A PROJECT REPORT

ON

"DESIGN OF HYDRAULIC CYLINDERS"

DONE AT

HINDALCO INDUSTRIES LTD.

RENUKOOT, U.P.

Contents

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INTRODUCTION

In a manufacturing company , production process is very important as it affects the efficiency through which the company can manufacture with minimum defects and wastes. Thus it is necessary to understand each parts and steps in the process of manufsacturing manchines for an employee, so that he can handle the machine properly and bring about possible innovative changes which can bring down the cost.

Undestanding about the production process have to cut down cost to provide the costomer product at minimum price. It is necessary for maintaining the quality of the product.

A good process maintains the standard necessary to be in competition. Thus it is the most important part to be understood in a company.

OBJECTIVE

The objective of this project is to study about the manufacturing process of different products of aluminium at Hindalco Industries Ltd.

- ✓ To know about the production process of the extrusion unit.
- ✓ To find out problems related to the process.
- ✓ How the hydraulic cylinders are designed.

SCOPE OF THE STUDY

This study is limited to the extrusion unit of fabrication department of Hindalco Industries Ltd. The reason for this is that there are various department in the company , each with its own complication and and it is quite impossible to document about each departments throughly.

METHODOLOGY

The data about the production process is collected by the dirtect interaction with the employee and by observing the working of the extrusion press.

LIST OF FIGURES :

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INTRODUCTION OF HINDALCO INDUSTRIES LIMITED

AN INDUSTRY LEADER IN ALUMINIUM AND COPPER :

An industry leader in aluminium and copper, Hindalco Industries Limited, the metals flagship company of the Aditya Birla Group is the world's largest aluminium rolling company and one of the biggest producers of primary aluminium in Asia. Its copper smelter is the world's largest custom smelter at a single location.

Established in 1958, we commissioned our aluminium facility at Renukoot in eastern Uttar Pradesh, India in 1962. Later acquisitions and mergers, with Indal, Birla Copper and the Nifty and Mt. Gordon copper mines in Australia, strengthened our position in value-added alumina, aluminium and copper products.

The acquisition of Novelis Inc. in 2007 positioned us among the top five aluminium majors worldwide and the largest vertically integrated aluminium company in India. Today we are a metals powerhouse with high-end rolling capabilities and a global footprint in 13 countries. Our consolidated turnover of USD 15.85 billion (Rs. 72,078 crore) places us in the Fortune 500 league.

ALUMINIUM:

Hindalco's major products include standard and speciality grade aluminas and hydrates, aluminium ingots, billets, wire rods, flat rolled products, extrusions and foil.

The integrated facility at Renukoot houses an alumina refinery and an aluminium smelter, along with facilities for the production of semi-fabricated products, namely, redraw rods, flat rolled products and extrusions. The plant is backed by a co-generation power unit and a 742 MW captive power plant at Renusagar to ensure the continuous supply of power for smelter and other operations.

A strong presence across the value chain and synergies between operations has given us a dominant share in the value-added products market. As a step towards expanding the market for value-added products and services, we have launched various brands in recent years — Everlast roofing sheets, Freshwrapp kitchen foil and Freshpakk semi-rigid containers.

Fig(1) : Aluminium Sheets

COPPER: Birla Copper, Hindalco's copper unit, is located at Dahej in Gujarat, India. The unit has the unique distinction of being the largest single-location copper smelter in the world. The smelter uses state-of-the-art technology and has a capacity of 500,000 tpa. Birla Copper also produces precious metals, fertilisers and sulphuric and phosphoric acid. The unit has captive power plants for continuous power generation and a captive jetty to facilitate logistics and transportation.

Birla Copper upholds its longstanding reputation for quality copper cathodes and continuous cast copper rods by assuring its management processes meet the highest standards. It has acquired certifications such as ISO-9001:2000 (Quality Management Systems), ISO-14001:2004 (Environmental Management System) and OHSAS-18001:2007 (Occupational Health and Safety Management Systems).

MINES:

Hindalco acquired two Australian copper mines, Nifty and Mt. Gordon, in 2003. The Birla Nifty copper mine consists of an underground mine, heap leach pads and a solvent extraction and electrowinning (SXEW) processing plant, which produces copper cathode.

The Mt. Gordon copper operation consists of an underground mine and a copper concentrate plant. Until recently, the operation produced copper cathode through the ferric leach process.

Both Nifty and Mt. Gordon have a long-term life of mine off-take agreement with Hindalco for supply of copper concentrate to the copper smelter at Dahej.

VISION , MISSION AND VALUES

Vision

To be a premium metals major, global in size and reach, excelling in everything we do, and creating value for its stakeholders.

Mission

To relentlessly pursue the creation of superior shareholder value, by exceeding customer expectation profitably, unleashing employee potential, while being a responsible corporate citizen, adhering to our values.

Values

Path to excellence.

- **Integrity -** Honesty in every action.
- **Commitment -** On the foundation of integrity, doing whatever it takes to deliver, as promised.
- **Passion -** Missionary zeal arising out of an emotional engagement with work.
- **Seamlessness -** Thinking and working together across functional silos, hierarchy levels, businesses and geographies.
- **Speed** - Responding to stakeholders with a sense of urgency.

PRIMARY ALUMINIUM PRODUCTS

Ingots:

Hindalco produces high-purity ingots through smelting. Alloy ingots of various grades are also produced and mainly used for the production of castings in the auto industry and in electrical applications. Both these products are re-melted and further processed into a large number of products for various downstream applications.

Hindalco metal is accepted under the high-grade aluminium contract on the London Metal Exchange (LME) as a registered brand.

