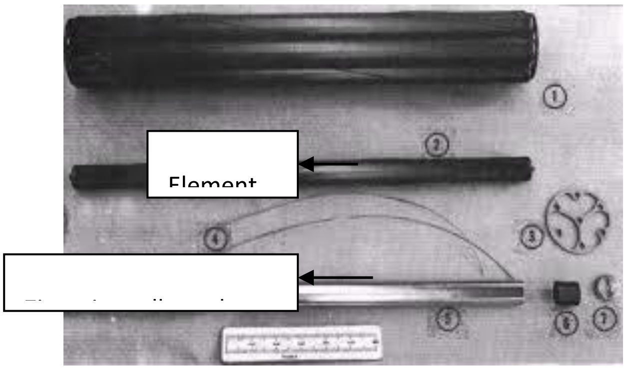
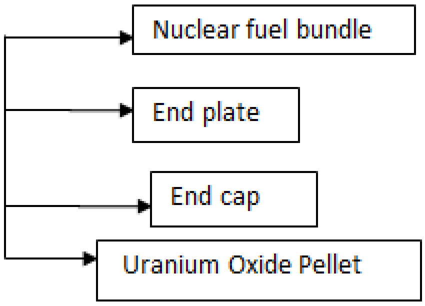


Fig.1.1 Parts manufactured in NFC



➢ ACTIVITIES:

➢ NUCLEAR PRODUCTS:

• Natural, Depleted, Recycled and Enriched Uranium Dioxide Fuel Assemblies.

• Thorium Oxide Pellets and Assemblies.

• Reactor-grade Zirconium Sponge and Zirconium Alloy components for fuel Assemblies and Core Structural for Water Cooled Nuclear Power Reactors.

• Stainless Steel Cladding Tubes, Fuel Sub Assembly Components, Blanket and Other Core Subassemblies for Sodium Cooled Fast Reactors.

• High Purity Advanced Material for strategic industries like Atomic Energy, Electronics, Defence, Space, etc.

• Production of Nuclear fuel bundles for Indian power reactors both Pressurized Heavy water & Boiling water reactor types.

• Production of zircaloy reactor core components like coolant tubes, calandria Tubes, flow-tubes etc.

Research & Analysis Journals

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

• Production of Fast Breeder test reactor (FBTR) core sub-assemblies.

• Production of very high purity (99.999%) materials for electronic and other Industries.

• Uranium Oxide Fuel Pellets and Zirconium Alloy Cladding Tubes andComponents for PHWR & BWR fuel bundles/ assemblies.

• Zirconium Alloy Structural for PHWR and BWR cores.

➢ NON-NUCLEAR PRODUCTS:

• SPECIAL SEAMLESS TUBES:

Stainless steels, titanium alloys, mar aging steel, high nickel alloys and zirconium

Alloys etc. for power stations, aerospace, marine propulsion, and chemical, Fertilizer and defense industries.

• HIGH PURITY MATERIALS (99.999 – 99.9999%):

Antimony, Boron, Bismuth, Cadmium, Gold, Lead, Tin, Zirconium, Silver, Indium, Selenium, Gallium, Tribromide etc.

• SPECIAL MATERIALS:

Tantalum & niobium metal ingots, components and power for strategic use;

Tantalum and niobium pent oxide powder for cutting tool application.

➢ 1.4 MAKING OF NUCLEAR FUEL AT NFC:

Natural Uranium is mined at Jaduguda in Jharkhand. It is converted into nuclear fuel assemblies in Nuclear Fuel Complex at Hyderabad. A 220 MW PHWR fuel bundle contains 15.2Kg of natural uranium dioxide. Uranium dioxide pellets, which generate heat while undergoing fission, also generate fission products.

The fission products, which are radioactive should be contained and not allowed to mix with coolant water. Hence the UO2, pellets are contained in Zirconium alloy tubes with both the ends sealed.

There is no combustion in uranium fuel and a fuel bundle comes out of the reactor in the same way as it went in. However, there is one important difference. When a fuel bundle is removed from the reactor after about 18 months of use, it contains radioactive by-products as a result of the fission process. This machinery also feeds new fuel bundles into the reactor.

The water cools the used fuel and, along with steel and concrete shielding, protects station workers from radiation. After a period of storage under water, the spent fuel bundles are taken in shielded containers to the reprocessing plant. In this plant, operated largely by remote control through heavy shielding, three main product streams are separated.

Fig 1.2 Nuclear Fuel bundles

• Depleted Uranium (about 98%) is stored for recycling in fast breeder reactor.

• Plutonium (about 0.4%) formed when neutrons are absorbed in atoms of nonfissionable uranium. This very valuable and can be used as fuel for fast reactors.

• Mixed long-lived radioactive fission products (about 1%) are vitrified and stored.

➢ URANIUM REFINING AND CONVERSION:

The raw material for the production of PHWR fuel in NFC is Magnesium Di-uranate (MDU) popularly known as 'Yellow Cake'.

The impure MDU is subjected to nitric acid dissolution followed by solvent extraction and precipitation with ammonia to get Ammonium Di-uranate (ADU).

By further steps of controlled calcination and reduction, sinter able uranium dioxide powder is formed which is then compacted in the form of cylindrical pellets and sintered at high temperature to get high density uranium dioxide pellets.

For BWRs, the enriched uranium hexafluoride is subjected to pyro-hydrolysis & converted to ammonium diuranate which is treated in the same way as natural ADU to obtain high density UO2 pellets.

Fig 1.3 Uranium Oxide Pellets

➢ ZIRCONIUM ALLOY PRODUCTION:

Zirconium alloy, also incorrectly called as zirconium alloy, is a group of high-zirconium alloys. One of the uses of zirconium alloy in nuclear industry is that, zirconium has very low absorption cross section of thermal neutrons and therefore it is frequently used as cladding material of fuel rods in nuclear reactors. Zirconium alloy consists of 1.5% tin. Other alloying elements can be niobium, chromium, iron and nickel.

The mechanical properties of zirconium alloy can be improved by adding small amount of nickel, resulting in nickel doped zirconium alloy, with significantly better resistance to nodular corrosion without worsening the uniform corrosion resistance and hydrogen absorption rate.

