KALE TEXNIQUE

MACHINE DESIGNERS AND MANUFACTURERS

SPECIALISED IN 3-D WOVEN PREFORM MANUFACURING MACHINES

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Definition of composites

To combine two or more materials together without having chemical reaction, to enhance the properties of both the materials or have new better properties.

Common examples-

1. Steel in concrete. Concrete has compressive strength, steel has tensile. They compensate each others drawbacks to give material that is strong in tension as well as compression.
2. Tire cord- nylon or steel threads layed in rubber matrix
3. Earthen wares made in Indus civilization or in Chinese civilization had grass fibers in the clay matrix to give strength and longer life to brics or earthen pots.
4. Frp sheets for roofing or fiber top of auto riksha

Properties of composites

- **Strength-to-weight ratio**
- **Corrosion resistant**
- **High impact strength**
- **Design flexibility**
- **Parts consolidation**
- **Dimensional stability**
- **Non conductive**
- **Non magnetic**
- **Radar transparent**
- **Acoustic dampers**
- **Low thermal conductivity**
- **Durable**
- **Finish**

Fiber reinforced plastic composites

The modern engineering composites are made up of two distinct elements

1. Reinforcing element which is made up of fiber in staple or continuous strand or continuous tapes or 3-d preform of fibers.
2. Second element is the plastic matrix or filling materials. The plastic can be thermoplast or thermo-set. Thermoplast plastic, when heated, softens at glass transition temperature and melts when further heated. Nylon polyester are examples. Thermoset plastics before polymerization are in fluid state or can be heated to get in molten form but when polymerized will not melt. If heated further it will burn at ignition temperature. Phenolic resins, Teflon are examples.
3. There are some other filling materials. Carbon in graphite form and silicon carbide ceramics are also used as filling materials. They are used in very high temperature applications.

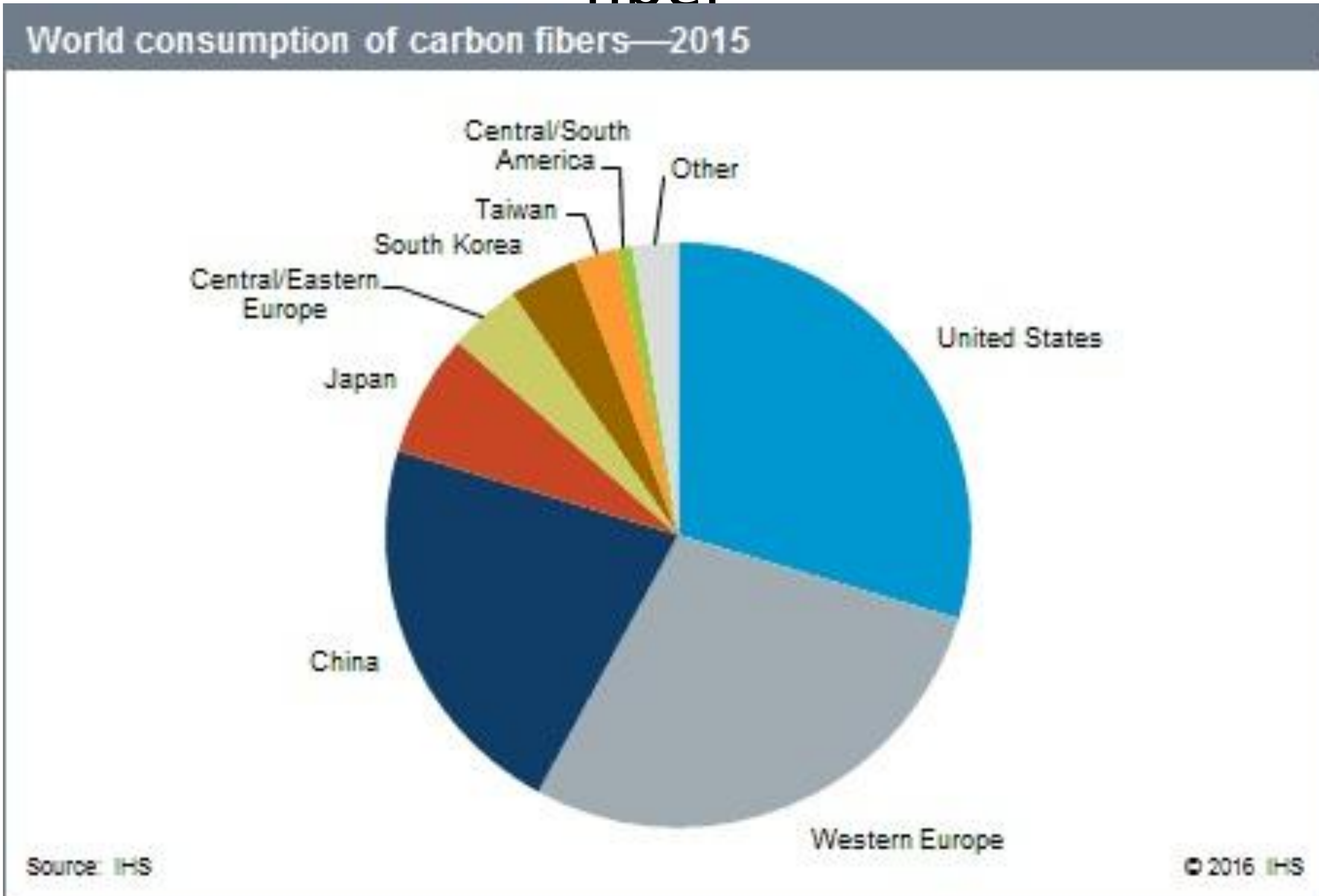
Why textile fibers are used as reinforcing elememt.

