FIBRE REINFORCED PLASTICS (FRP)

CORPORATE TRAINING AND PLANNING

9.1 INTRODUCTION

➲ Reinforced plastics-Generally similar to laminates in a number of applications.

➲ FRP- Polymeric resin and reinforcement usually in fibre form along with other additives such as filler, catalyst, initiator, lubricants etc.

➲ Both thermoplastics and thermosets are used in FRP but thermosets are most widely used.

9.1.1 COMPOSITE

- Reinforced materials are simply referred to as composite or filled plastics.

- The term composite is generally applied to fibre reinforced engineering structural materials, in which the fibre are continuous or long enough that they can be oriented to produce enhanced strength properties in one direction.

For E.g. Polyester resin reinforced by continuous glass fibre.

Fig.1 Composite car.

➲ A reinforced plastic consists of two main components: a matrix, which may be either thermosetting or thermoplastics and reinforcing filler, which usually takes the form of fibres.

➲ Other materials such as fillers, pigments, catalyst may also be present.

➲ In general the matrix has a low strength in comparison to the reinforcement, which is also much stiffer, but brittle.

Fig. 2(a) Windsurf **(b)** Water jet gun

Fig.3(a) Storage box cooker **(b)** Spot light solar

Fig.4(a) Series of ceramic fibre products **(b)** Nose cone

Fig.5(a) Flexible smoke carriers **b.**Educational lab equipments

9.1.2 WHY USE FRP?

Reinforced plastics comprise a large portion of the industry, because

1. High strength/weight ratio.
2. Rigidity
3. Virtually unlimited moulding size.
4. Ease of fabrication.
5. Wide range of manufacturing techniques.
6. Low capital out lay.
7. Design versatility.
8. Excellent water resistance.
9. Chemical resistance.
10. Weathering resistance.

9.2.2 REINFORCEMENT

- The reinforcement type and form depend on performance requirements and the method of processing.

They are used

- to improve the mechanical properties of the cured resin and to provide usable products.

Surface tissue:

- consists of a thin randomly distributed fibrous mat. They are available in different thickness ranging from 0.08 to 0.34 mm manufactured from C- glass or synthetic fibre such as PAN or PET.

Advantages of surfacing tissue are

- They provide a resin rich finish with improved chemical and weathering resistance.
- Ensure adequate bond between the resin- rich surface layer and the bulk laminate.
- Help to mask the pattern of the underlying glass reinforcement.
- Provide a degree of elasticity to the surface layer to improve impact and abrasion resistance.

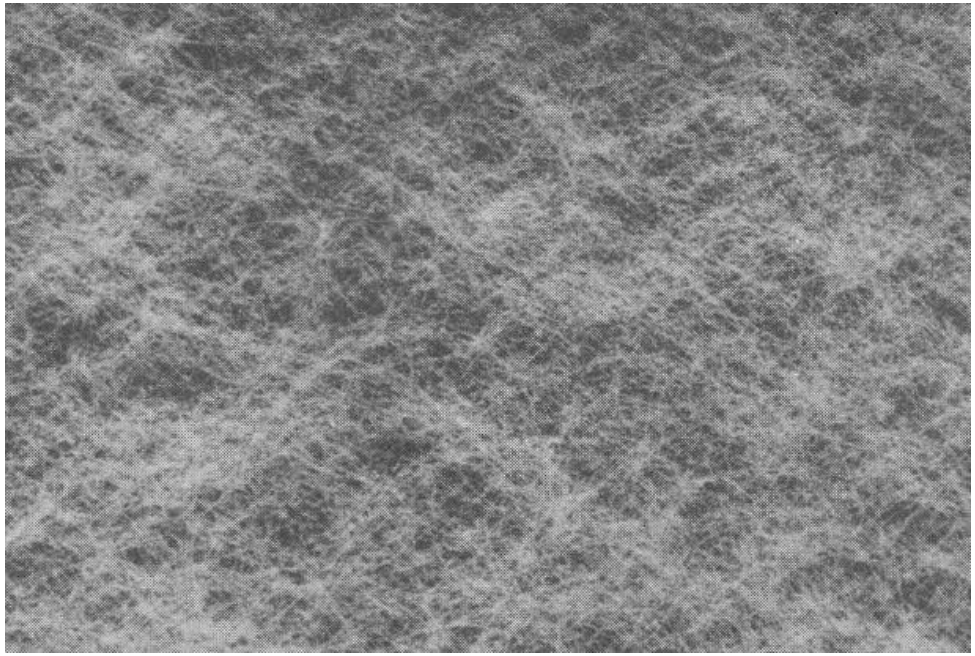


Fig.7 Surfacing tissue.

➲ Industrially the most important fibre used with polyester and epoxy resins is glass fibre, which is relatively inexpensive.

- High strength and rigid carbon fibres reinforced resin system, coupled with their low density is ideal for applications where strength to weight ratio is primary importance.

- Typical application include aerospace and reciprocating machine parts.

- Aramide fibres provide upto 30% weight saving over glass and upto 50% over aluminum alloys.

- Asbestos fibre provide composite with greater stiffness than glass reinforcement alone.

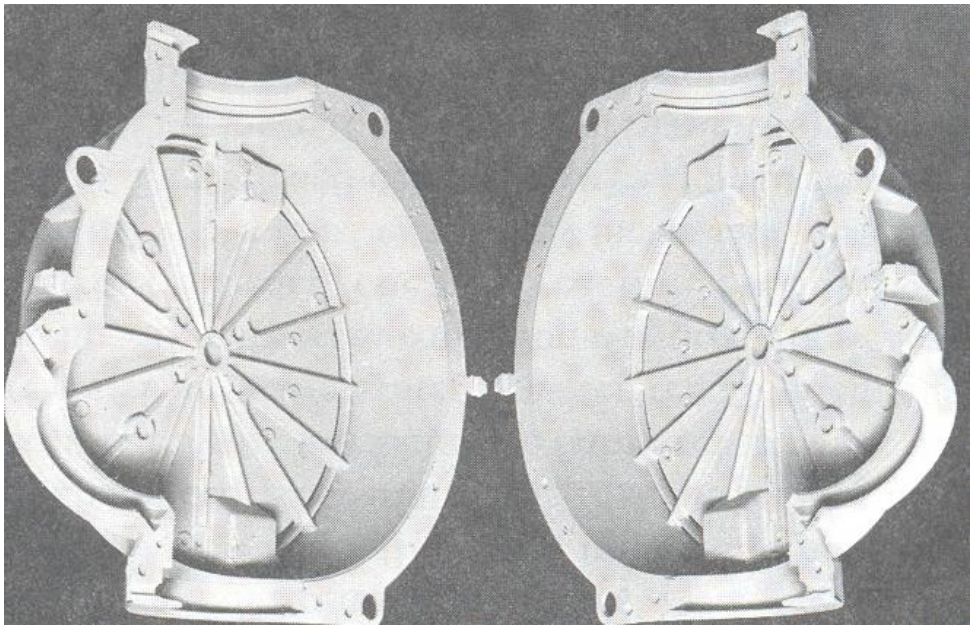


Fig.8 Prime pneumatic air conveyor valve containing 15% glass reinforcement

➲ Different types of glass are ‘A’ or alkali glass which is the basic material for glass fibre production,

E or electrical grade glass,

C or chemical resistance glass and

High strength glasses such as R & S glass used mostly for aerospace application.

- Aramide fibre have excellent strength and stiffness/weight ratio, excellent impact resistance, good fatigue resistance, high resistance to solvents, fuels, lubricants, acid and alkali, good vibration damping properties, superior dielectric property.

- They are normally used as reinforcement in epoxy resin matrices.

RESIN

- Unmodified epoxy resin - mild to moderate skin irritants
- Fully cured Epoxy - practically non toxic, non – irritant and non – sensitizing to the skin.
- Dust from machining of epoxy resin and composites -health hazards
- follow dust extraction procedure
- Follow normal handling precaution -Furan resins and pronged skin contact may cause irritation.
- Wear Gloves and safety goggles
- Use well-ventilated areas.
- Polyester resin - moderate to severe skin irritants.
- Eye contact - acute eye irritation - goggle should be worn.

Curing Agents And Catalyst

- Wear Protective clothing
- Well ventilated areas.

- Aliphatic amines such as diethylene triamine is volatile and strong irritants and potent sensitizers.

- Avoid all contact

- advice of doctor should be sought immediately on skin damage .

- Aromatic amines - less irritating and less sensitizing than aliphatic amines.

- Cycloaliphatic amines - extremely irritating to the eyes.

- Anhydride curing agents - irritating to the skin, eyes, mucous membranes and respiratory track and may cause burn

- Peroxide catalyst - should always be handled with caution.

- Handled in well-ventilated area and inhalation of fumes avoided.

- If peroxide is swallowed, large quantity of water must be drunk and vomiting induced immediate medical attention must be obtained.