Fig 2 : Aluminium Ingots

Wire rods:

Hindalco manufactures wire rods in a continuous casting and rolling process. Electrical conductor (EC) wire rods are used for the production of cables and ACSR and AAC conductors. Alloy wire rods are used to produce AAAC conductors.

Fig 3 : Aluminium Wire Rods

Billets:

Hindalco's aluminium billets are produced by a state-of-the-art Wagstaff casting process using Airslip technology. These are top-quality billets with a smooth finish. They are used mainly to produce extrusions and forgings.

Fig 4 : Aluminium Billets

PRODUCTION PROCESS

ALUMINIUM PRODUCTION PROCESS:

The 5 steps in the aluminium cycle-

Recycling ⟹ Mining ⟹ Refining ⟹ Smelting ⟹ Fabrication

Recycling: The most valuable material in the waste stream. For example, over 66 billion cans were recycled last year and 85-95% of Aluminium inn cars is recycled. It uses 5% of the energy of producing Aluminium from ore.

Mining: Bauxite is an ore rich in Aluminium Oxide (Al_2O_3).

Refining: Bauxite is turned into Aluminium Oxide. First Bauxite is ground and mixed with lime and castic soda. Then it is heated in a high-pressure container and what is left is Aluminium Oxide.

Smelting: Aluminium Oxide (Alumina) turns into Aluminium through an electrolytic reaction.

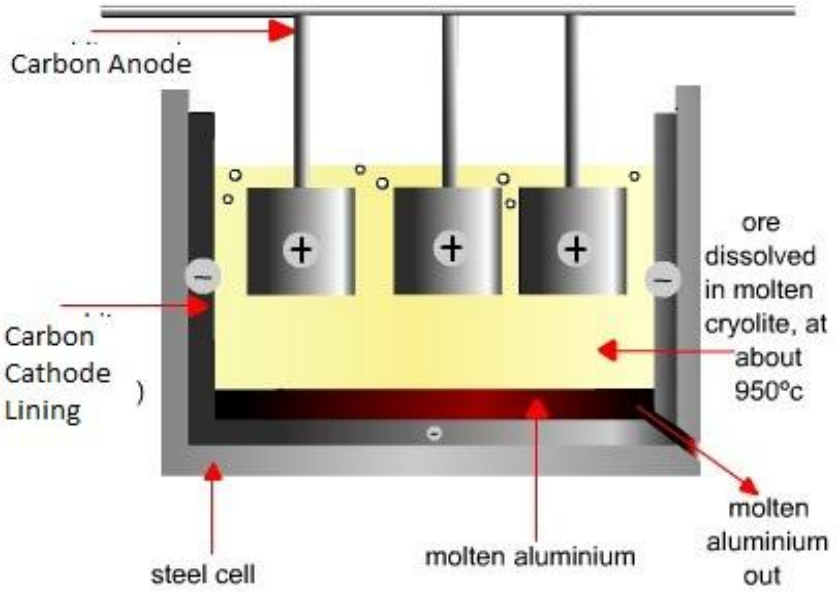
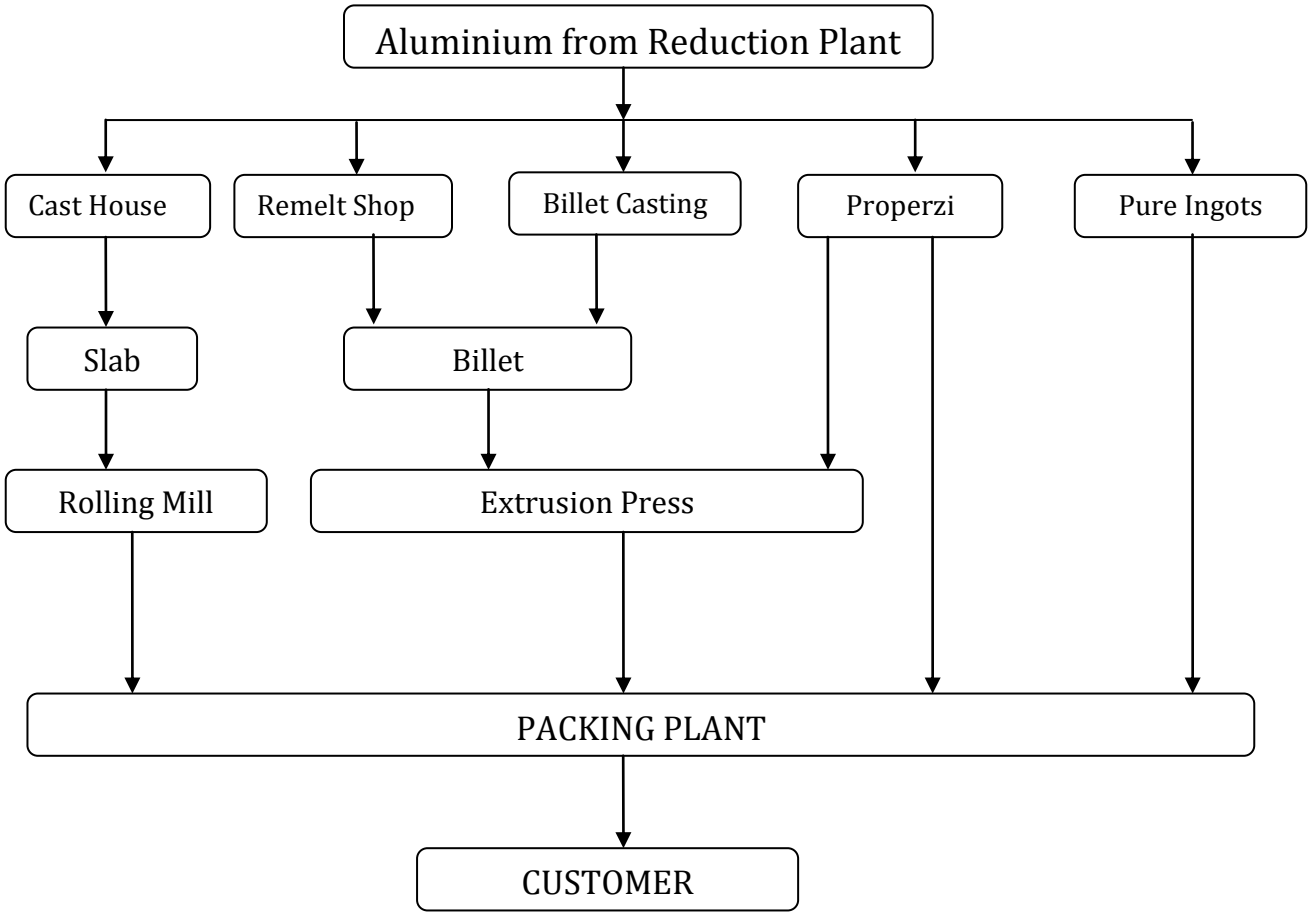