1. Textile fibers have very good tensile strength.
2. They are light in weight.
3. They are inert to chemical reaction.
4. They are economical.
5. They are pliable to form any shape.
6. The can be woven, braded, tufted, needled to form a required form.
7. They can be wetted by matrix material.
8. Synthetic fibers if used have low water absorbency.
9. They have similar physical properties with matrix such as thermal expansion or extension because of load.

FIBERS USED IN COMPOSITES

- CARBON
- KEVLAR
- GLASS
- CERAMIC
- BASALT
- SYNTHETC FIBERS LIKE POLY AMIDES, POLY ESTERS
- NATURAL FIBERS

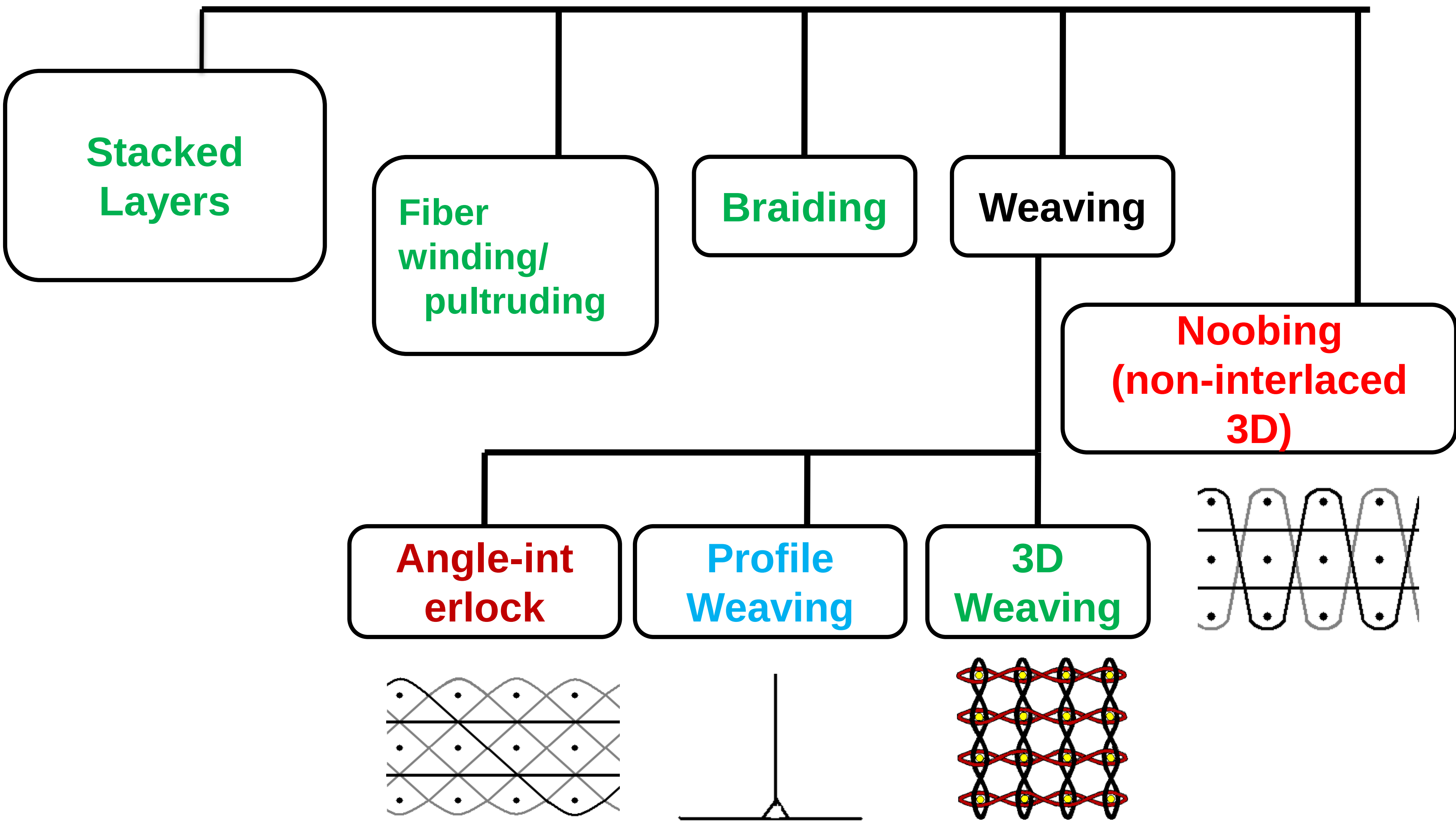
World wide consumption of carbon fiber



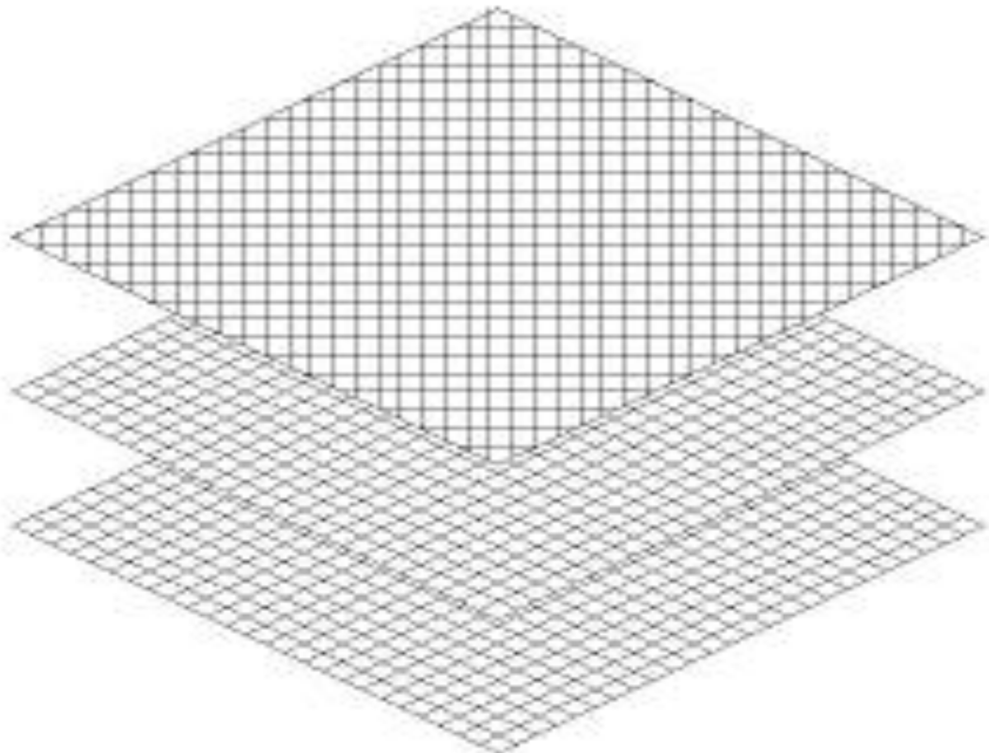
Care to be taken for preform

- The yarn and fabric damage should be avoided.
- The crimp should be minimum or possibly absent.
- Preform should have predetermined density.
- Fabric should be even