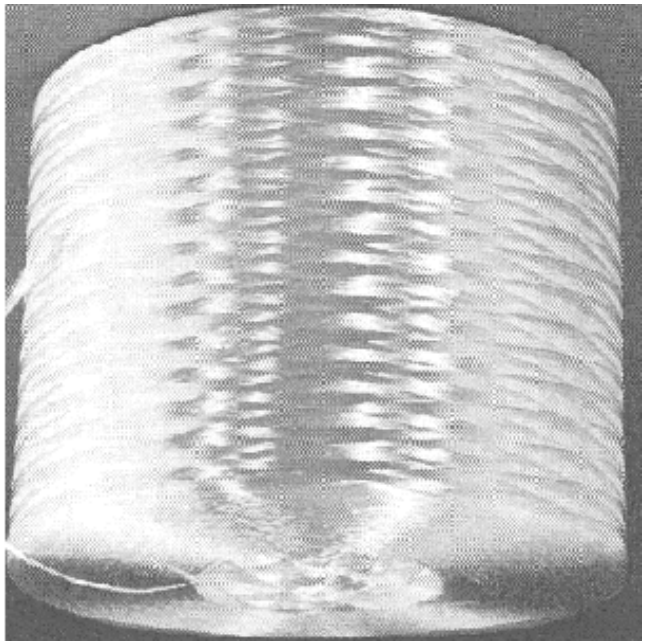
PIGMENT

➲ Some of pigment and fillers- give to health problems when inhaled

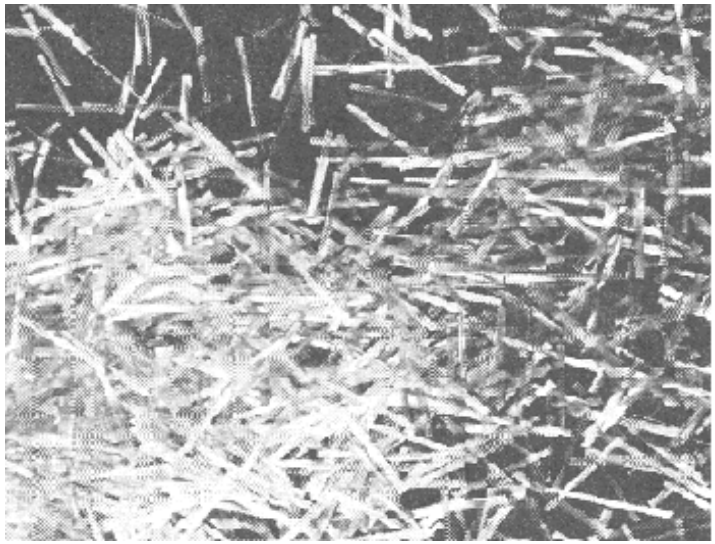
➲ Appropriate precautions may need to be taken with their handling and use, particularly with silica containing materials.

➲ Silica and blue asbestos are very dangerous when they are heated.

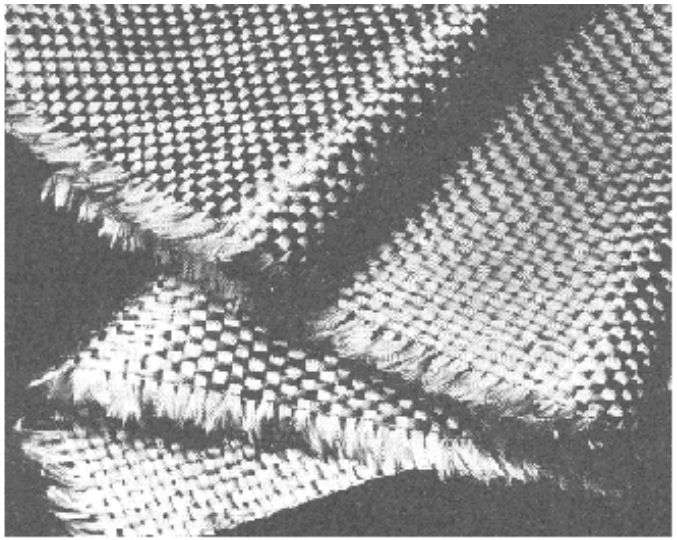
Fig.9(a) Chopped strand mat**.**



(b) Continuous strand roving.



(c) Chopped fiberglass strand.



(d) Woven roving fabric.

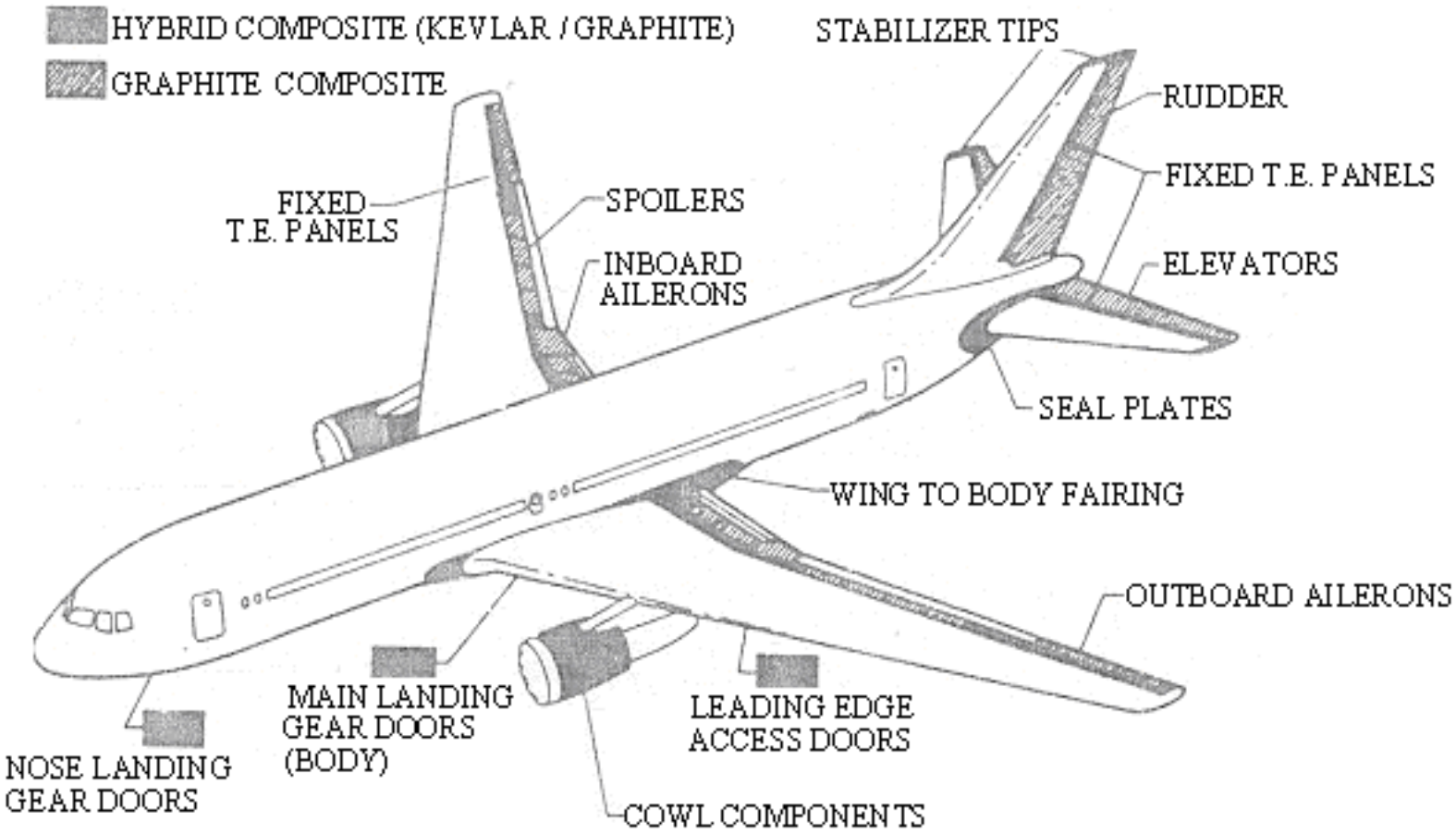


Fig. 14 Use of composites in air frame application

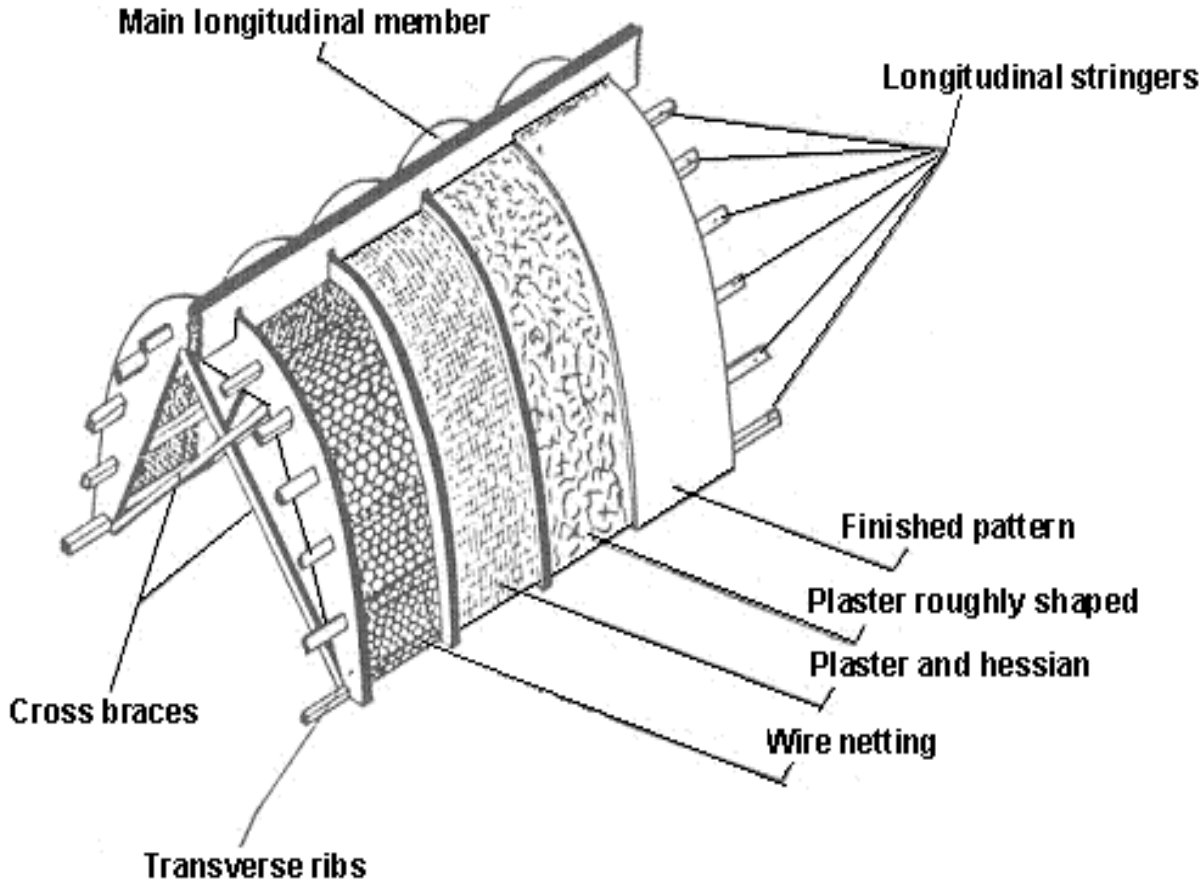


Fig.15 Construction of a Plaster Pattern.