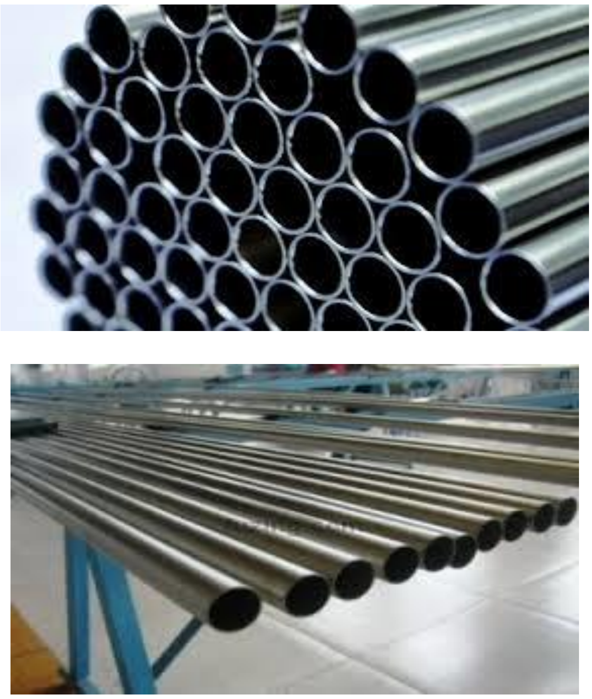


Fig1.4 Zirconium alloy tubes

Zircon sand is processed through caustic fusion, dissolution, solvent extraction (to

Remove hafnium), and precipitation & calcination steps to get zirconium oxide. Further, the pure zirconium oxide is subjected to high temperature chlorination, reactive metal reduction & vacuum distillation to get arcs melted to get homogeneous zirconium alloy ingots which are then converted into seamless tubes, sheets & bars by extrusion, pilgering and finishing operations.

Fig 1.5 Zirconium sand

- **NUCLEAR POWER PROGRAMME:** India is pursuing an indigenous three stage nuclear power programme involving closed fuel cycles of pressurized heavy water reactors (PWHRs) and liquid metal cooled fast breeder reactors (LMFBRs) for judicious utilization of the relatively limited reserves of uranium and vast resources of thorium. PHWRs form the first stage of the power programme which uses Zirconium alloy as clad and natural uranium dioxide as fuel. In addition, India is operating two boiling water reactors (BWRs) for the last 30 years. The Zirconium alloy clad enriched uranium dioxide fuel elements and assemblies for these reactors are fabricated at NFC with enriched uranium from imported source.

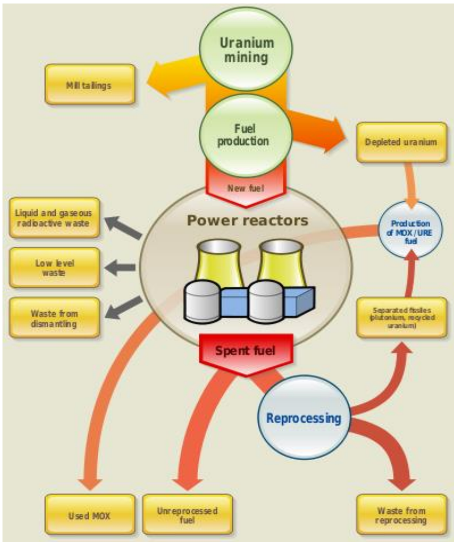


Fig 1.6 Nuclear Power Programme

- **NUCLEAR WASTE MANAGEMENT:**

Nuclear power, like all industries, gives rise to wastes. Because they are in general Radioactive, they are subject to strict control. In India, the basic philosophy of radioactive

Waste management has been to concentrate and contain as much radioactivity as possible and discharge effluents to the environment effluents at as low a concentration level as practicable. The various waste management schemes adopted are:

• All the gaseous effluents are rounded to the atmosphere through highly efficientparticulate air filters for removal of particulate radioactivity.

• Liquid waste facility provides chemical treatment followed by ion exchange treatment. The wastes are then diluted to achieve the final stipulated discharge concentration limit as necessary.

• For long lived, highly active solid wastes generated from at various plants, a three - stage approach has been adopted. Firstly, the waste will be incorporated in suitable & inert solid matrices. The conditioned waste will then be placed in canisters and kept in a retrievable store under cooling and constant surveillance. Ultimately, canisters will be stored in suitable geological media. India is one of these countries who have mastered the vitrification technology for converting radioactive waste into glass.

➢ **NFC MANUFACTURES AND SUPPLIES:**

• Fuel assemblies, core structural components and sub-assemblies for nuclear power reactors

• Stainless steel and special alloy seamless tubes and high purity materials.

Fig 1.7.1 Pellets and tube   Fig 1.7.2 Nuclear fuel bundle

<u>CHAPTER-2</u>

EXTRUSION

- Extrusion is a process used to create objects of a fixed cross-sectional profile. A material is pushed or drawn through a dieof the desired cross-section.
- The two main advantages of this process over other manufacturing processes are its ability to create very complex cross-sections, and to work materials that are brittle, because the material only encounters compressive and shear stresses.
- It also forms parts with an excellent surface finish.
- Extrusion may be continuous (theoretically producing indefinitely long material) or semi-continuous (producing many pieces).
- The extrusion process can be done with the material hot or cold.
- Commonly extruded materials include metals, polymers, ceramics, concrete, play dough, and foodstuffs.
- The products of extrusion are generally called "*extrudates*".
- Hollow cavities within extruded material cannot be produced using a simple flat extrusion die, because there would be no way to support the center barrier of the die.
- Instead, the die assumes the shape of a block with depth, beginning first with a shape profile that supports the center section.
- The die shape then internally changes along its length into the final shape, with the suspended center pieces supported from the back of the die.

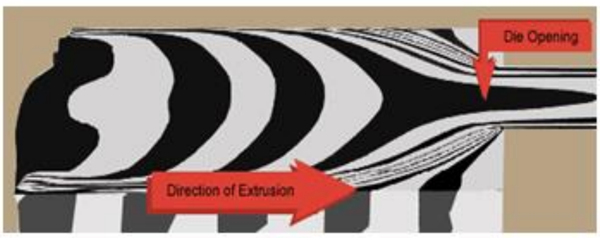


Fig 2.1 Direction of extrusion

➢ **TYPES OF EXTRUSION:**

There are four basic types of extrusion. They include the following:

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

- **DIRECT EXTRUSION**: This is similar to forcing the paste through the opening of a toothpaste tube. The billet slides relative to the container wall; the wall friction increases the ram forces considerably. The dummy block or pressure plate is placed at the end of the ram in contact with the billet.