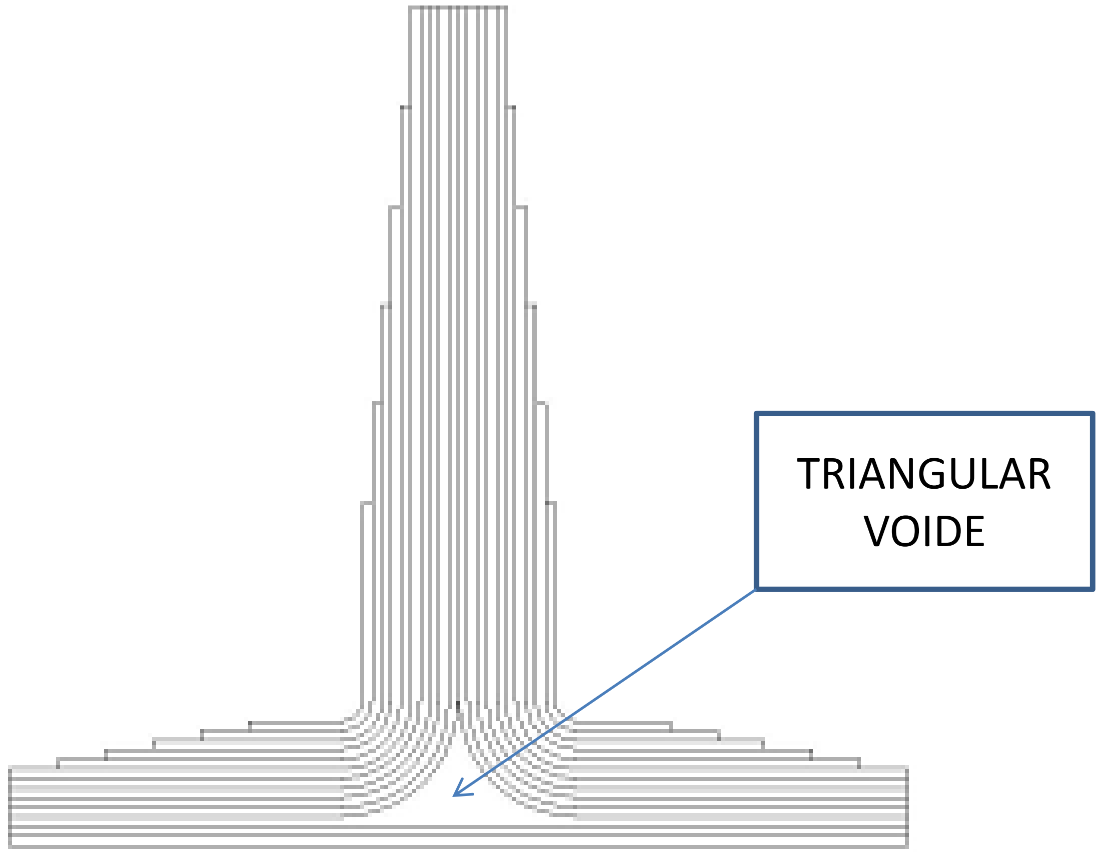
3D Reinforcement Technologies



Process of laminating



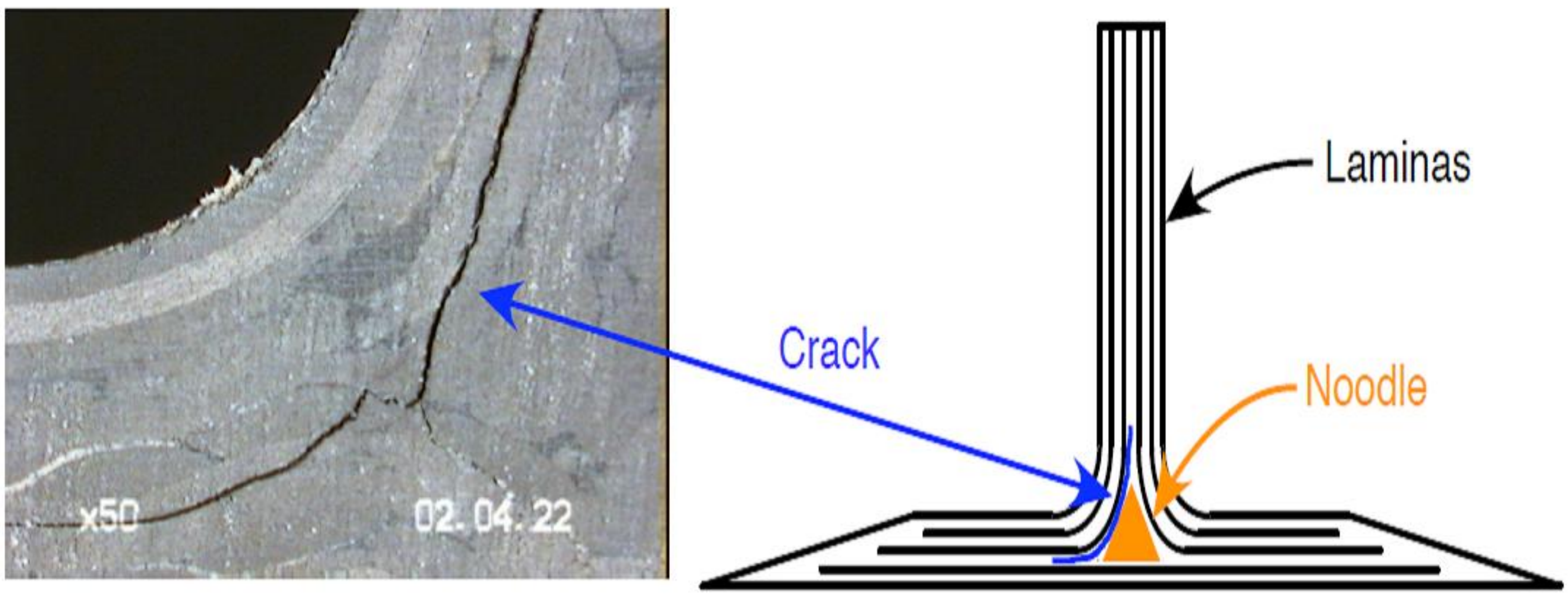
Typical example of lamination layup



Advantages of lamination

- Most of the components today are manufactured using this setup.
- Trained operators are available.
- Intricate shape can be developed by using appropriate tools
- Orientation of fibers can be easily achieved.