➲ Most common FRP process

- ✓ Contact moulding process
  1. Hand lay-up/open moulding process
  2. Spray up/open moulding process
  3. Vacuum bag
  4. Pressure bag
  5. Autoclave

- ✓ Matched moulding process
  1. Cold press
  2. Compression moulding or hot press.
  3. Transfer moulding
  4. Resin transfer moulding
  5. Injection moulding

- ✓ Continuous process
  1. Continuous laminating
  2. Pultrusion

- ✓ Other processes
  1. Filament Winding
  2. Centrifugal Casting
  3. Sandwich construction

9.5.1 CONTACT MOULDING

➲ Most common method for making both small and large reinforced polyester products such as boat hulls, vehicle bodies, building panels, cladding, ducts and tanks.

1. Hand Lay –up Process

➲ Although labour intensive and difficult to control the hand laminating process is still widely used because of its inherent flexibility and the low capital outlay in moulds and equipments.

The various stages of this technique is shown in figure No.16

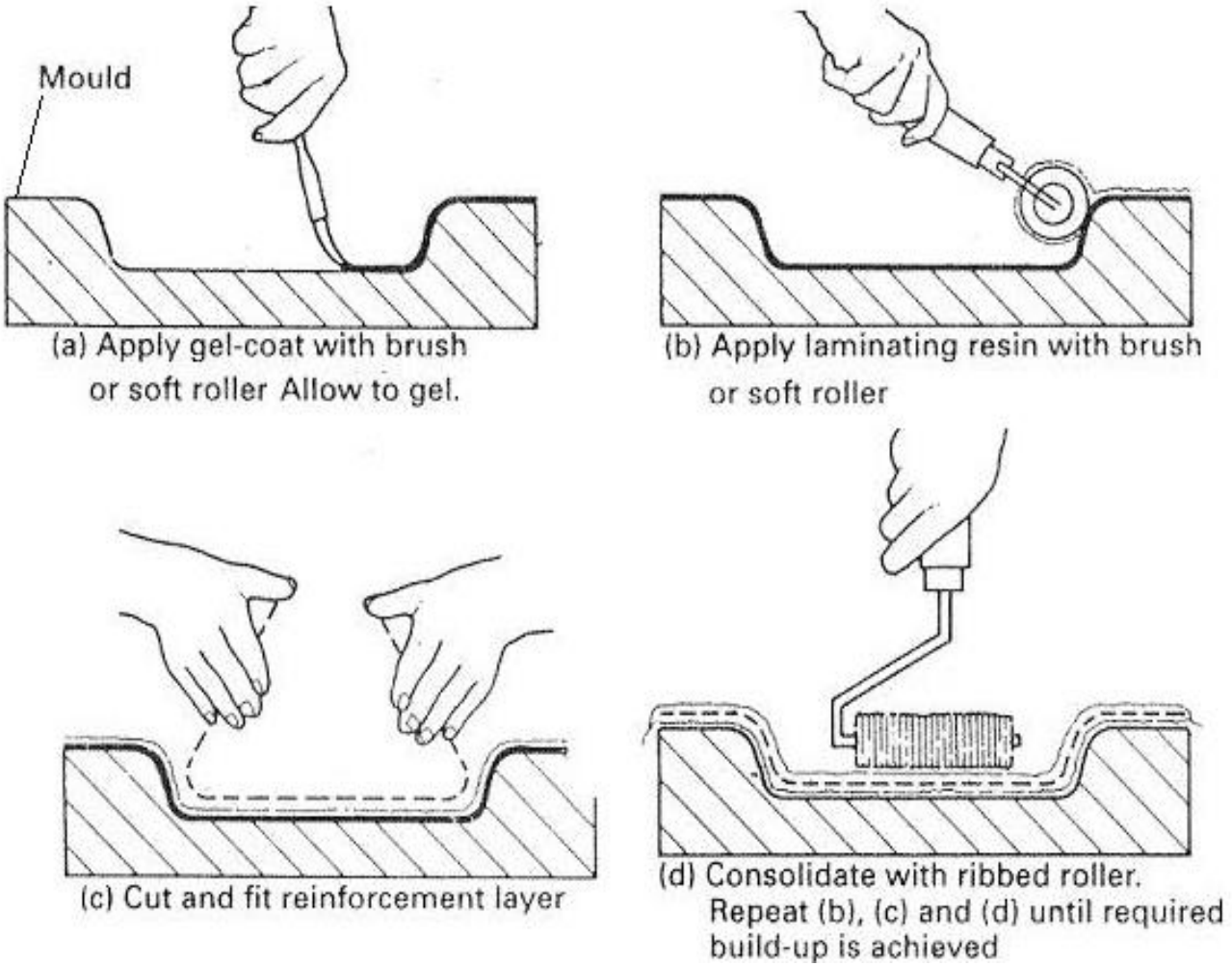


Fig.16 Various stages of Hand Lay Up Process

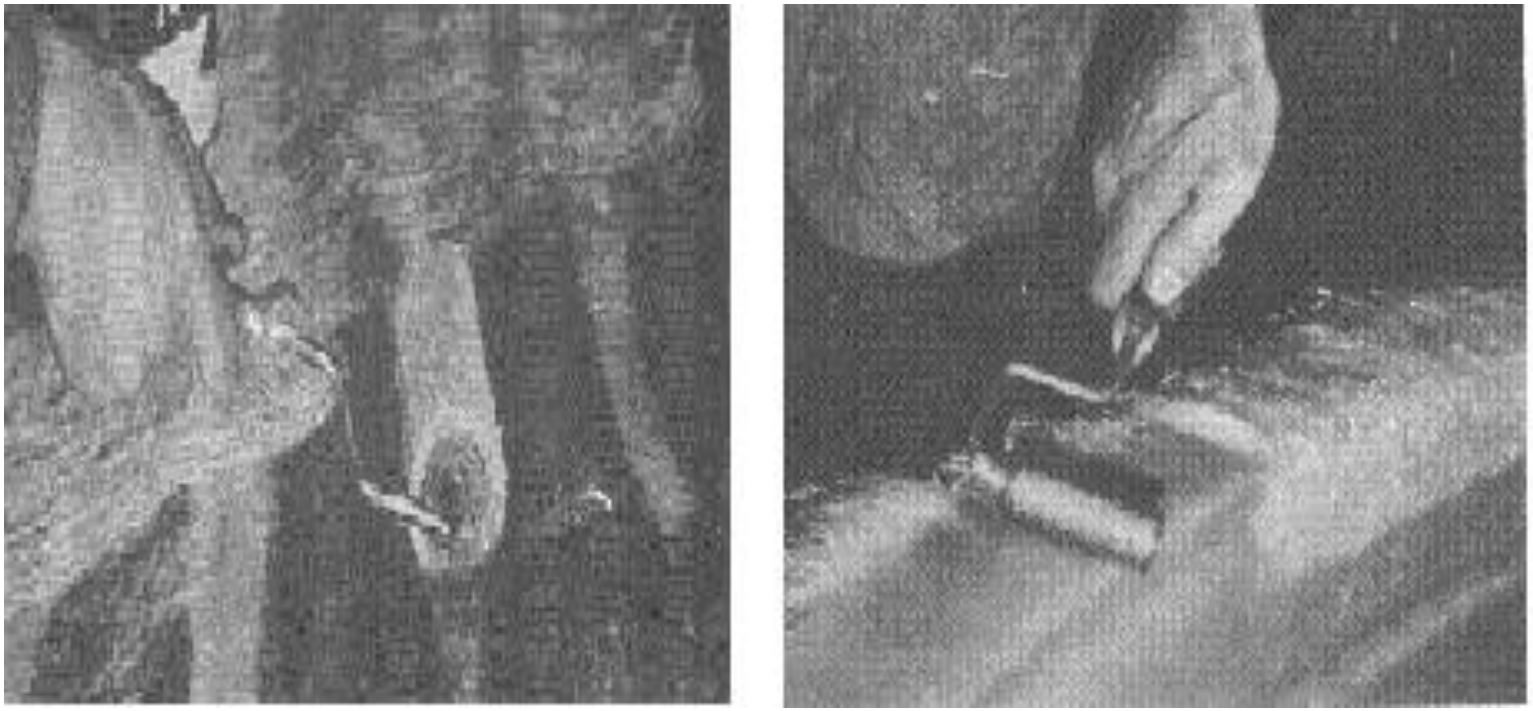


Fig.17 Hand lay up laminating using chopped strand mat

➲ The mould surface must be coated with a good quality silicone free wax and thoroughly polished to give a smooth glassy finish. A mould release agent such as PVA is then generally applied using spray or sponge.

➲ When the release agent is completely dry, the gelcoat is applied by brush or spray.

➲ When the gelcoat has been given time to partially cure, the main reinforcement is partially applied.

➲ The advantage of this technique is that the strength and stiffness of the composite can be controlled by building up the thickness with additional layers of mat and resin as desired.

➲ Alternative layers of resin and reinforcement applied to the mould and a rubber metal roller (See Fig. 18) used to consolidate the laminate (See Fig.17).

Spray –up Process

➥ Both resin and fibre are sprayed into the mould simultaneously. (See fig.19 and 20)

✓ Air-driver chopper unit is mounted on a resin spray gun.

✓ Chapped fibre reinforcement and resins are dispensed and positioned simultaneously in the mould.

✓ Consolidation

By hand rolling as in hand laminating,

But is easier as the reinforcement contains no binder and the fibre content is more inform.