Fig 5 : Electrolytic Reaction of Alumina

Fabrication: First Aluminium is alloyed according to requirement. Metal is added to give specific design characteristics. It is done through different types of fabrication process which includes:-

(1) Casting
(2) Rolling
(3) Forging
(4) Drawing
(5) Extruding

FABRICATION PLANT LAYOUT



WHAT IS EXTRUSION:

In general, extrusion is the process of giving the desired shape to a block of metal. It is a plastic deformation process in which a block of metal (billet) is forced to flow by compression through the die opening of smaller cross-sectional area than that of original billet. The extruded product takes the same shape and size, as that of die.

CLASSIFICATION OF EXTRUSION:

1) **Depending on temperature:** (a) Hot extrusion (b) Cold extrusion
   In hot extrusion, the billet is pre-heated to facilitate plastic deformation.

2) **Depending on flow:** (a) Direct extrusion (b) Indirect extrusion

In Direct extrusion, the direction of metal flow will be in the same direction as ram travel. Billet is placed in the container and pushed through the die by the ram travel. During this process, the billet slides relative to the walls of container. The process has been described as having three distinct regions:

I. The billet is upset, and pressure rises rapidly to its peak value.

II. The pressure decreases, and what is termed "steady state" extrusion proceeds.

III. The pressure reaches its minimum value followed by a sharp rise as the "discard" is compacted.

In HINDALCO Direct-Hot extrusion is employed.

TERMINOLGY IN EXTRUSION:

1) **Extrusion Ratio:** It is defined as the ratio of area container to the finial area of extruded product.

Extrusion ratio= A_c / A_E

Where,

A_C = Area of container

A_E = Area of extrusion

2) Die Factor: It is the ratio of die perimeter to kg per meter of die or extruded product.

Die factor = die perimeter/ (kg/meter)

Criticality of die depends on die factor. As the die factor increases, criticality of section increases.

Calculation of Multiplication Factor for Each Press:

We know,

The density (ρ) of Aluminum = 2.71gm/cm^3

= 0.00271kg/cm^3

Now,

Mass (m) = volume × density

$= \pi/4 \times d^2 \times l \times 0.00271$

Where,

d= diameter of billet

l= length of billet

Hence,

$m/l = \pi/4 \times d^2 \times 0.00271$ kg/cm

Now for press 1 and 5, d= 9”

$m/l = \pi/4 \times (9 \times 2.54)^2 \times 0.00271$ kg/cm= $0.013731 \times d^2$

=1.11kg/cm

Hence Multiplication Factor for Each Press....

PRESS	BILLET SIZE (mm)	MULTIPLICATION FACTOR (kg/cm)
1	9”	1.11
2	6”	0.494
3	8”	0.8787
5	9”	1.11

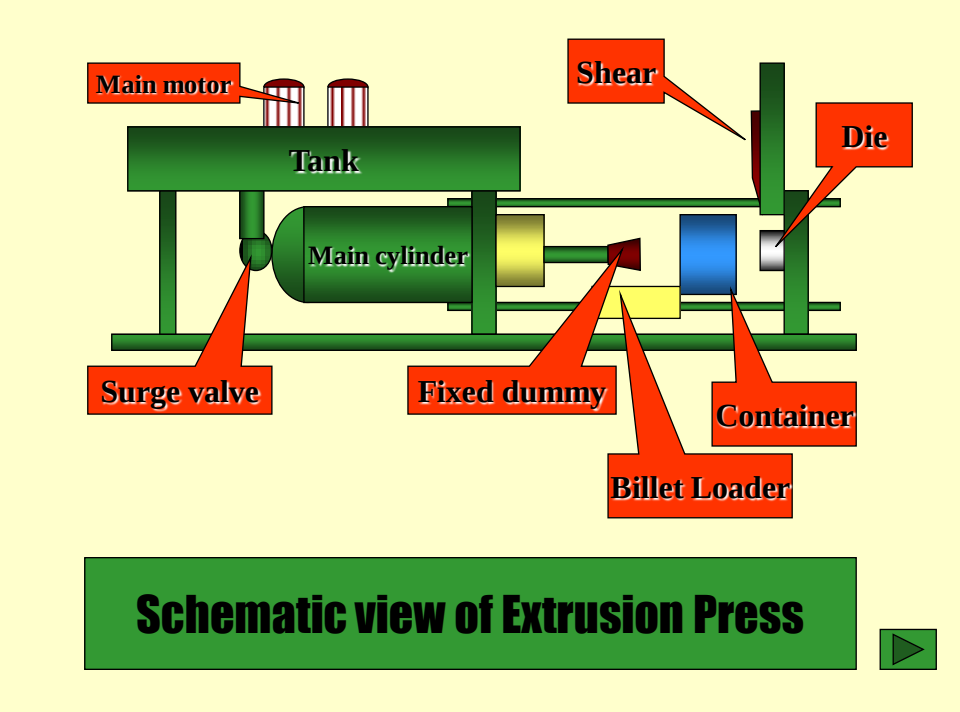


Fig 6 : Schematic View of Extrusion Process

PRESS SPECIFICATIONS:

Capacity=2200MT (Hydraulic Force)

1. Manufacturer : Clecim (France)
2. Installed In : 2006
3. Working Pressure : 300 Bar (Max Working Pressure-4215psi)
4. Main Ram Stroke : 1000 mm
5. Main Ram Speed : 23 mm/sec (But Max Speed Can Be 16.9)
6. Billet Dia : 229 mm (9")
7. Billet Length : 450 to 800 mm
8. Container Bore : 239 mm (9.375")
9. Hole Dia In Platen : 260 mm
10. Container Heater : 44 kw
11. Main Motor : 3x160 kw
12. Main Ram Dia : 970 mm
13. Installed Power : 560 kw
14. Control Panel : Plc Controlled With Display Console
15. Hydraulic : Oilgear/ Towler Make
16. Die Slide : Cassette Type Two Position (Tool Changer Device)
17. Billet Loader : Telescope Retractable Type Robotic
18. Weight : 115 Tones
19. Hydraulic Tank Capacity : 6500ltr
20. Main Cylinder Area : 7389 cm^2
21. Container Cylinder : 2 Nos (Φ250 X 160 mm^2, Stroke-1100 mm)
22. Side Cylinder : 2 Nos (Φ250 X 160 mm^2, Stroke-1100 mm)
23. Platen Saw Position : 7.5 met- 10.5 met
24. Puller Capacity : 300 Kg

BILLET HEATER (Induction Heating):

1. Manufacturer : Pioneer (India)
2. Capacity : 950 kw
3. Induction Coil For Billet Dia : 229 mm
4. Length Of Heater : 3.2 Meter
5. Billet Temperature : 450-530ºc
6. Fully Plc Controlled : Siemens

PUMP DETAILS:

There are total six pumps (axial piston pump, positive displacement type) for press operation out of which:

3 main pumps - 2 pilot pressure pumps and 1 container sealing pump.

a) Main Pump:

1. Make : Oilgear
2. Model : PVR- 270 (i.e. discharge of 270cm^3/rev)
3. Flow : 380 LPM
4. Pressure : 300 bar

b) Pilot Pump:

1. Flow : 65 LPM
2. Pressure : 60 bar

c) DM Water Pump (For Billet Heater):

1. No of Pumps : Two (one always stand-by)
2. Total Head (H) : 79 meter
3. Discharge (Q) : 32.70 m^3/ hr
4. Speed (N) : 2900 rpm

5. Pump Input : 15.13 kw
6. Recommended Prime Mover rating: 18.50 kw

d) Quenching Water Pump:

1. No Of Pumps : Two (One Always Stand-By)
2. Total Head : 19 meter
3. Discharge : 45 lit/ sec (2700 lpm)
4. Pump Efficiency : 69%
5. Speed : 1450 rpm
6. Power : 15 kw

e) Oil Cooler Pump:

1. Head : 37 meter
2. Discharge : 65 m^3/ hr
3. Pump Input : 8.340 kw
4. Speed : 2900 rpm
5. Prime Mover rating : 11 kw

TERMINOLOGIES IN OPERATION:

1) Specific Pressure: This is the pressure inside the container. It is defined as unit pressure i.e. force per unit container area. As the container bore increases, the specific pressure inside the container decreases, and as a result, extrusion capability decreases.

2) Up-Setting: Whenever a hot billet going to extrude, first it takes the shape same as that of container by the ram pressure.

3) Break-Through: after upsetting of billet, ram continues to pressurize the billet. Break-through pressure is that pressure at which shear deformation or intermetallic deformation of billet metal starts.

4) Dead Cycle Time: It is defined as non-productive time, in which extrusion of metal does not take place.

5) Burp Cycle: The burp cycle is used with bridge, porthole and sometimes-flat dies. It does not affect the basic cycle except to interrupt it for a short period. The purpose of burp cycle is to release trapped air at the die face. Otherwise, extrusion defects like blisters etc may take place.

6) Dry cycle: The press cycle without the billet is known as dry cycle. This is done for testing of press.

7) End Slow Stroke: At the end of extrusion, we slow down the speed of ram and hence extrusion. The main reason is that, during extrusion, when billet length becomes shorter, the pressure increases on die. So, there may be chances of breaking of die or cracking of extruded product. This phenomenon generally happens with harder alloy. So, we decide and feed the length of billet in PLC, from which we need to slow down the extrusion speed.

PRESS OPERATION:

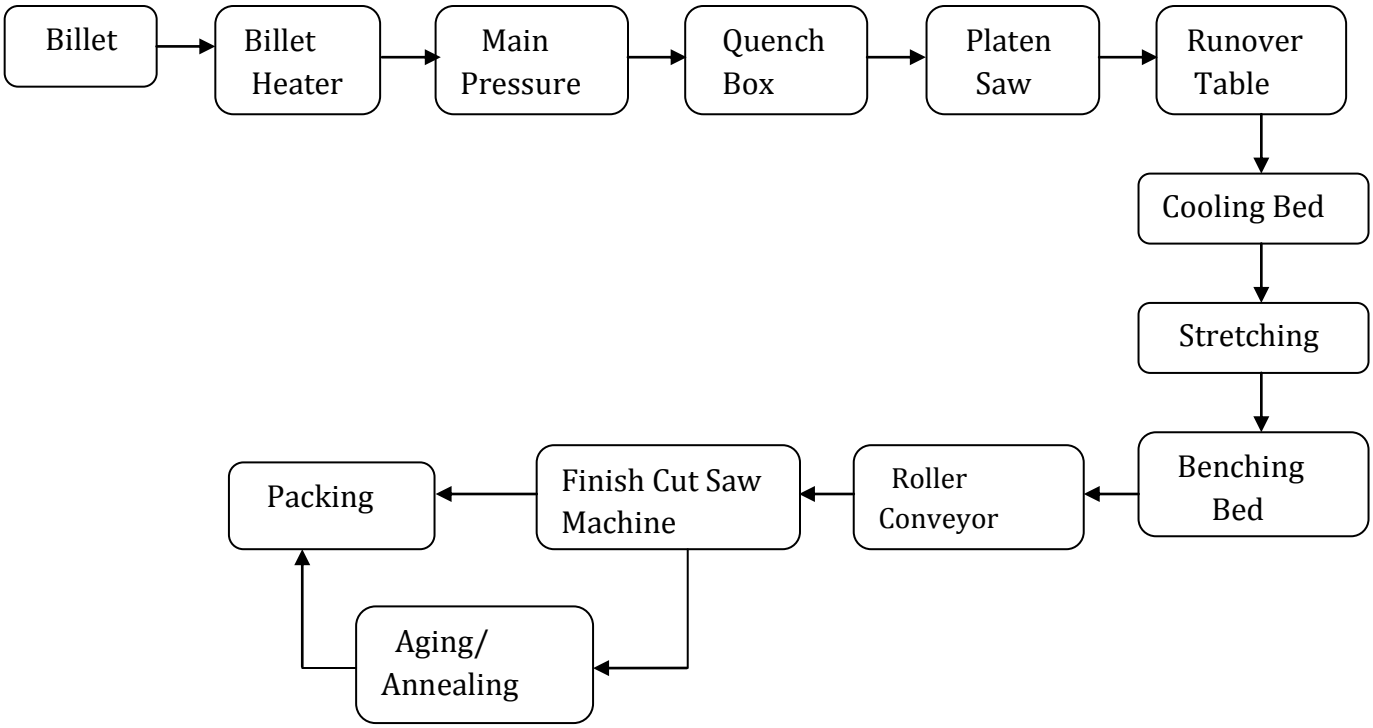
1. First of all, billet is loaded on billet heater with the help of billet elevator. Billet pusher, pushes the billet hydraulically into the billet heater.
2. After the predetermined temp of billet is reached, it is automatically rejected from billet heater and goes to billet loader unit.
3. Billet loader takes the billet up to the acetylene-cracking unit. After the acetylene cracking, loader waits for commencement of next press cycle.
4. As the next press cycle starts, billet loader moves in between container and die tool stack. As the billet center coincides with container and die center, main ram moves forward and pinch the billet at 20 bars.
5. After the pinching, upper jaw of billet loader opens and then lower jaw. Now loader moves back.
6. After the loader out, it operates the limit switch to close the container at 280 bars. The extrusion will not start if
    a) The distance between container and die face exceeds 6 mm.
    b) The sealing pressure is less than 1500 psi.
7. Now main ram moves forward for extrusion. When upsetting pressure is reached, the container will then open, pushing the ram back and releasing trapped air at the die face.
8. After the end of extrusion, container with the stem decompressed.
9. As the container continues its opening stroke, it gives the signal for shear down. The shear completes its down stoke at preset speed and after shearing of butt, it returns to its initial up position.
10. At the end of cycle, billet loader is ready with billet for commencement of next cycle.
11. After emerging from platen hole, the extruded profile goes to quenching box. According to requirement we run the profile in air or water. The thumb rule that, if profile thickness is below 2mm, then quenching will be in air. Another thumb rule is that, if profile kg/met is below 2.5, then quenching will be in air.

12. The platen saw is adjusted to cut the profile on hot saw. Platen saw is so adjusted, as we can get sufficient margin as well as recovery.
13. The runout length is calculated based on the weight of the billet, the butt, and the weight per unit length of actual extrusion:

    Runout = (Billet wt – butt wt)/ wt per unit length of extrusion

14. After runout table the material is transferred to cooling bed. There are under bed cooling fans, for cooling the material.
15. Then material is transferred to stretcher, to remove the waviness and giving the hardness to the profile. The profile length is increased 1% to 3% in stretching.
16. After stretching the material is transferred to batch bed and then to finish cut saw rollers. On the finish cut saw gauge stopper, for finial cut, adjusts the required profile length.

PROCESS FLOW DIAGRAM



Billet Temperature Range:

Al Alloy Group	Billet Temp Range (°C)	Detail
1XXX	400-450	99% pure Al
2XXX	450-470	Cu
3XXX	440-470	Mn
4XXX	440-470	Si
5XXX	460-500	Mg
6XXX	440-500	Mn & Mg
7XXX	460-490	--

APPLICATION OF MAJOR ALLOYS:

1XXX - Electrical Conductors, Cables etc.

2XXX - High Stressed Components, Aircrafts etc.

4XXX - Welding Wire.

5XXX - Structure Exposed to marine atmosphere, Wire ropes etc.

6XXX - Structural and general Engg. Items, Electrical Bus Car etc.

7XXX - Very High strength structure used in defence.

Aging:

To get the required mechanical properties of the material, aging is done. It is the process of heating and soaking the material to the required length of time. Whenever a customer needs the material designated with T6 and T6-2, which means they require the material with good hardness and hardness with bending property respectively, so the material must undergone through aging.