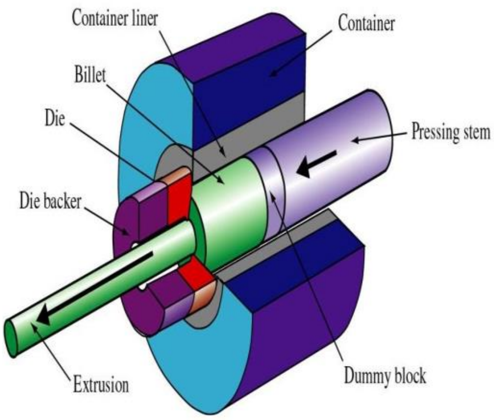


Fig 2.2 direct extrusion

- **INDIRECT EXTRUSION**:Here, the die moves towards the billet; thus, except at the die, there is no relative motion at the billet-container interface. As a consequence, the frictional forces are lower and the power required for extrusion is less than that for direct extrusion. In practice, a hollow ram carries a die, while the other end of the container is closed with a plate. Frequently, for indirect extrusion, the ram containing the die is kept stationary, and the container with the billet is made to move.

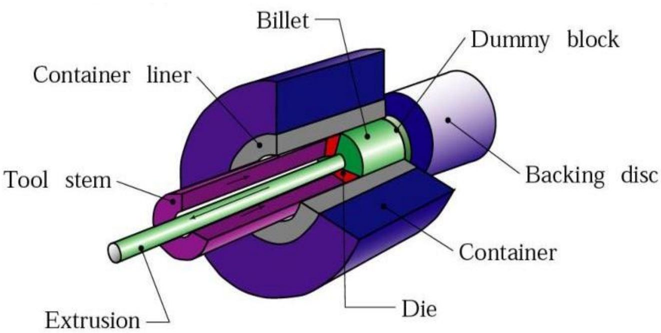


Fig 2.3 indirect extrusion

- **HYDROSTATIC EXTRUSION**:In this process, the chamber is filled with a fluid that transmits the pressure to the billet, which is then extruded through the die. There is no friction along the walls of the container. Because the billet is subjected to uniform hydrostatic pressure, it does not upset to fill the bore of the container as it would in conventional extrusion. This means that the billet may have a large length of diameter ratio (even coils of wires can be extruded) or it may have an irregular cross section. Because of this pressurised fluid, lubrication is very effective, and the extruded product has good surface finish and dimensional accuracy. Since friction is nearly absent, it is possible to use dies with very low semi-cone angle which greatly minimises the redundant deformation. The limitation with this process is the practical limit of fluid pressure that may be used because of constraint involving the strength of the container and the requirement that the fluid not solidify at high pressure.

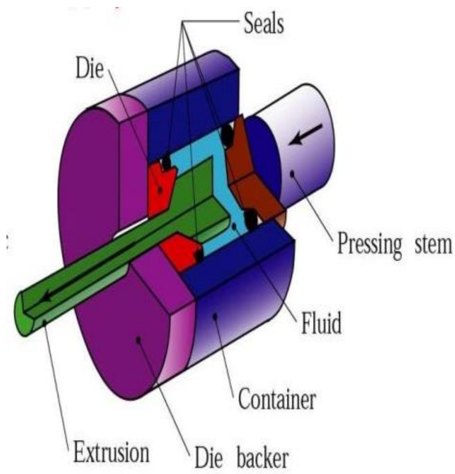


fig 2.4hydrostatic extrusion

Fig 2.5graph of hydrostatic extrusion

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

- **IMPACT EXTRUSION**: It is a form of indirect extrusion and is particularly suitable for hollow shapes. It is usually performed on a high speed mechanical press. The punch descends at a high speed and strikes the blank, extruding it upwards. The thickness of the extruded tubular section is a function of the clearance between the punch and the die cavity. Although the process is performed cold, considerable heating results from the high speed deformation. Impact extrusion is restricted to softer metals such as lead, tin, aluminium and copper.

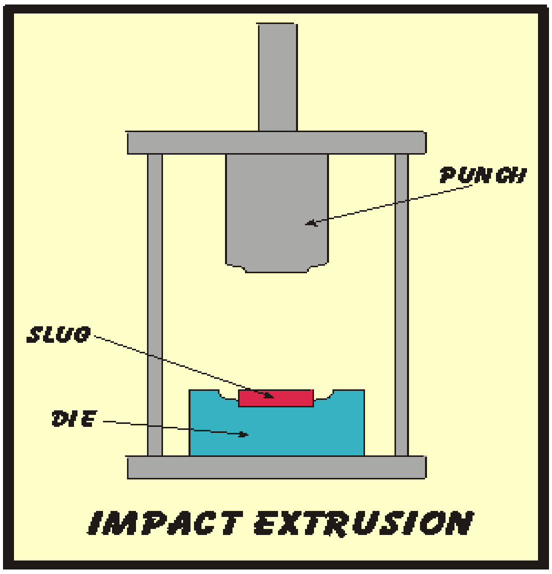


Fig 2.6 impact extrusion

- **ISOTHERMAL EXTRUSION**:Extrusion with a constant exit temperature of the extruded product is known as isothermal extrusion. This is of practical interest for achieving a uniform product quality or for making the most efficient use of the maximum speed that the alloy can withstand without hot shortness developing. The basic idea of so called isothermal extrusion developed from knowledge of the relationship between the exit temperature and the ram speed. The exit speed is varied via the press control system to give a constant exit temperature.

- **CLASSIFICATION BASED ON TEMPERATURE:**

Usually, because of large forces required in extrusion, most metals are extruded hot under the conditions where the deformation resistance of the metal is low. Cold extrusion is also possible for many metals. On this basis we can classify extrusion as:

- **HOT EXTRUSION**: Hot extrusion is basically hot working process. Hot extrusion may be defined as a tri-axial compressive deformation process by which a block of heated metal at temperatures above recrystallization temperature is reduced in cross section, by forcing it to flow through a die under high pressure. Hot working takes advantage of decrease in flow stress at higher temperatures to lower tool forces and, consequently,

equipment size and power requirements.