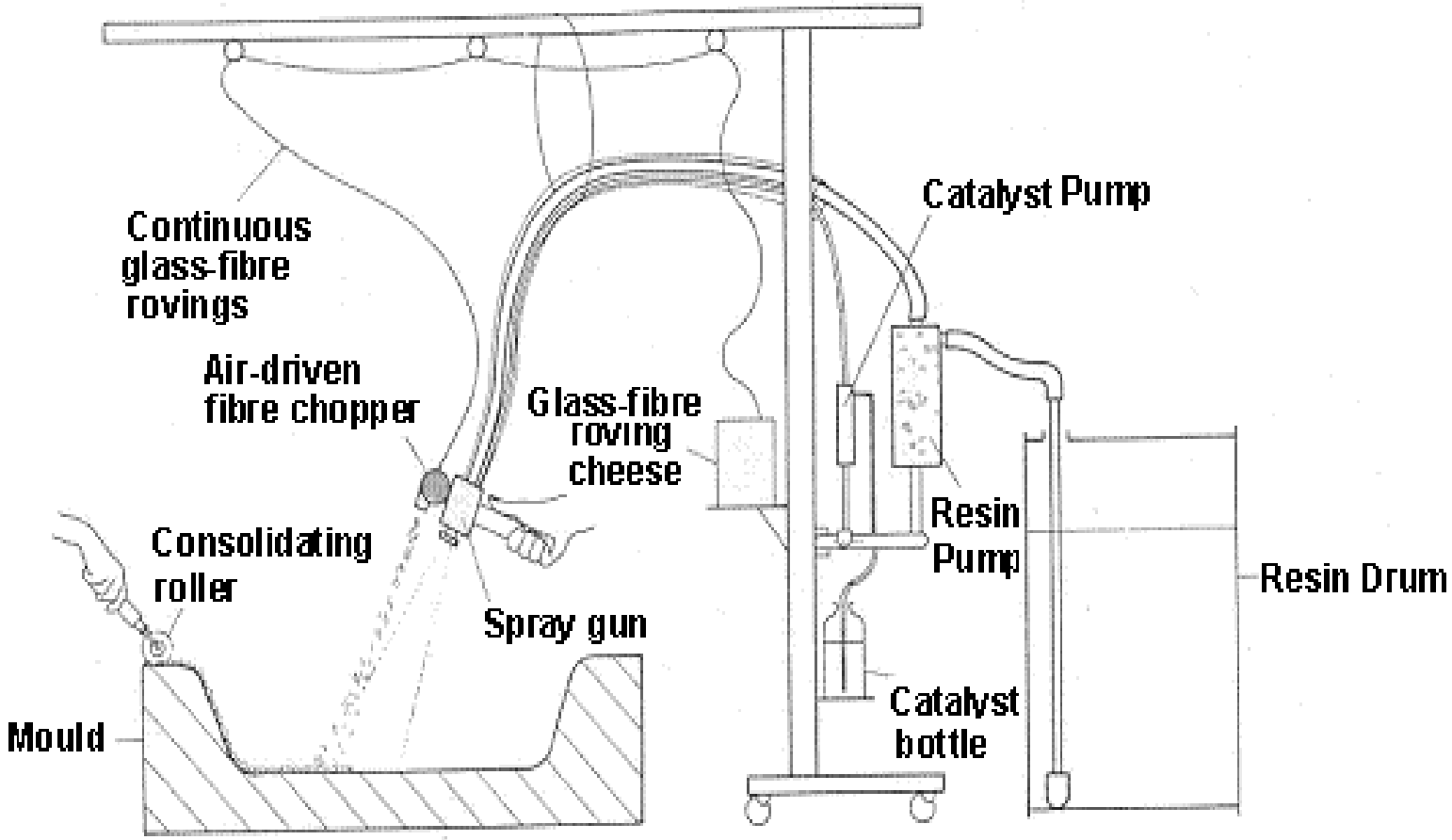


Fig. 19 Spray – up Process

- A stronger laminate can be produced if alternate layers are sprayed at 90° to each other.

- As in hand lay up the first layer of a gelcoat may be applied over the mould, followed by successive passes of the sprayed - on composite before a final gelcoat is applied.

- Spray-up - highly productive process but thickness is entirely in the hands of the operator.

- This makes the process unsuitable for critical applications.

- But it is popular for high volume, non – critical products.

9.5.2 VACUUM AND PRESSURE BAG MOULDING.

1. Vacuum bag

➲ Simplest form of the closed mold process

➲ Reinforcement and resin are applied by hand laminating to a simple open mould.

➲ A release film is then laid over the laminate followed by a rubber bag which is clamped to the edge of the mould.

➲ The space between the bag and the mould is evacuated so that atmospheric pressure is applied over the surface of the laminate .(See fig.21)

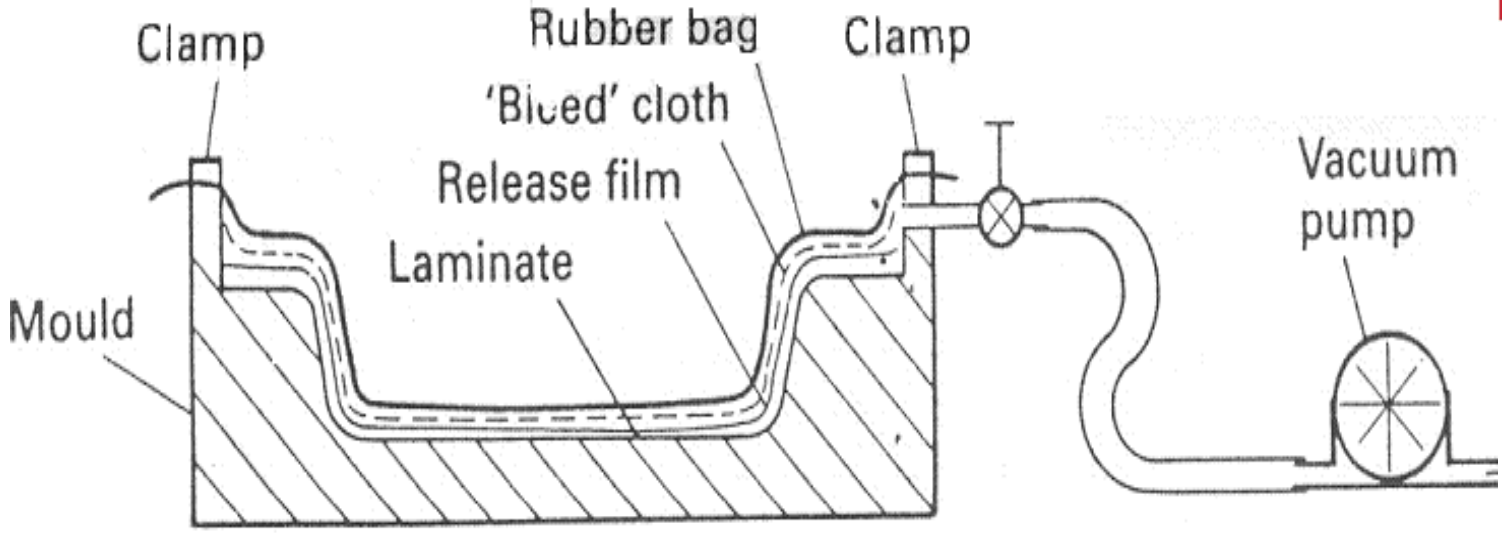


Fig. 21 Vacuum bag

- Prepreg system based on polyester sheet moulding compounds, epoxy resin impregnated cloths used.

- Automated tape laying machine accurately placing the glass or carbon fibre prepreg onto moulds.

- This machine provides fast and accuracy.
- One advantage that accurate fibre alignment can be achieved.

  This can be essential for aerospace application where strength to weight ratio is of prime importance.

- Vacuum bagging produces a fairer finish than hand laminating
- Very effective method for bonding sandwich laminate together and for making thin section.

9.5.3 Pressure Bag Moulding.

➲ Similar to vacuum bag but Use higher pressure (upto 3.5 bar) than atmospheric.

➲ An inflatable elastic pressure bag is positioned within the preform and the assembly is put into a closed mould. (See fig.22)

➲ Resin is injected into the preform, and the pressure bag is inflated to the required pressure, heat (by air or steam) is applied and the part is cured within the mould.

➲ When curing is complete, the bag is deflated and pulled through an opening at the end of the mould before the part is removed.

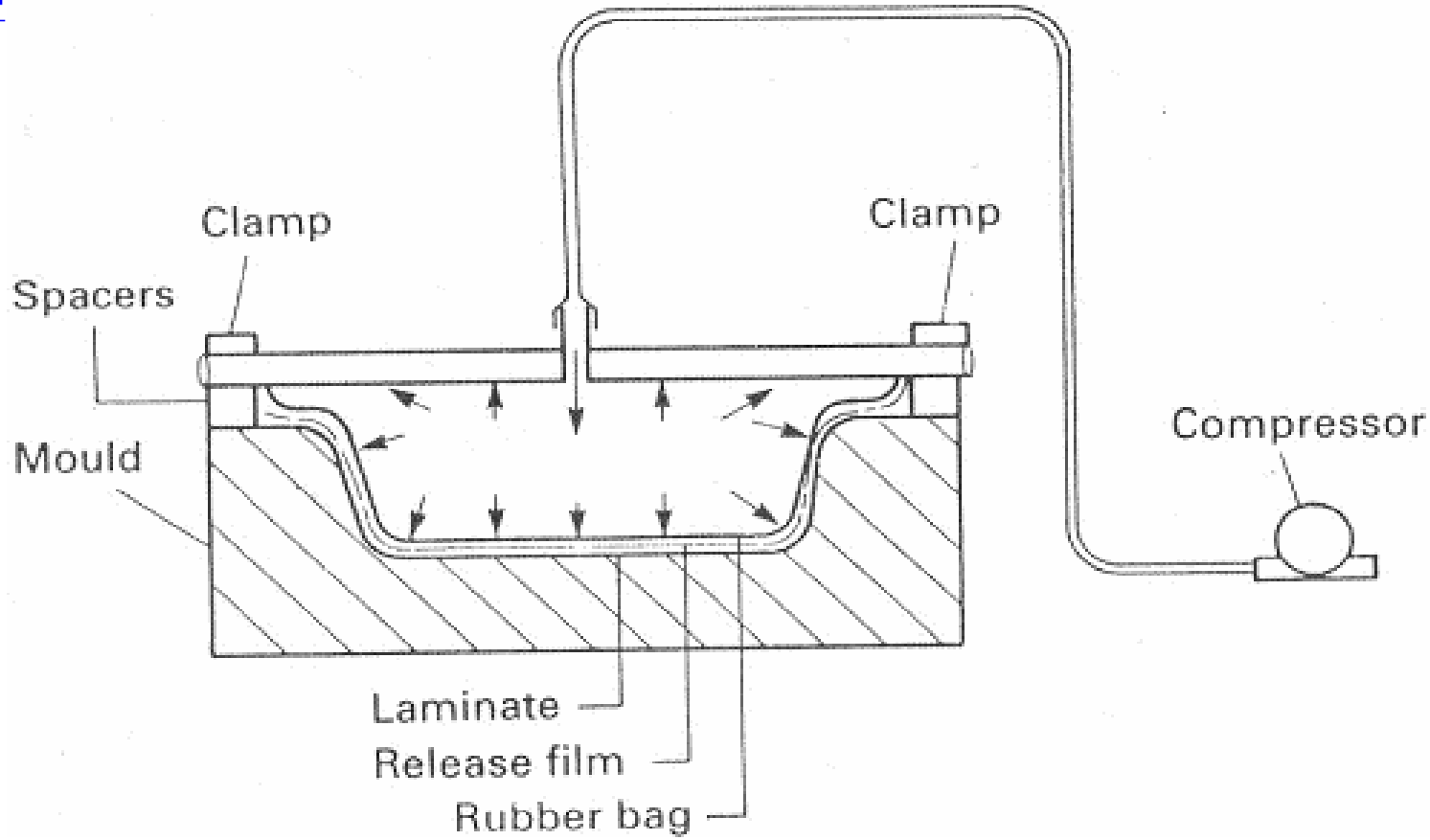


Fig.22 Pressure Bag

9.5.3 AUTOCLAVE

➲ Combination of vacuum and pressure bag moulding

➲ The process uses a vacuum bag assembly inside a heated and pressurized vessel.