The following designation is adopted for some material in our plant:

R1- aging at 217ºC for 11 hours, coundutivity-56.5%

R2- aging at 211ºC for 10 hours, coundutivity-55%

EXTRUSION PROCESS SCRAP :

Butt Scrap : 3% to 5%
End Scrap : 10% to 15%

MAJOR EXTRUSION DEFECTS :

- Off Dimension
- Scratches, Dent etc.
- Blister
- Die Lining
- Bend and Kink
- Orange Peel
- Co-ring or Piping
- Chatter
- Failure of the Mechanical properties

DESIGN OF HYDRAULIC CYLINDERS

Hydraulic Cylinder:

A Hydraulic cylinder (also called a linear hydraulic motor) is a mechanical actuator that is used to give a unidirectional force through a unidirectional stroke.

Hydraulic cylinders get their power from pressurized hydraulic fluid, which is typically oil. The hydraulic cylinder consists of a cylinder barrel, in which a piston connected to a piston rod moves back and forth. The barrel is closed on each end by the cylinder bottom (also called the cap end) and by the cylinder head where the piston rod comes out of the cylinder. The piston has sliding rings and seals. The piston divides the inside of the cylinder in two chambers, the bottom chamber (cap end) and the piston rod side chamber (rod end). The hydraulic pressure acts on the piston to do linear work and motion.

Flanges, trunnions, and/or clevisses are mounted to the cylinder body. The piston rod also has mounting attachments to connect the cylinder to the object or machine component that it is pushing.

A hydraulic cylinder is the actuator or "motor" side of this system. The "generator" side of the hydraulic system is the hydraulic pump which brings in a fixed or regulated flow of oil to the bottom side of the hydraulic cylinder, to move the piston rod upwards. The piston pushes the oil in the other chamber back to the reservoir. If we assume that the oil pressure in the piston rod chamber is approximately zero, the force F on the piston rod equals the pressure P in the cylinder times the piston area A:

Fig 7: Schematic View of a Hydraulic Cylinder

➢ Types of cylinders

- Standard Double-Acting Cylinder
- Single-Acting Cylinder
- Double Rod Cylinder
- Spring Return, Single-Acting Cylinder
- Ram Type, Single-Acting Cylinder
- Telescoping Cylinder
- Tandem Cylinder

➢ Parts of a hydraulic cylinder

A hydraulic cylinder consists of the following parts-

Cylinder barrel:

The cylinder barrel is mostly a seamless thick walled forged pipe that must be machined internally. The cylinder barrel is ground and/or honed internally.

Cylinder Barrel Material - *ASTM A106 GR.B / ST52*

Table (a) : Grade and Chemical Composition (%) :

Grade	C≤	Mn	P≤	S≤	Si≥	Cr≤	Cu≤	Mo≤	Ni≤	V≤
A	0.25	0.27-0.93	0.035	0.035	0.10	0.40	0.40	0.15	0.40	0.08
B	0.30	0.29-1.06	0.035	0.035	0.10	0.40	0.40	0.15	0.40	0.08
C	0.35	0.29-1.06	0.035	0.035	0.10	0.40	0.40	0.15	0.40	0.08

Table (b) : Mechanical Properties :

Grade	Mpa Tensile Strength(Rm)	Yield Point(Mpa)	Elongation(%)	Delivery Condition
A	≥330	≥205	20	Annealed
B	≥415	≥240	20	Annealed
C	≥485	≥275	20	Annealed

Table (c) : Dimension Tolerances :

Pipe Type	Pipe Sizes		Tolerances
Cold Drawn	OD	≤48.3mm	±0.40mm
		≥60.3mm	±1%mm
	WT		±12.5%

Table- (a,b,c): Grade , Chemical Composition , Mechanical Properties and Dimensional Tolerances of a Cylinder Barrel

Cylinder base or cap:

In most hydraulic cylinders, the barrel and the bottom portion are welded together. This can damage the inside of the barrel if done poorly. Therefore, some cylinder designs have a screwed or flanged connection from the cylinder end cap to the barrel. (See "Tie rod cylinder", below) In this type the barrel can be disassembled and repaired.

Cylinder head:

The cylinder head is sometimes connected to the barrel with a sort of a simple lock (for simple cylinders). In general, however, the connection is screwed or flanged. Flange connections are the best, but also the most expensive. A flange has to be welded to the pipe before machining. The advantage is that the connection is bolted and always simple to remove. For larger cylinder sizes, the disconnection of a screw with a diameter of 300 to 600 mm is a huge problem as well as the alignment during mounting.

Piston:

The piston is a short, cylindrical metal component that separates the two parts of the cylinder barrel internally. The piston is usually machined with grooves to fit elastomeric or metal seals. These seals are often O-ring, U-cups or cast iron rings. They prevent the pressurized hydraulic oil from passing by the piston to the chamber on the opposite side. This difference in pressure between the two sides of the piston causes the cylinder to extend and retract. Piston seals vary in design and material according to the pressure and temperature requirements that the cylinder will see in service. Generally speaking, elastomeric seals made from nitrile rubber or other materials are best in lower temperature environments, while seals made of Viton are better for higher temperatures. The best seals for high temperature are cast iron piston rings.

Piston rod:

The piston rod is typically a hard chrome-plated piece of cold-rolled steel which attaches to the piston and extends from the cylinder through the rod-end head. In double rod-end cylinders, the actuator has a rod extending from both sides of the piston and out both ends of the barrel. The piston rod connects the hydraulic actuator to the machine component doing the work. This connection can be in the form of a machine thread or a mounting attachment, such as a rod-clevis or rod-eye. These mounting attachments can be threaded or welded to the piston rod or, in some cases, they are a machined part of the rod-end.