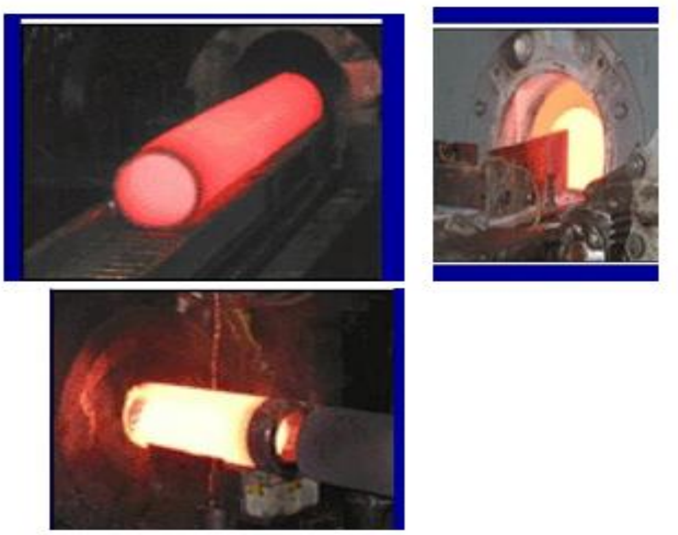


Fig 2.7. Hot extrusion

- **COLD EXTRUSION**: Cold extrusion is the process done below recrystallisation temperature. This process can be used for most materials- subjected to designing robust enough tooling that can withstand the stresses created by extrusion. Examples of the metals that can be extruded are lead, tin, aluminium alloys, copper, titanium, molybdenum, vanadium, steel...etc. Examples of the parts that are cold extruded are collapsible tubes, aluminium cans, cylinders, gear blanks.

- **EXTRUSION CAN ALSO BE DIVIDED INTO :**

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

- **FORWARD EXTRUSION:**
  - Metal is forced to flow in the same direction as the punch.
  - The punch closely fits the die cavity to prevent backward flow of the material.

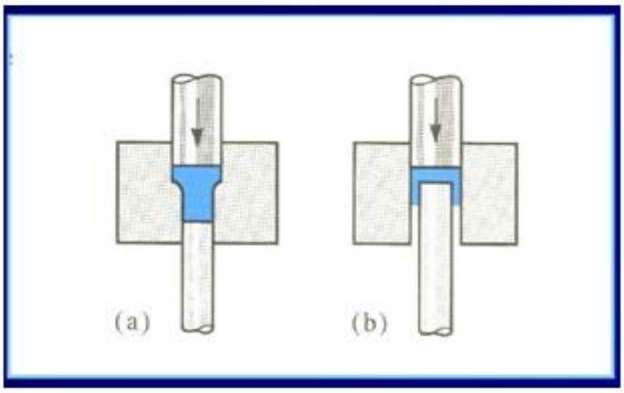


Fig 2.8. Forward extrusion

- **BACKWARD EXTRUSION:**
  - Metal id forced to flow in the direction opposite to the punch movement.
  - Metal can also be forced to flow into recesses in the punch

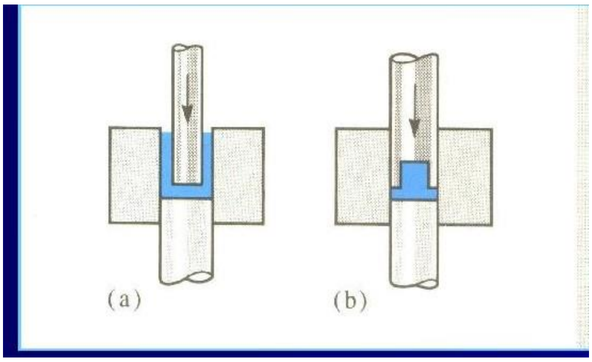


Fig2.9 backward extrusion

CHAPTER-3

HYDRAULICS

- Hydraulics is a topic in applied science and engineering dealing with the mechanical properties of liquids.
- At a very basic level hydraulics is the liquid version of pneumatics. Fluid mechanics provides the theoretical foundation for hydraulics, which focuses on the engineering uses of fluid properties.
- In fluid power, hydraulics is used for the generation, control, and transmission of power by the use of pressurized liquids.
- Hydraulic topics range through some part of science and most of engineering modules, and cover concepts such as pipe flow, dam design, fluidics and fluid control
  circuitry, pumps,turbines, hydropower, computational fluid dynamics, flow measurement, river channel behavior and erosion.

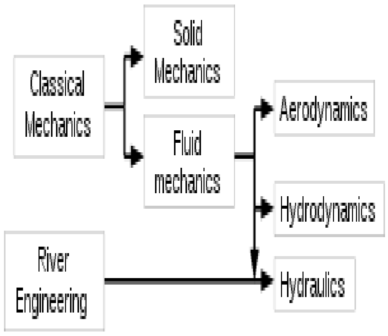


Fig 3.1 classification of hydraulics

- Hydraulics is a branch of science and mechanical engineering concerned with the use of fluids to perform mechanical tasks.

- **HYDRAULIC ACCUMULATORS**
  - A hydraulic accumulator is a pressure storage reservoir in which a non-compressible hydraulic fluid is held under pressure by an external source.
  - The external source can be a spring, a raised weight, or a compressed gas.
  - An accumulator enables a hydraulic system to cope with extremes of demand using a less powerful pump, to respond more quickly to a temporary demand, and to smooth out pulsations.
  - It is a type of energy storage device.
  - Compressed gas accumulators, also called hydro-pneumatic accumulators, are by far the most common type.

- **HYDRAULIC FLUIDS**
  - Hydraulic fluids, also called hydraulic liquids, are the medium by which power is transferred in hydraulic machinery.
  - Common hydraulic fluids are based on mineral oil or water.
  - Examples of equipment that might use hydraulic fluids include excavators and backhoes, hydraulic brakes, power steering systems, transmissions,

garbage trucks, aircraft flight control systems, lifts, and industrial machinery.

- Hydraulic systems like the ones mentioned above will work most efficiently if the hydraulic fluid used has zero compressibility.

3.3 FUNCTIONS AND PROPERTIES

The primary function of a hydraulic fluid is to convey power. In use, however, there are other important functions of hydraulic fluid such as protection of the hydraulic machine components. The table below lists the major functions of a hydraulic fluid and the properties of a fluid that affect its ability to perform that function.