➲ Layers of prepreg materials are laid on the mould to make up the full thickness.

➲ Bleed cloth, release film and vacuum bag are placed over the prepreg.

➲ Laminate subjected to vacuum pressure and heat simultaneously.

➲ This ensures that all air is extracted from the laminate and full consolidation and cure is achieved.

➲ Advantage-Moulds are not subjected to large force and can therefore be of reasonably light construction.

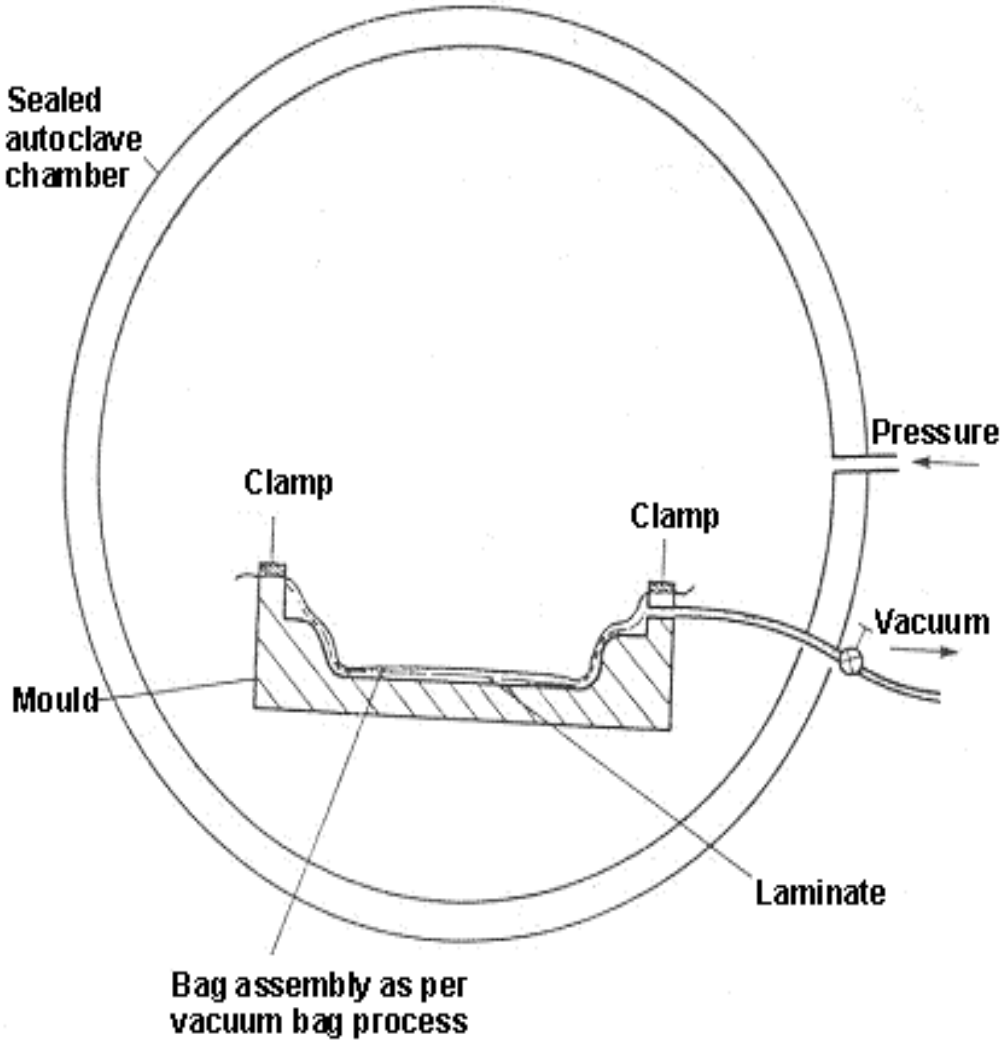


Fig. 23 Autoclave

9.5.5 COLD PRESS MOULDING

➲ Uses low-pressure room temperature curing resin, and inexpensive moulds.(20-50 Psi)

➲ Release agent and gelcoat are applied to the mould surface and a glass mat is laid into the lower part of the open mould.

➲ The activated resin is then poured on top of the mat and when the mould is closed the resin spreads throughout the reinforcement. (See fig.25)

➲ Advantage over hand lay-up-Two smooth surfaces are produced on the moulding, since it is formed between matched metal mould surfaces.

➲ Produces accurate components at a reasonable rate with modest tooling costs.

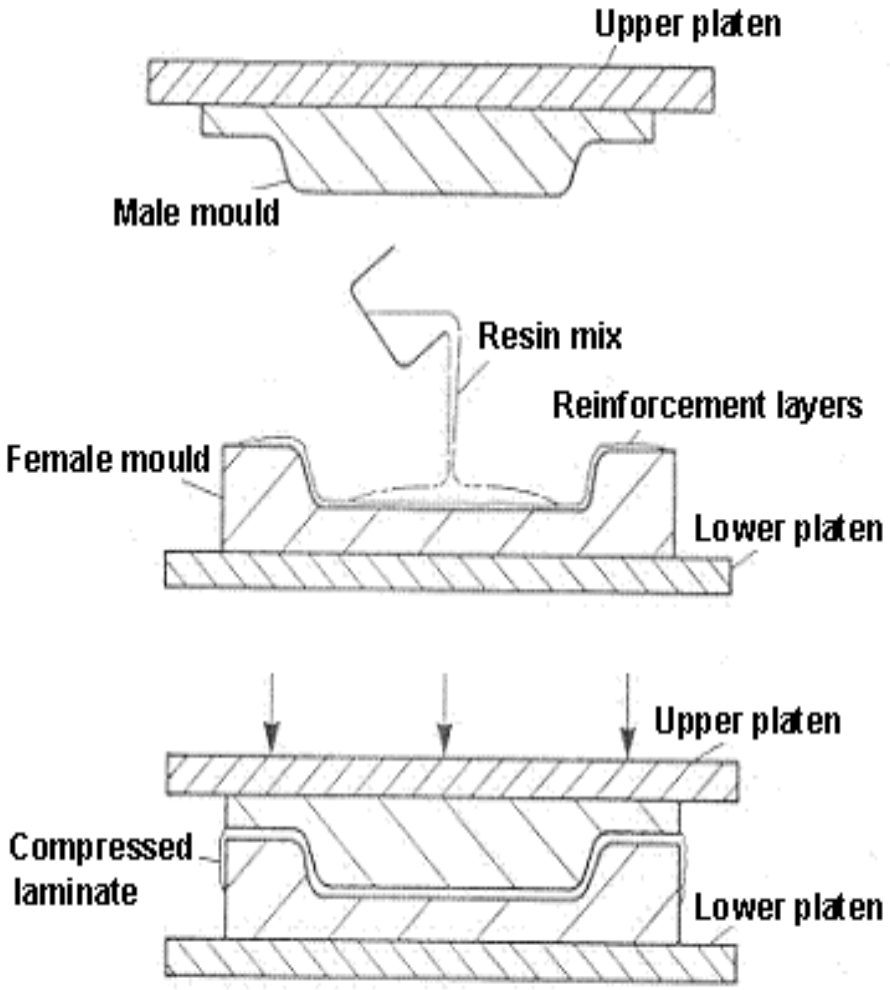


Fig. 25 Cold press Moulding

9.5.9 Filament winding

➲ Simple hallow shapes, rocket motors, gas bottles, pipes, tubes, cylinders and sphere shape and is frequently used for the construction of large tank and pipe work for the chemical industry.

➲ particularly suitable for pressure vessels

➲ Highest strength to weight ratios and can have glass contents of upto 80% by weight.