Rod gland:

The cylinder head is fitted with seals to prevent the pressurized oil from leaking past the interface between the rod and the head. This area is called the rod gland. It often has another seal called a rod wiper which prevents contaminants from entering the cylinder when the extended rod retracts back into the cylinder. The rod gland also has a rod wear ring. This wear ring acts as a liner bearing to support the weight of the piston rod and guides it as it passes back and forth through the rod gland. In some cases, especially in small hydraulic cylinders, the rod gland and the rod wear ring are made from a single integral machined part.

Other parts:

- Cylinder base connection
- Seals
- Cushions

Hydraulic cylinder designs:

There are primarily two styles of hydraulic cylinder construction used in industry:

- Tie rod style cylinders and
- Welded body style cylinders

Tie rod cylinder:

Tie rod style hydraulic cylinders use high strength threaded steel rods to hold the two end caps to the cylinder barrel. This method of construction is most often seen in industrial factory applications. Small bore cylinders usually have 4 tie rods, while large bore cylinders may require as many as 16 or 20 tie rods in order to retain the end caps under the tremendous forces produced. Tie rod style cylinders can be completely disassembled for service and repair.

The National Fluid Power Association (NFPA) has standardized the dimensions of hydraulic tie rod cylinders. This enables cylinders from different manufacturers to interchange within the same mountings.

Welded body cylinder:

Welded body cylinders have no tie rods. The barrel is welded directly to the end caps. The ports are welded to the barrel. The front rod gland is usually threaded into or bolted to the cylinder barrel. This allows the piston rod assembly and the rod seals to be removed for service.

Welded body cylinders have a number of advantages over tie rod style cylinders. Welded cylinders have a narrower body and often a shorter overall length enabling them to fit better into the tight confines of machinery. Welded cylinders do not suffer from failure due to tie rod stretch at high pressures and long strokes. The welded design also lends itself to customization. Special features are easily added to the cylinder body. The smooth outer body of welded cylinders also enables the design of multi-stage telescopic cylinders.

Welded body hydraulic cylinders dominate the mobile hydraulic equipment market such as construction equipment (excavators, bulldozers, and road graders) and material handling equipment (forklift trucks, telehandlers, and lift-gates). They are also used in heavy industry such as cranes, oil rigs, and large off-road vehicles in above-ground mining.

Piston rod construction:

The piston rod of an hydraulic cylinder operates both inside and outside the barrel, and consequently both in and out of the hydraulic fluid and surrounding atmosphere.

Coatings:

Wear and corrosion resistant surface are desirable on the outer diameter of the piston rod. The surfaces are often applied using coating techniques such as Chrome Plating, Laser Cladding, PTA welding and Thermal Spraying. These coatings can be finished to the desirable surface roughness (Ra, Rz) where the seals show optimum performance. All these coating methods have their specific advantages and disadvantages. It is for this reason that coating experts play a crucial role in selecting the optimum surface treatment procedure for protecting Hydraulic Cylinders.

Cylinders are used in different operational conditions and that makes it a challenge finding the right coating solution. In dredging there might be impact from stones or other parts, in salt water environment there is extreme corrosion attack, in off-shore cylinderes facing bending and impact in combination with salt water, steel industry there are high temperatures involved, etc... It is important to understand that currently there is no single coating solution which successfully combats all the specific operational wear conditions. Every single technique has its own benefits and disadvantages.

Length:

Piston rods are generally available in lengths which are cut to suit the application. As the common rods have a soft or mild steel core, their ends can be welded or machined for a screwe thread.

STANDARD GROOVES OF A PISTON

Series-No	Bore Diameter DN H9			Groove Diameter	Groove Width	radius	Radial clearance S max.*			O-ring Cross-section
	Standard application	Light application	Heavy duty application	D1 H9	L1+0.2	r1	10Mpa	20Mpa	40Mpa	d2
PT00	8-14.9	15-39.9	--	DN-4.9	2.2	0.4	0.40	0.30	0.20	1.78
PT01	15-39.9	40-79.9	--	DN-7.5	3.2	0.6	0.60	0.50	0.30	2.62
PT02	40-79.9	80-132.9	15-39.9	DN-11.0	4.2	1.0	0.70	0.50	0.30	3.53
PT03	80-132.9	133-329.9	40-73.9	DN-15.5	6.3	1.3	0.80	0.60	0.40	5.33
PT04	133-329.9	330-669.9	80-132.9	DN-21.0	8.1	1.8	0.80	0.60	0.40	7.00
PT08	330-669.9	670-999.9	133-329.9	DN-24.5	8.1	1.8	0.90	0.70	0.50	7.00
PT05	670-999.9	--	310-669.9	DN-28.0	9.5	2.5	1.00	0.80	0.60	8.40
PT05 X	--	1000-1200	--	DN-28.0	9.5	2.5	1.00	0.80	0.60	8.40
PT06	--	--	670-999.9	DN-38.0	13.8	3.0	1.20	0.90	0.70	12.00
PT06 X	1000-2700	--	--	DN-38.0	13.8	3.0	1.20	0.90	0.70	12.00

Table : Standards grooves of a piston

Seal Materials :

S.No.	Material Name	Colour	Melting Temp.
1	Polyurethane	Red	30°to110°C
2	Nitrile rubber	Black	30°to150°C
3	Fluoroelstomer	Brown	20°to200°C
4	EPDM rubber	Black	45°to150°C
5	Silicon rubber	Blue, White, Orange	60°to200°C
6	PTFE/Glass	White	200°to260°C
7	PTFE/Bronze	Gray	200°to260°C
8	PTFE/Nickel	Gray	200°to260°C