Function	Property
Medium for power transfer and control	• Non compressible (high bulk modulus) • Fast air release • Low foaming tendency • Low volatility
Medium for heat transfer	• Good thermal capacity and conductivity
Sealing Medium	• Adequate viscosity and viscosity index • Shear stability
Lubricant	• Viscosity for film maintenance • Low temperature fluidity • Thermal and oxidative stability • Hydrolytic stability / water tolerance • Cleanliness and filterability • Demulsibility • Antiwear characteristics • Corrosion control
Pump efficiency	• Proper viscosity to minimize internal leakage • High viscosity index
Special function	• Fire resistance • Friction modifications • Radiation resistance
Environmental impact	• Low toxicity when new or decomposed • Biodegradability
Functioning life	• Material compatibility

AUXILIARY HYDRAULIC SYSTEM

- An **auxiliary hydraulic system** delivers pressurized hydraulic fluid from a hydraulic pump to operate auxiliary equipment or attachments.
- The addition of an auxiliary hydraulic system to heavy construction equipment increases the versatility of the vehicle by allowing it to perform additional functions with different attachments.

CHAPTER-4

INTRODUCTION TO ZIRCALOY

Because of low thermal neutron captured cross-section, adequate mechanical properties and good corrosion resistance, zirconium alloys are used in the nuclear industry.

For example: It can survive fuel cladding and core structure material. However, with the development of the concept of high burn-up enhancement of the performance of zirconium and its alloy are increasingly required.

For the last decade, the development of Zr based alloys has been at the fore front of CWR and PWR fuel technology. The corrosion behaviour of fuel cladding and structural components of a limits economic improvement in fuel utilization such as those associated with higher heat fluxer, fuel temperatures and core residence times.

This challenge to fuel performance has been adressed in the past through optimization of the chemistry and micro structure of the existing commercial alloys, zircaloy-2 and 4,zirclo and the Zr-1.0% and 2.5%Nb alloys.

Alloying element for zirconium can be classified into two groups α and β-stabilizers which were added to zirconium metal will extended phase diagram area of α and β phase respectively. Elements of β stabilizers such as iron and niobium also improve mechanism properties of zirconium.

CHAPTER-5

WORKING PROCESS OF AN 3780T HORIZONTAL EXTRUSION PRESS

STARTING:

- Ensure that the rotary switches of main ram and piercing ram are in return position and all other rotary switches are in stop position
- Switch on the main supply.
- Switch on the hydraulic tanks ensuring that no work is going on in the press.

Research & Analysis Journals

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

- Open PA Station main shut off valve for the constant system.
- Open the angular shut off valve.
- Open the electro hydraulic operated shut off valve.
- Open the bypass valve of constant system.
- Change the prefiller with air upto 12kg/sq.cm
- Bleed the air from the system at piercing, main ram, return stroke cylinders.
- Check the press for the following operation:
    a. Container forward and return stroke.
    b. Piercer forward and return.
    c. Main ram slow idle and rapid idle.
    d. Billet tray in and out movements.
    e. Hot saw movements.
    f. Dummy block pusher and glassing carriage.
- Close the bypass valve of constant system.
- Start the variable pump in PA Station and open the main shutoff valve of the variable system.
- Open the bypass valve of variable system.
- Check for idle operation of working stroke of main ram.
- Close the bypass valve of variable system.
- Check the pressure in constant and variable system pressure gauge as specified.

➢ **STOPPING:**

- Ensure that the rotary switches of main ram and piercer ram in return position and all other switches in stop position.
- Drain the prefiller pressure to zero.
- Switch off the electromagnetic valve.
- Switch off all hydraulic pumps.
- Close the angular shutoff valve.
- Switch off the control panel.
- Stop PA Station pumps.
- Close the manual shut off valves of constant and variable system.

➢ **REMOVAL OF STALLED BILLET:**

- Use sticker tool for removal of stalled billet.
- Centre the sticker tool with help of crane.
- Seal it between containers and die holder.
- Initially apply prefiller pressure to remove the stalled billet from container.
- If billet is not coming out with prefiller pressure then use working stroke of piercer ram to remove the stalled billet from the container.

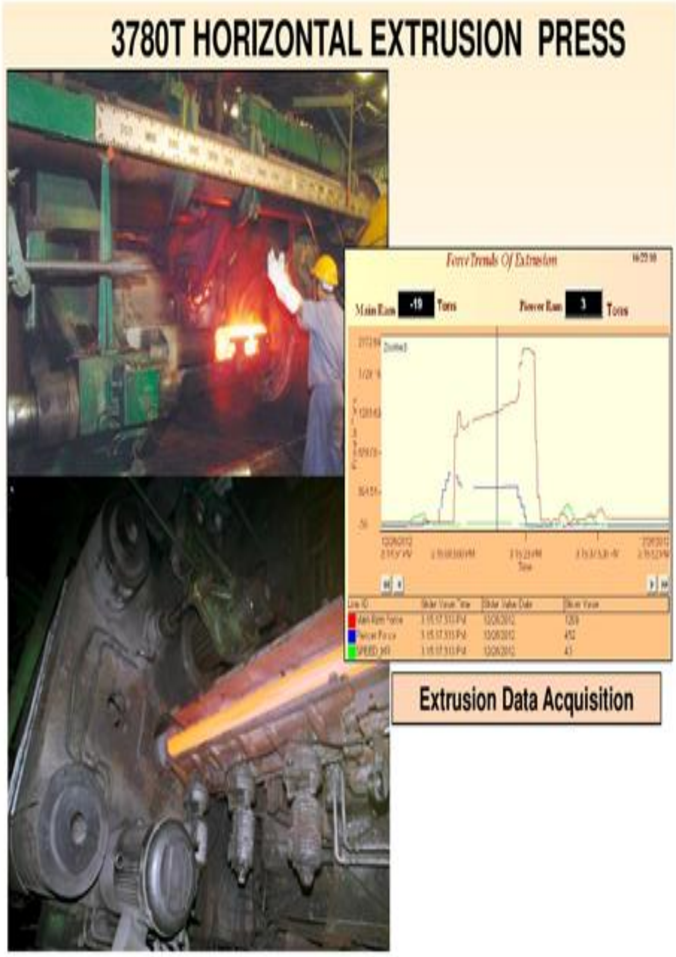


Fig 5.1 working process during extrusion

CHAPTER-6

COMPONENTS OF HYDRAULIC EXTRUSION PRESS AND ITS FUNCTION

➢ **PARTS OF THE HYDRAULIC EXTRUSION PRESS:**

Understanding how a hydraulic extrusion press works requires identifying the hydraulic extrusion press parts and explaining their use.

A hydraulic extrusion press is made up of a front platen and back platen held together by four tie rods.