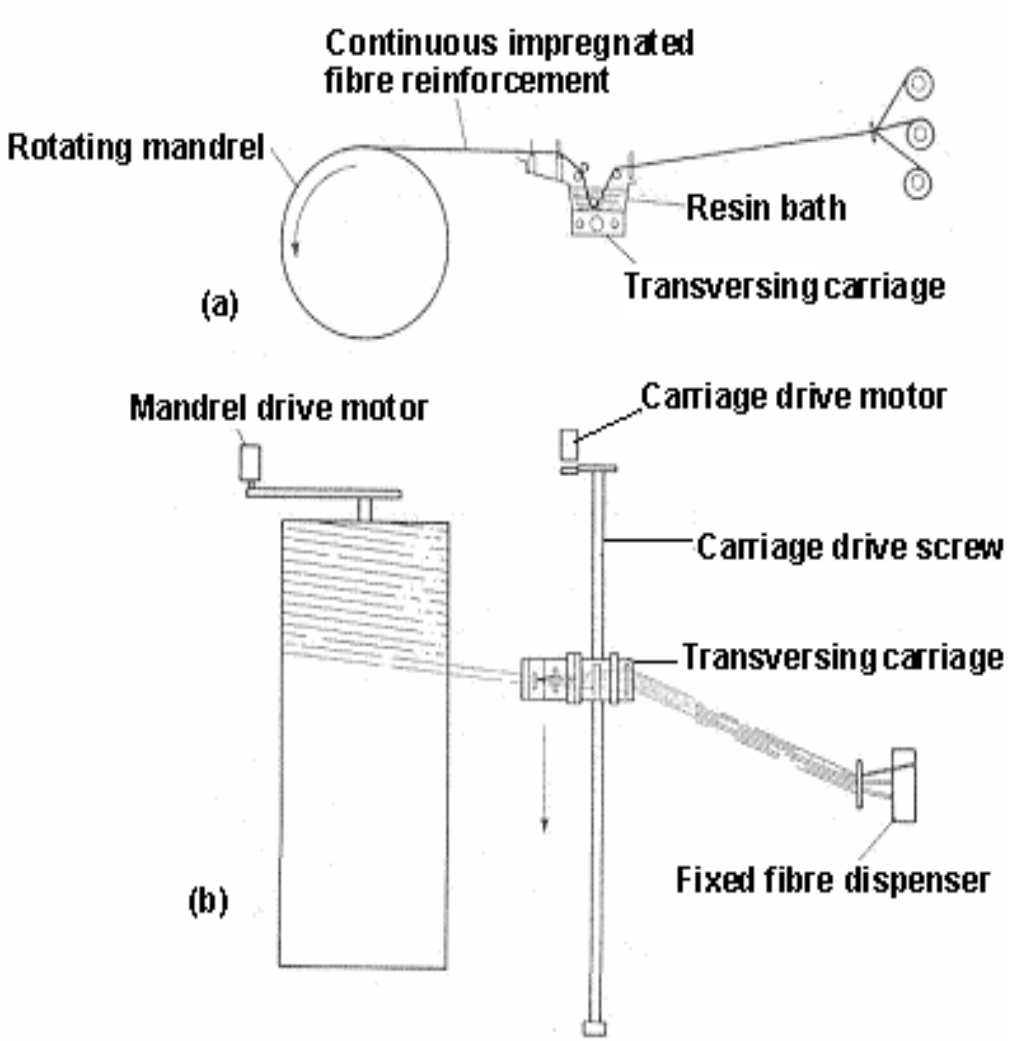


Fig.30 Filament winding (a) Sectional elevation (b) Plan view

9.5.10 Pultrusion Technique

➲ Reinforcement is impregnated with resin and pulled through a heated die, which gives the product shape.

➲ Product emerges from the die at speed upto 1.5m/min and then passes through a tunnel oven to accelerate the curing of the resin.

➲ The pultruded composite is eventually cut to length for storage.

➲ Continuous production method similar in concept with extrusion

➲ Profiles, structural I-beams, L-channels, Tubes, angles, rod etc.

- Machine- Reinforcement handling system (creel as used in textile weaving), a resin impregnation station and material forming area.

  - ✓ Designed to heat, continuously pull, and cut the profile to the desired length

- Continuous yarn, woven cloth and mat reinforcement used

- Open and closed profile with close tolerance and multicellular profiles are possible

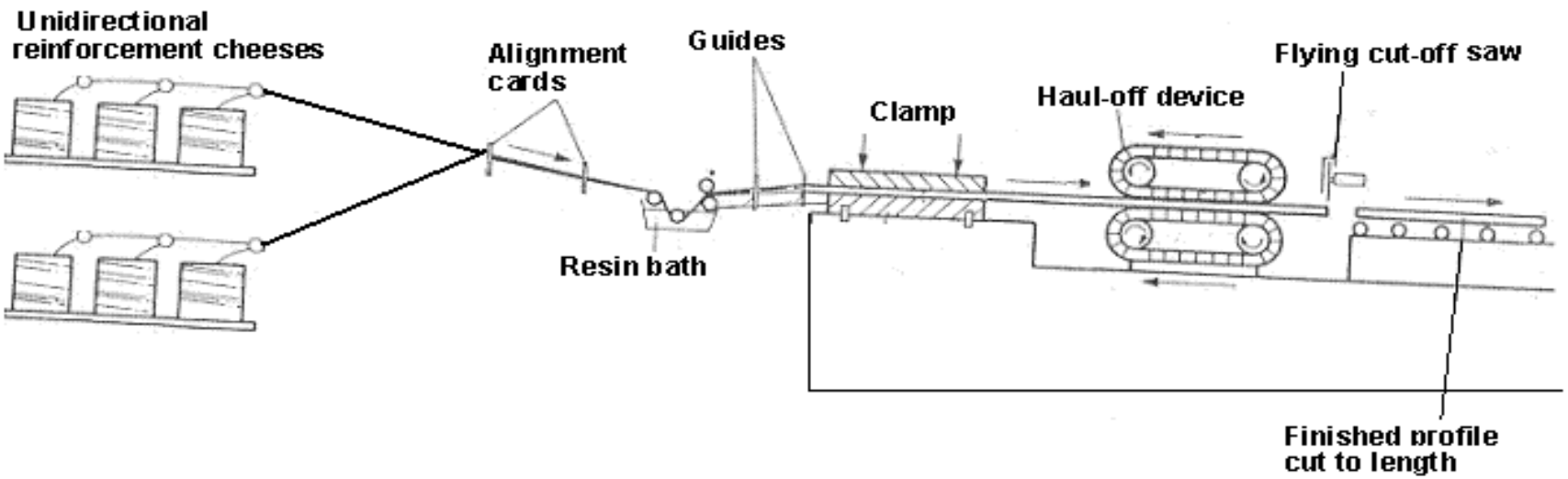


Fig. 33 Pultrusion

APPLICATION

TRANSPORTATION : 1.Land

- Automotive components
  - Automotive trunk lids and hoods
  - Flat sheet for vehicle bodies
  - External body panel
  - Head lamp housing
  - Bumper beams
  - Glove box doors
  - Instrument panels
  - Battery trays
  - Seat back
  - Sun roof frame
  - Heat shields,
  - Radiator support
  - Roofing

- ✓ Engineering parts
  - Leaf for trucks
  - Bumper fascia
  - Front grill
  - Acoustic shields.

- ✓ Under bonnet components
  - Oil pump and rocker cover
  - Air channel.

- ✓ Special applications
  - Lightweight armour for police protection
  - Special vehicle body
  - Tanks for oil
  - Gasoline
- ✓ Railway
  - Housing and covers
  - Aerodynamic front ends of the High-speed trains.

Fig. 50(a) Electric bus

(b) Car speaker

Fig. 48(a) Pedal car

(b) FRP body

Fig.49(a) Pocket Bike

(b) Side panel

2. Sea

Boats

Boat hull

- ✓ Marine uses

Powerboats sailboats

Canoes

Marine muffler

Engine covers

Storage boxes and spars

Super structure and fitting of large ships.

Fig.52 The first all GRP off shore lifeboat

Fig.51 Boats

3. Air

- ✓ Aircraft parts
  - Main landing gear doors (body)
  - Landing gear doors
  - Cowl components
  - Seal plates
  - Elevators
  - Rudder
  - Spoilers
  - Radoms
  - Nose cones
  - Aircraft pulley wheels
  - Rocket motors
  - Tail rotor blade for helicopters
  - Ceiling panel and tail and other interior parts

Front fuselage

Wings

Fin

Control devices

Doors

Engine covers

Helicopter interior

Helicopter freshwater or wastewater holding tank overhead storage pin etc.

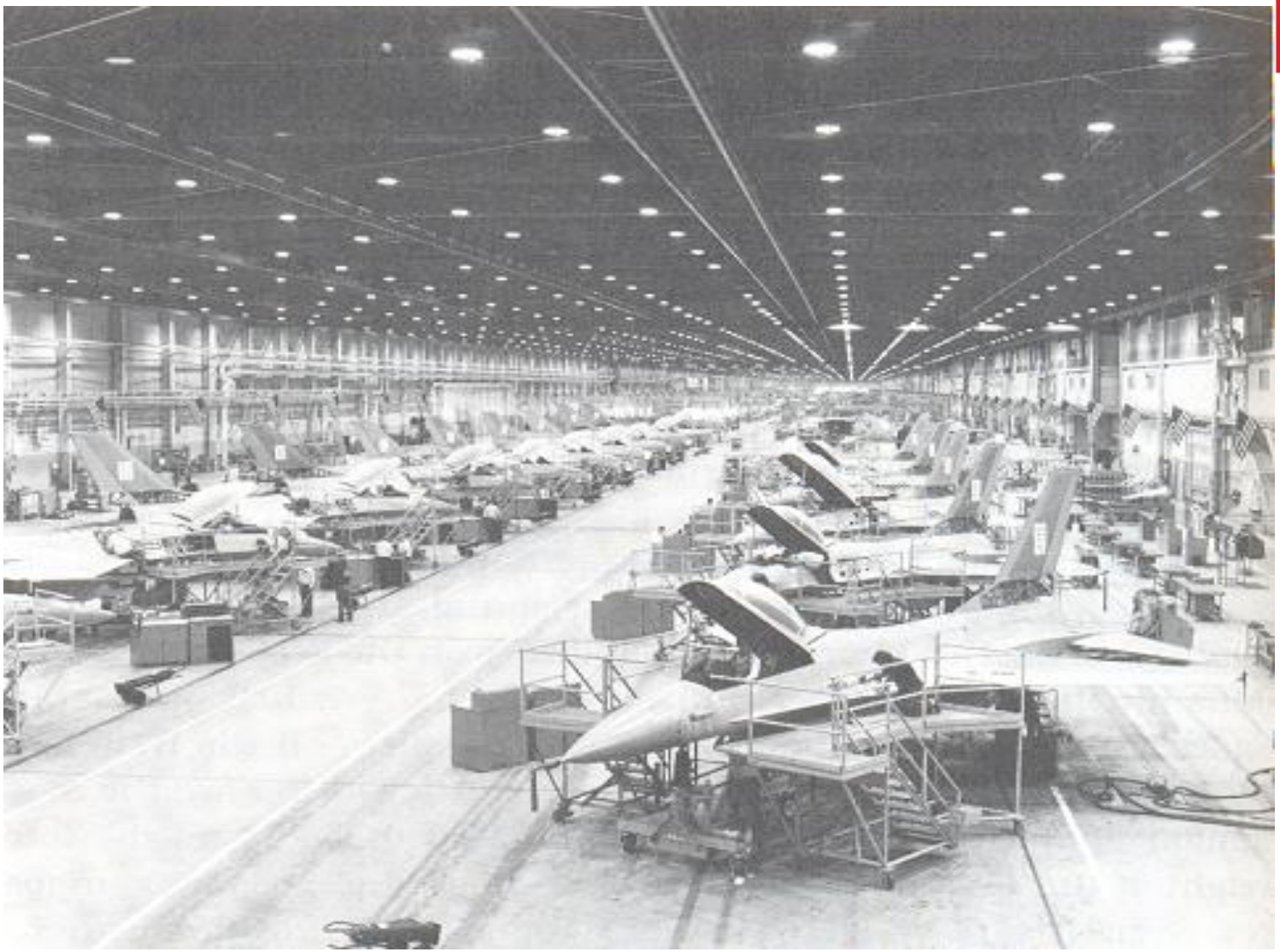


Fig.54 Fighters are composed of many composite

Fig.53 Helicoptor remote hornet

ELECTRICAL AND ELECTRONICS

- Roofing lights
  Electrical insulator
  Encapsulating electronic components
  Switchgear sky lighting
  Printed circuit Board
  Switch gears
  Tie bar
  Brush holder
  Motor housing
  Bushing
  Circuit breakers
  Bobbins
  Compressor bases
  Power tool housing