Table : Seal Marerials

DESIGN OF HYDRAULIC CYLINDER AND THEIR PARTS

GIVEN DATA

Pressure P = 200 bar
Dia of barrel ID φ = 50mm
Dia of piston rod = 36mm
FOS = 1.5

BARREL DESIGN

Cylinder material = ASTM A106 GR.B
(sut) tensile strength σ = 415 MPa = 415N/mm^2

Calculation:

- ✓ Thickness of cylinder wall , t = PD/2σ
  = 20*50/2*(415/1.5)
  =**1.8 mm**
- ✓ Outer dia of barrel φ = D+2t
  = 50+1.8*2 = **53.6 mm**

{ From Standard recommendation /using dia 40-79.9 mm }

PISTON & BARREL CLEARENCE :

Radial Clarence for 50 mm dia C = **0.60 mm**

PISTON DESIGN :

Material of Piston – Steel

Outer dia of piston = ID of barrel – Clearance

= 50 - 1.20

= **48.80 mm**

PISTON ROD DESIGN:

EN9---070M55 (Black carbon steel)

Chromium Plating on Piston Rod

A piston rod must have a high tensile strength, it must have a hard surface, it must be corrosion resistant and it must be smooth. It must resist wear from the side load forces that a hydraulic cylinder will see in service. It must provide a low friction surface as it moves back and forth in the hydraulic cylinder passing over seals, wipers and bearing surfaces.

Thickness of chromium plating = 50-80 micron

- ✓ **Force on both side of piston :**

  Tensile strength of EN19 = **500-800 N/mm^2**

  Dia of piston rod = **36 mm**

$F_1 = P * A_1$

$= (200 * 10^5 / 10^6) * \pi/4 * 50^2$

= **39.2699 kN**

$F_2 = P * A_2$

$= (200 * 10^5 / 10^6) * \pi/4 \{ 50^2 – 36^2 \}$

= **18.9123 kN**

So Piston Rod Dia = (36 - 0.000050)

=**35.99995 mm**

Surface finish(Ra):

Piston and barrel finishing of surface = **0.25-0.30 micron**

THREAD DESIGN:

Thread fail in shear and not in tension, therefore stripping strength of assembly depend on shear strength of nut & bolt material.

Force , $F=S_{us} * A_{ts}$

Where,

S_{us} = strength of nut

A_{ts} = cross sectional area through which shear occur

$A_{ts} = 0.5\pi * dp * le$

$dp = (D - 0.64952 * P)$

$le = (2*A_t) / (0.5\pi * \{D - 0.64952* P \})$

$At = \pi/4 [D - 0.938194 * P]^2$

where ,

dp= pitch circle dia

P = screw thread pitch

Le= engagement length

A_t = tensile strength area

D = dia of piston rod

SEAL/PACKING FOR PISTON

Series-No = **PT03**

Material of seal packing (piston, piston rod gland) = **NBR. {hardness 70 shore}**

Main sealing = **PTFE/Nickel**

Groove Diameter = **DN-15.5 mm**

Groove Width = **6.3 mm**

Radius = **1.3mm**

O-ring Cross-sec d_2 = **5.33 mm**

FLANGE CONECTION:

- Thread Type
- Direct Welding

Edge Preparation

- The edge grooves need to be made correctly and uniformly.
- The grooves for automatic welding are to be made as per the design.
- The supervisor must confirm the cleanliness of grooves, moisture, grease, rust and paint free, which otherwise would cause defects in welding.

Welding Neck flange:

These flanges are bored to match the inside diameter of the mating pipe or fitting so there will be no restriction of product flow. This prevents turbulence at the joint and reduces erosion. They also provide excellent stress distribution through the tapered hub and are easily radiographed for flaw detection.
This flange type will be welded to a pipe or fitting with a single full penetration, V weld (Buttweld).

Lap Joint flange:

They may be used at all pressures and are available in a full size range. These flanges slip over the pipe, and are not welded or otherwise fastened to it. Bolting pressure is transmitted to the gasket by the pressure of the flange against the back of the pipe lap (Stub End).

Threaded flange:

Threaded Flanges are used for special circumstances with their main advantage being that they can be attached to the pipe without welding. Sometimes a seal weld is also used in conjunction with the threaded connection.

OBSERVATION AND SUGGESTIONS

- All the billets are in container and they are made to fall down on the ground manually through a hook to take it to the billet elevator. Thus there are chances of accidents if a new or an inexperienced person will do this job.
  Suggestion: It should be automated.

- On the saw conveyor belt, there are 20-25 rollers to help the extruded long material in moving forward. But many times the length of the extruded material is less than half of the saw conveyor belt and still every rollers have to work which results in more consumption of electricity.
  Suggestion: The control of 5 rollers can be made to one switch and through this way only the required rollers can be switched ON.

- Initially the end of the extruded material has to be aligned manually through a hook to the puller. This may invite any accidents as the material is hot.
  Suggestion: An automated circuilar plate with a hole can be used which will move along with extruded material till the puller.

- Near some press more number of billet containers are kept than needed which not only occupies floor area but also inhibits movement of employer.
  Suggestion: The billets should be brought to the press as per consumption rate.

CONCLUSION

The production process in the fabrication department of Hindalco Industries Limited, though cannot be changed much as it is done through machines. But the other things such as input material (billet), machine handling, cost cutting, efficiency, work load etc can be improvised.

Inventory management can be done through JIT mathod instead of keeping extra billets container near pess on the shop floor. It follows 5S method to improve efficiency and quality of the product. Cutting down costs include recycling of waste, use of waste material if possible, avoiding damages to machine parts. Workload is lowered by transferring men from one press to another if they are free. This helps to build up good work invironment and improves overall efficiency.

But the only thing to be done is need of more automation in billet handling and finished material comes out of saw cuting machine. This will avoid manual labour and accidents.

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