The parts of the hydraulic press that actually make the extrusion are as follows:

Main cylinder- chamber and cylinder of an extrusion press into which hydraulic fluid is pumped to generate the desired ram pressure and movement.

Hydraulic pressure- pressure used to move the ram forward at the required pounds per squareinch.

Main ram- a steel rod attached to the main cylinder with a

Research & Analysis Journals

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

dummy block on the end that enters the container and applies pressure to the billet.

MANDREL - A tool component that grips or clamps materials to be machined. A tool component that can be used to grip other moving tool components.

PIERCER RAM -The solid billet which is first pierced by a piercing ram of the extrusion press. After the billet is pierced, the piercing ram remains in its position extending through the billet, and then the hydraulic ram compresses the billet to force it through the extrusion die while the piercing ram acts as a mandrel along which the work material moves.

The tension to which such a piercing ram is subject by the extruded material rubbing against the same sometimes becomes so great that the result is a failure of the piercing ram with consequent shutting down of the apparatus and a replacement of the broken piercing ram.

Dummy block- a tight fitting steel block attached to the ram stem on a press which seals the billet in the container and prevents metal from leaking backward.

Billet- aluminum log cut to specific lengths which are fed into the press as extrusion materials.

Container- chamber in an extrusion press which holds the billet as it is pushed through a die at one end while under pressure from a dummy block and ram entering at the other end. The container resides in the container housing. All containers are lined with a liner which holds the billet in place while it is being extruded.

Tool stack (die assembly) - solid: die ring, die, backer, bolster, and sub-bolster (sub-bolsters are not used in carthage or newnan). Hollow: die ring, die mandrel, die cap, bolster, sub-bolster

Dieholder- container of the tool stack.

Die lock- locks the die into the die holder.

Log oven/ billet oven- press component used to heat the logs/ billets to extrusion temperature. Presses equipped with log shears have log ovens; others have billet ovens.

Log shear- used for cutting logs to desired billet lengths (only on presses with log ovens).

Butt shear- shears off the unextruded portion of the billet (butt) remaining in the container after the extrusion cycle is completed. The butt is where oxides are located after the ram has pushed the billet through the container.
Die oven- oven where dies are heated to 750° - 900° f for 12-13 hoursbefore being used.
Cradle- holds the billet while it is being pushed into the extrusion press by the pressure from the ram.
Press leadout table- table which supports extrusion between the die and run out table.
Run out table- table at immediate exit of press leadout equipment which helps guide and support extrusions.
Platen pressure ring- a hardened tool steel ring inserted into the platen to support the die stack. Pressure applied by the main cylinder to the ring causes stress and wear resulting in a need for periodic replacement.

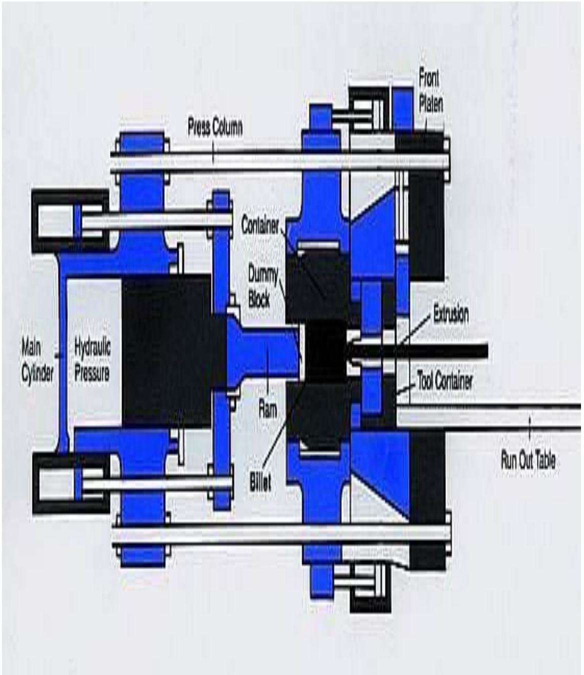


Fig 6.1 Components of horizontal press

CHAPTER-7

BILLETS

- A billet is a length of metal that has a round or square cross-section, with an area less than 36 sq in (230 cm^2).
- Billets are created directly via continuous casting or extrusion or indirectly via hot rolling an ingot.
- Billets are further processed via profile rolling and drawing. Final products include barstock and wire.
- Ingots are large rough castings designed for storage and transportation. The shape usually resembles a rectangle or square with generousfillets. They are tapered, usually with the big-end-downe.

- Centrifugal casting is also used to produce short circular tubes as billets, usually to achieve a precise metallurgical structure.
- They are commonly used as cylinder sleeves where the inner and outer diameters are ground and machined to length. Because their size is not modified significantly, they are not always classified as semi-finished casting products.
- In copper production, a billet is a 30' log, about 8" diameter, of pure copper.
- In general, Billet is defined as semi-finished solid metal form, generally having a cross-section of 105 to 230 square centimeters (... square inch), and rolled into finished 'long products' such as bars, channels, and rods.

Extrusion is the process of shaping aluminium by forcing it to flow through a specifically shaped opening in a die.

- The extruded aluminum comes out as an elongated piece with the same profile as the die opening.
- We produce around 350,000 metric tonnes per anum of high quality extrusion ingots.
- Extrusion ingots are widely used in the construction industry (for windows and door frames), transportation, engineering, and consumer durables.
- The quality parameters for extruded products such as, surface quality, mechanical properties and the inherent metallurgical features are achieved in the production process.

FEATURES:

- Our extrusion ingot is supplied in either cut-to-length billet form from 500mm long or more commonly in long form with a saleable length of up to 7,600mm.
- The common log length to fit inside a container for shipment by sea is 5,800mm.
- In the extrusion plant the log we supply is cut to shorter length billets using either a saw or more commonly a hot shear.
- The cut billet is then used in the extrusion of various section profiles in solid and hollow form.

APPLICATIONS:

- Our extrusion ingot is capable of being extruded into a range of profiles for soft to high strength applications and good surface finish for value added finishing applications such as anodising and powder coating.
- Typical uses of extruded products from the ingot supplied by Alba include architectural applications, building and kitchen suite sections, which are produced from soft alloys.
- On the other hand, sections extruded from hard alloys are used in a variety of engineering and transport applications.
- The use of extruded sections in automotive applications is an increasingly important area and one that is supported by the high quality extrusion ingot that we supply

EXTRUSION BILLET:

- Extrusion Billet is an aluminum log that is produced in many different diameters and cut to various lengths.
- The billet is heated to a plastic state and hydraulically forced through a die to obtain desired shape.
- Extrusion billet is used in the manufacturing of residential and commercial windows, shower enclosures, computer heat sinks, and decorative trim.
- Noranda produces aluminum extrusion billet for sale only to active extruders.