Stand off rods
Electrical Junction boxes
Cherry picker buckets
Electrical trucking conduit
Electrical housing etc.
Frames
Bases
Fan in the manufacture of computers
Vacuum cleaners
Air conditioner
Refrigerators

➲ GRP insulators are used for overhead lines particularly for very high transmission voltages from 420 KV upwards

- ✓Distribution power poles
- ✓ Protection boxes
- ✓ Shock proof tiles etc.

Fig.55 Wire Connector

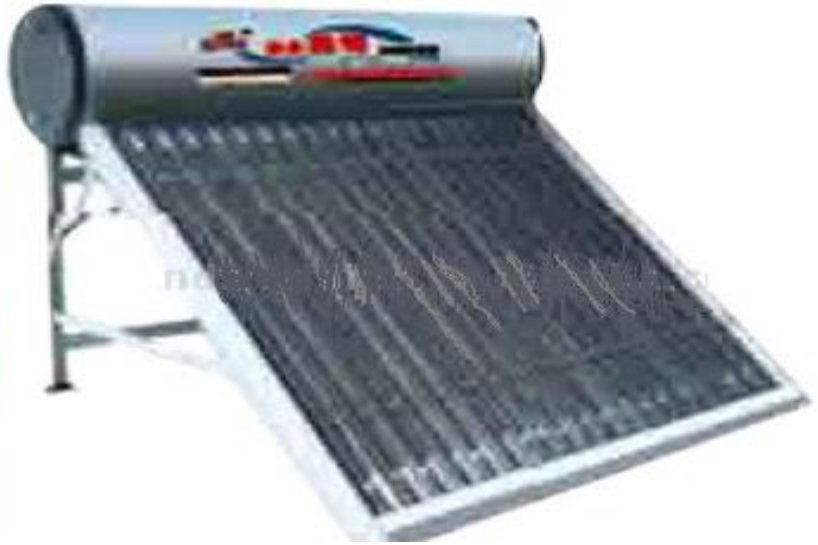


Fig.56 Solar heater

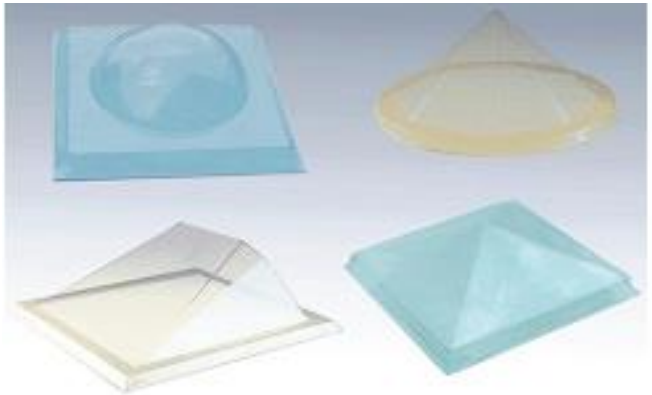


Fig.57 Lighting Dome

Fig.58 Fuse Isolators

BUILDING AND CONSTRUCTION

- Pipes for building
  - Highways
  - Bridges & decks
  - Building panels
  - Cladding panel
  - Sheet for roofing
  - Building insulation
  - Pipe for ice machine
  - Pumps
  - Signal
  - Turbine pump
  - Swimming pools
  - Cooling towers

Showers
Sky lights
Food processing wall panel
Roof fitting
Structural frame
Doors & windows
Interior decorations
Washbasin
Sinks
Toilets
Flooring
Septic tank
Letter boxer

Meter housing

Corrugated sheeting

Composite bridge

Fire doors

Moulded telephone booth

Roof rear wall

Door component

Side panel trim

Industrial building etc.

Fig.59 GRP panel for car park

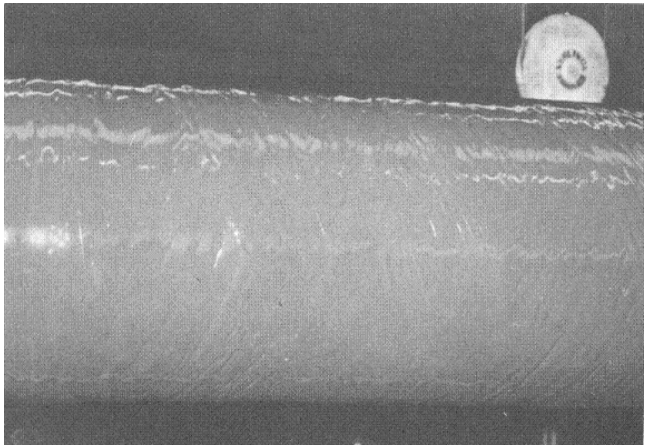


Fig.60 Filament wound epoxy pipe.

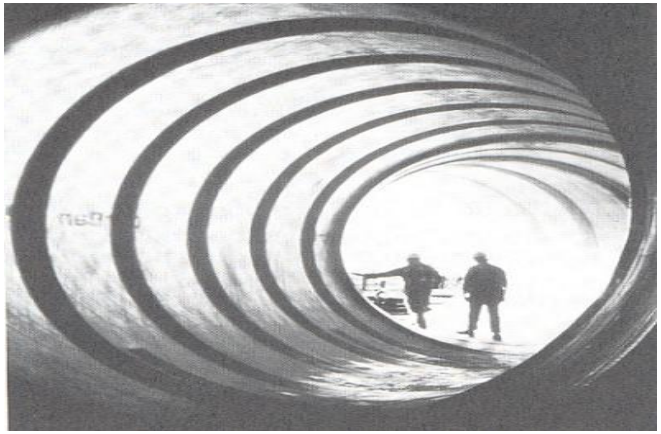


Fig.61 Nine foot diameter pipe from fibre glass

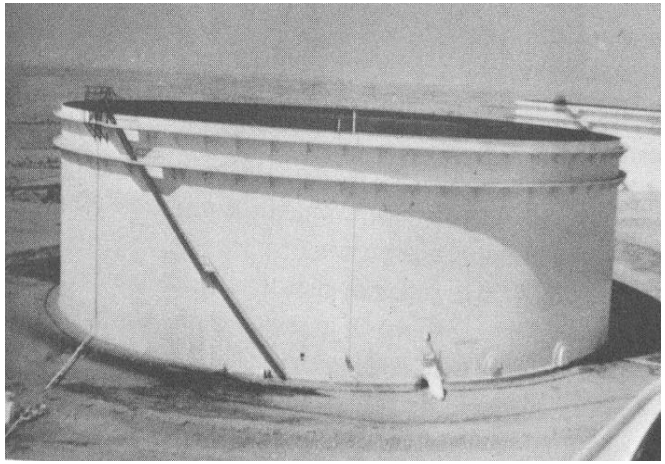


Fig.62 Floating roof crude oil storage tank

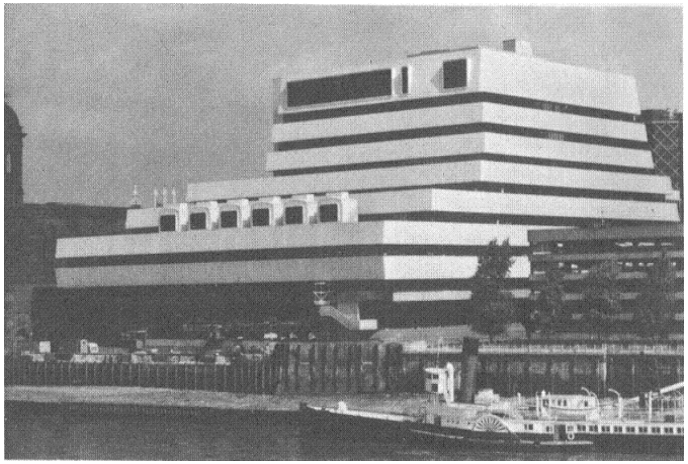


Fig.63 Post office building panel moulded from GR

Fig.64 Ceiling

Fig.65 Glass Wash basin

Fig.66 Pipe Clamp

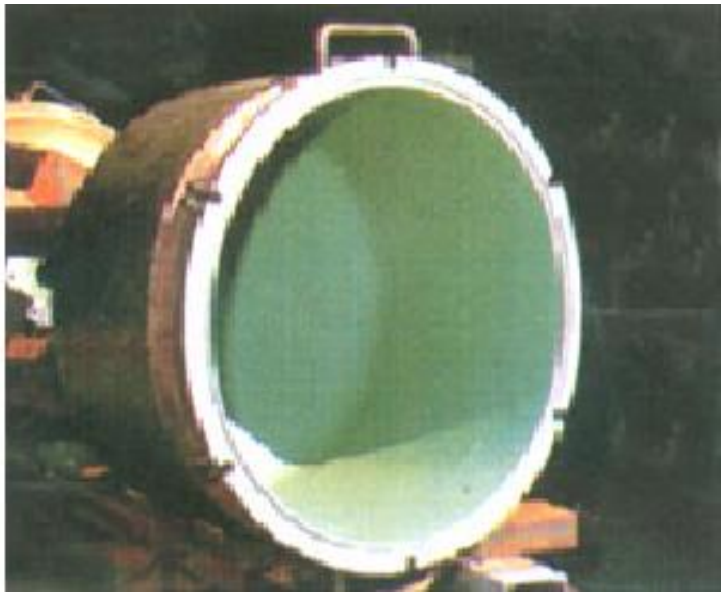


Fig.67 Reaction tanker

Fig.68 Tent

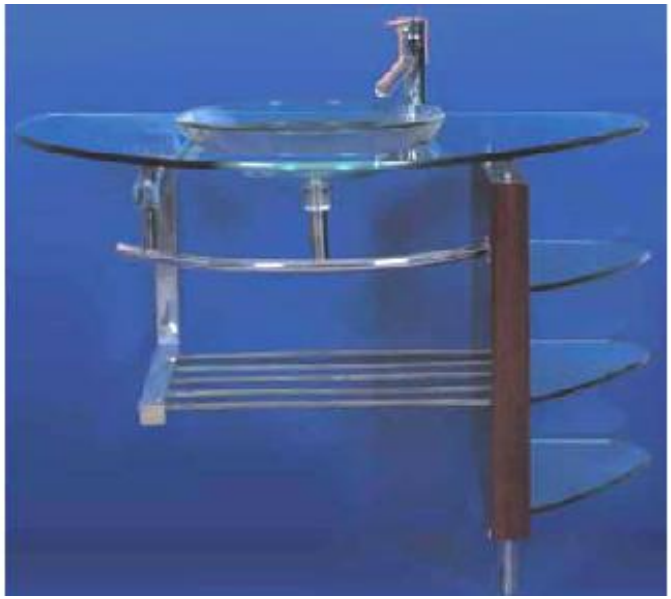


Fig.69 Wash basin

Fig.70 Gazemo

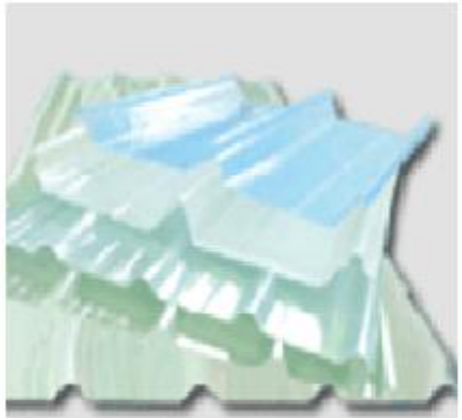


Fig.71 Translucent panel

Fig.72 Fibre playground

LAMINATE AND FURNITURE

- Building panels

Beams
Outdoor structural panel
Roofing
Corrugated panels
Office furniture
Chairs
Tables and other modern furniture design

- Electrical laminate
  - Slot wedges in electric motors
  - Terminal boards
  - Printed circuit board
  - Transformer.

- ✓ Aircraft and automobile components
- ✓ Laboratory bench tops
- ✓ Floorings
- ✓ Road surfaces
- ✓ Radiator supporter

Fig.73(a) Shampoo Chair

(b) Bubble Chair

(c) Seat

(d) Glass fibre racing car seat

MISCELLANEOUS

- FRP lining are applied to prevent corrosion of vessel to prevent leakage and predicts contamination in tanks, ductwork, pumps etc by spraying resin onto the surface with the glass-reinforcing media laid down by hand

- One of the most important industrial applications is FRP pipes, tank and pressure vessel.

- Machine covers and guards, for coal, oil slurries

  - ✓ Railway tank cars
  - ✓ Off shore oil platform
  - ✓ Heater & boiler tubes
  - ✓ Heating panel designed to operate at upto 200 & 400°C
  - ✓ Compressor blades
  - ✓ Wheel
  - ✓ Fastener nail
  - ✓ Propeller
  - ✓ High-tech bicycle wheel etc.

- **Appliance and sports**
  - Trays
  - Containers
  - Housing
  - Boxes
  - Luggage
  - Seating
  - Kitchenware
  - Dishwasher inner door
  - Refrigerator base support

- ✓ Tops of washer and driers
- ✓ Air conditioner parts
- ✓ Fishing rods
- ✓ Golf club shafts
- ✓ Golf crates
- ✓ Snow skis and water skis
- ✓ Computer terminal housing
- ✓ Washing machine gear housing etc.

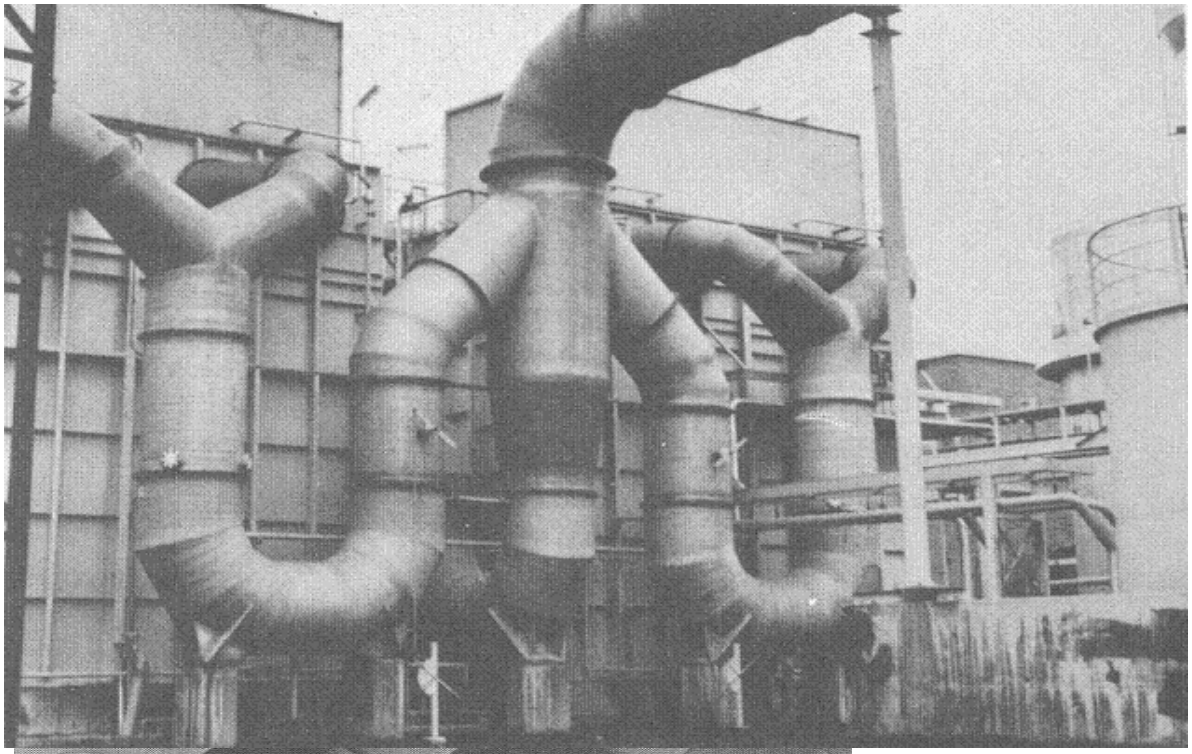


Fig.75 GRP gas main for sulphuric acid plant

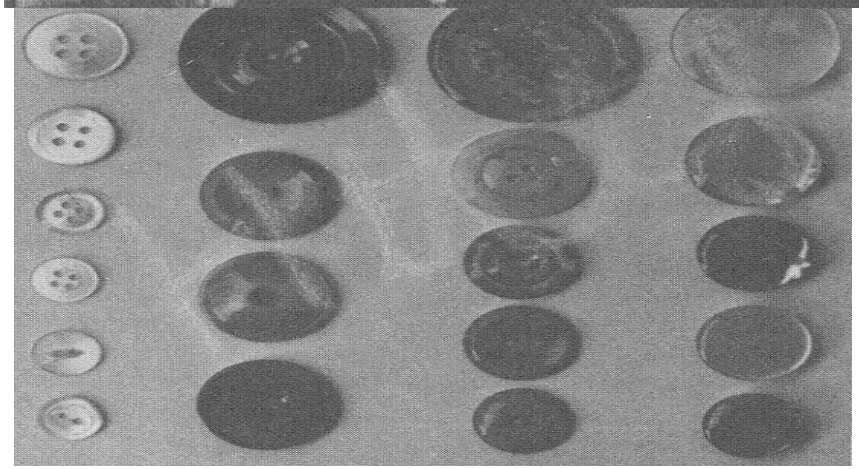


Fig.76 Various polyester resin buttons

Fig.77 Artificial wildlife trophy-Leopard head

Fig.78 Body slim wet steam sauna capsule

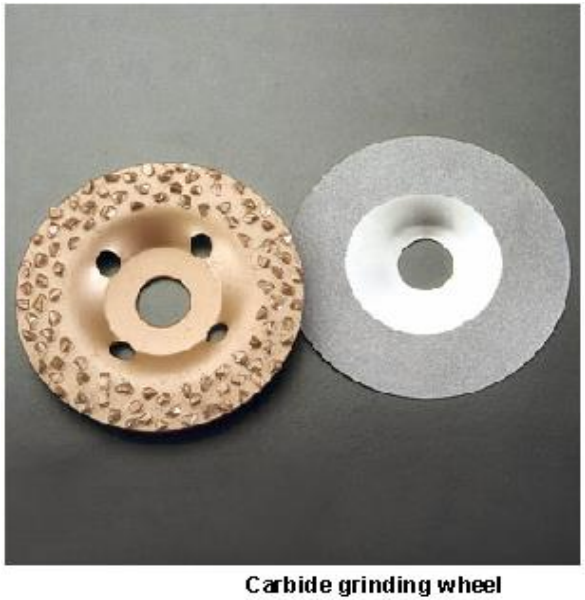


Fig.79 Carbide grinding wheel

Fig. 80 Fibre glass planter

Fig. 85 Decorative

Fig.81 Fibre glass self adhesive mesh tape

Fig.82 Fire Suit

Fig.83 Home Theatre

Fig.84 Plastic doll