Fig 7.1. Raw materials of uranium

- The most common alloys produced are 6063, 6060, 6005A, 6061, & 6463 with all other alloys being subject to inquiry.
- Current diameters available are 6, 7, 8, 9, 10, & 11 inches in lengths from 20" to 288".

REDRAW ROD:

- Redraw Rod is manufactured in five thousand-pound coils that are produced by drawing aluminum rod through a series of dies to obtain the desired thickness.
- Redraw rod is used in the manufacturing of electrical wire and various types of cable, as well as for deoxidizing steel.

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

Fig 7.2. zircaloy bundles

- Our aluminum rod is produced in diameters of .375 & .470 inches in alloys 1350, & 8176 for use in the electrical and mechanical markets.

➢ **FOUNDRY INGOT:**

- Foundry Ingot is an aluminum alloy cast into thirty pound ingots. Some examples of products that are made using foundry ingot are automotive wheels, truck hubs and gas pump nozzles.
- We are licensed by Aluminium Rheinfelden GmbH to produce and distribute Magsimal ® & Silafont ® (Aluminum Association Alloy 365.1) for use in high strength and/or high elongation applications.

Fig 7.3 Billets for extrusion

➢ **BLOOM:**

- Blooms are similar to billets except the cross-sectional area is greater than 36 sq in (230 cm^2). Blooms are usually further processed via rotary piercing, structural shape rolling and profile rolling.
- Common final products include structural shapes, rails, rods, and seamless pipes.

➢ **SLAB:**

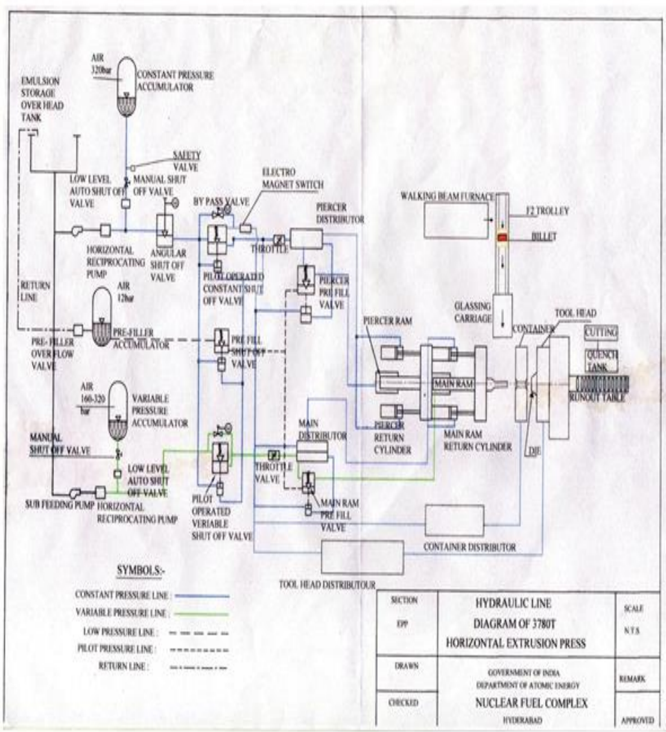
- A slab is a length of metal that is rectangular in cross-section. It is created directly from continuous casting or indirectly by rolling an ingot.
- Slabs are usually further processed via flat rolling, skelping, and pipe rolling. Common final products include sheet metal, plates, strip metal, pipes, and tubes.

Fig 7.4 oxygen gas torch cutting a slab

Fig 7.5 Steel slabs

CHAPTER-8

LINE DIAGRAM



FLOW DIAGRAM OF FORMATION OF BILLETS

Billet stand
↓
Watching Beam Furnace / Induction Furnace
↓
Rollers
(Slides The Billet Till Billet Tray)
↓
Billet Tray
(Holds Billet And Places Dummy Block)
↓
Mandreal Movement
(Inserted in the 1D of Billet)
↓
Stem Movement
(Moves Billet Into The Container)
↓
Die
↓
Tube Formation
↓
Quenching
↓
Cutting And Detecting
↓
Rejacketing

CHAPTER-9

LUBRICANTS

A lubricant is a substance introduced to reduce friction between moving surfaces. It may also have the function of transporting foreign particles. The property of reducing friction is known as lubricity (or slipperiness).

In addition to industrial applications, lubricants are used for many other purposes. Other uses include cooking (oils and fats in use in frying pans, in baking to prevent food sticking), bio-medical applications on humans (e.g. lubricants for artificial joints), ultrasound examination, internal examinations for males and females, and the use of personal lubricant for sexual purposes.

➢ **HOT EXTRUSION LUBRICANTS:**

- Low shear strength.
- Stable enough to prevent break down at high temperature.
- **Molten glass:** is the most common lubricant for steel and nickel based alloys (high temperature extrusion).
- Ugine Sejornet Process:
- **Graphite based lubricant:** are also be used at high extrusion temperature.

➢ **UGINE SEJOURNET PROCESS**:

- The billet is heated in an inert atmosphere and coated with glass powder before being pressed. The pad placed between the die and the billet provide the main source of lubricant.
- The glass coating is soften during extrusion to provide a lubrication film (25μm thick), which serves not only as a lubricant but also a thermal insulator to reduce heat loss to tools.
- The coating thickness depends on complex interaction between the optimum lubricant, the temperature and the ram speed.
- Lubricant film must be complete and continuous to be successful otherwise defects as surface crack will result.
- Too low ram speed →thick lubricant coating with low initial extrusion pressure → limit the length of extrusion.
- Too high ram speed → dangerously thick coating.

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

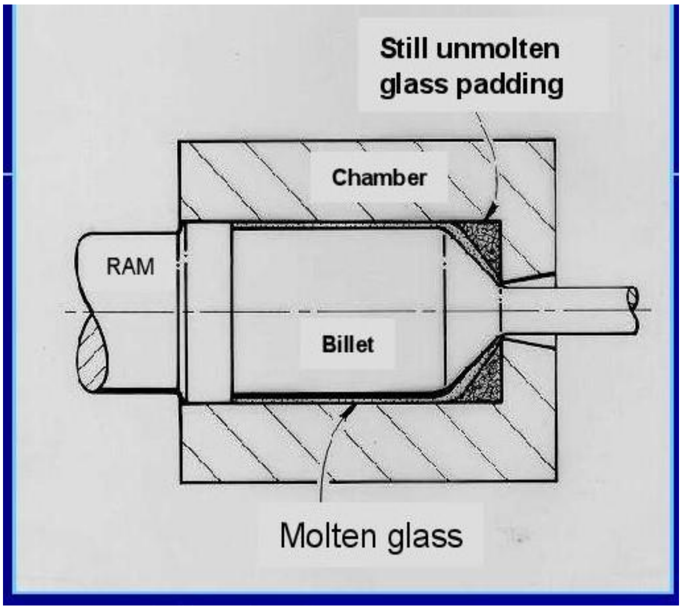


Fig 10.1molten glass as a lubricant

➢ **CHARECTERISTICS OF A GOOD LUBRICANT**

A good lubricant possesses the following characteristics:

- high boiling point and low freezing point (in order to stay liquid within a wide range of temperature)
- high viscosity index
- thermal stability
- hydraulic stability
- demulsibility
- corrosion prevention
- High resistance to oxidation.

➢ **APPLICATIONS:**

Lubricants perform the following key functions:

- Keep moving parts apart
- Reduce friction
- Transfer heat
- Carry away contaminants & debris
- Transmit power
- Protect against wear
- Prevent corrosion
- Seal for gases
- Stop the risk of smoke and fire of objects
- Prevent rust.
- One of the single largest applications for lubricants, in the form of motor oil, is protecting the internal combustion engines in motor vehicles and powered equipment.
- Lubricants such as 2-cycle oil are added to fuels like gasoline which has low lubricity. Sulfur impurities in fuels also provide some lubrication properties, which has to be taken in account when switching to a low-sulfur diesel; biodiesel is a popular diesel fuel additive providing additional lubricity.
- Another approach to reducing friction and wear is to use bearings such as ball bearings, roller bearings or air bearings, which in turn require internal lubrication themselves, or to use sound, in the case of acoustic lubrication.

CHAPTER-10

EXTRUSION DEFECTS

➢ **Surface cracking (also called hot shortness)**

• If temperature, friction or speed is too high, intergranular cracks occur.

• Common in aluminum, magnesium, and zinc alloys.

• Bamboo defects are periodic surface cracks that develop due to the extruded product sticking to the die land.

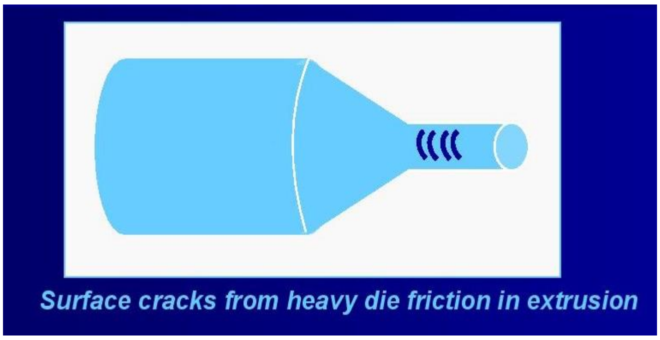


Fig 11.1 surface cracks from heavy die friction in extrusion

➢ **Pipe defect (also called tailpipe or fishtailing)**

• Metal flow pattern draws surface oxides and impurities toward thecenter of the billet, like a funnel.

• To prevent, modify flow pattern to be more uniform, control frictionand minimize temperature gradients, remove scale and impurities bymachining or chemical etching prior to extrusion.

➢ **Internal cracking (also called center-burst, chevron cracking)**

• Due to hydrostatic tensile stress at centerline of deformation zone.(similar to necking in a tensile test specimen).

• Increases with increased die angle, impurities. Decreases with increased extrusion ratio and friction.

RA Journal of Applied Research
||Volume||3||Issue||06||Pages-917-931||June-2017|| ISSN (e): 2394-6709
www.rajournals.in

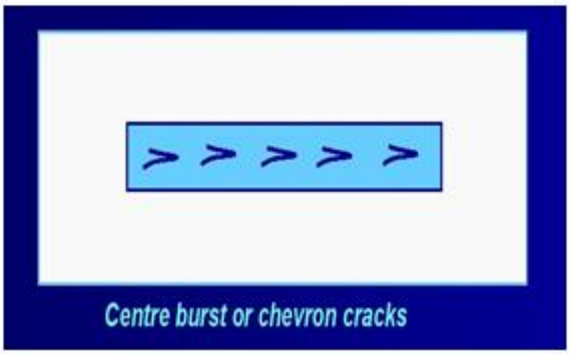


Fig 11.2 centre burst

- **Variations in structure and properties**
  - Within the extrusions due to non-uniform deformation for example at the front and the back of the extrusion in both longitudinal and transverse directions.
  - Regions of exaggerated grain growth, see Fig, due to high hot working temperature.

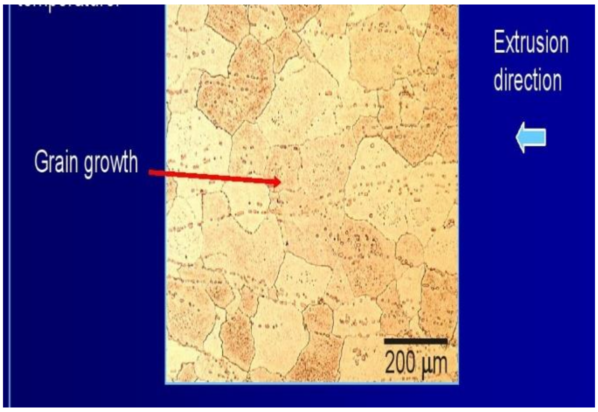


Fig 11.3 grain growth

CONCLUSION

We have learnt the process of 3780T horizontal extrusion press and its hydraulic system. How the extrusion process takes place and how extruded product comes out from the press and why PA station is used what's the purpose behind it. We also learnt what are accumulators, valves and why are they used in PA station. We also have absorbed why the billet is being heated to a certain temperature and above that in the furnaces. We have also seen the manufacturing process of seamless tubes and rods. How billets are made. Types of material used for the billet and size of the extruded part will be formed. We also learned the purpose of each and every part of the press and what is need of it, working process of press &etc.