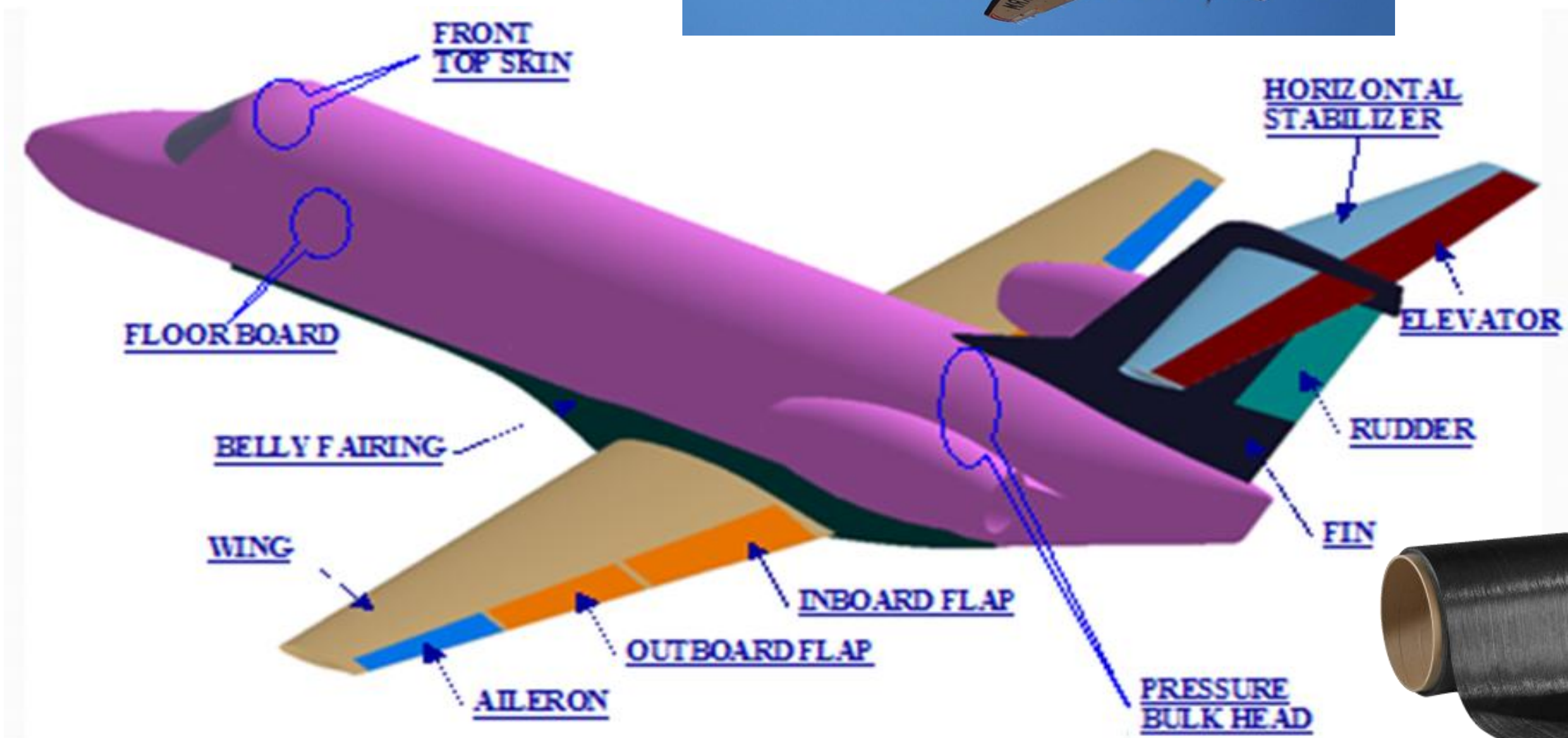
Delamination of laminates



Drawbacks of lay up

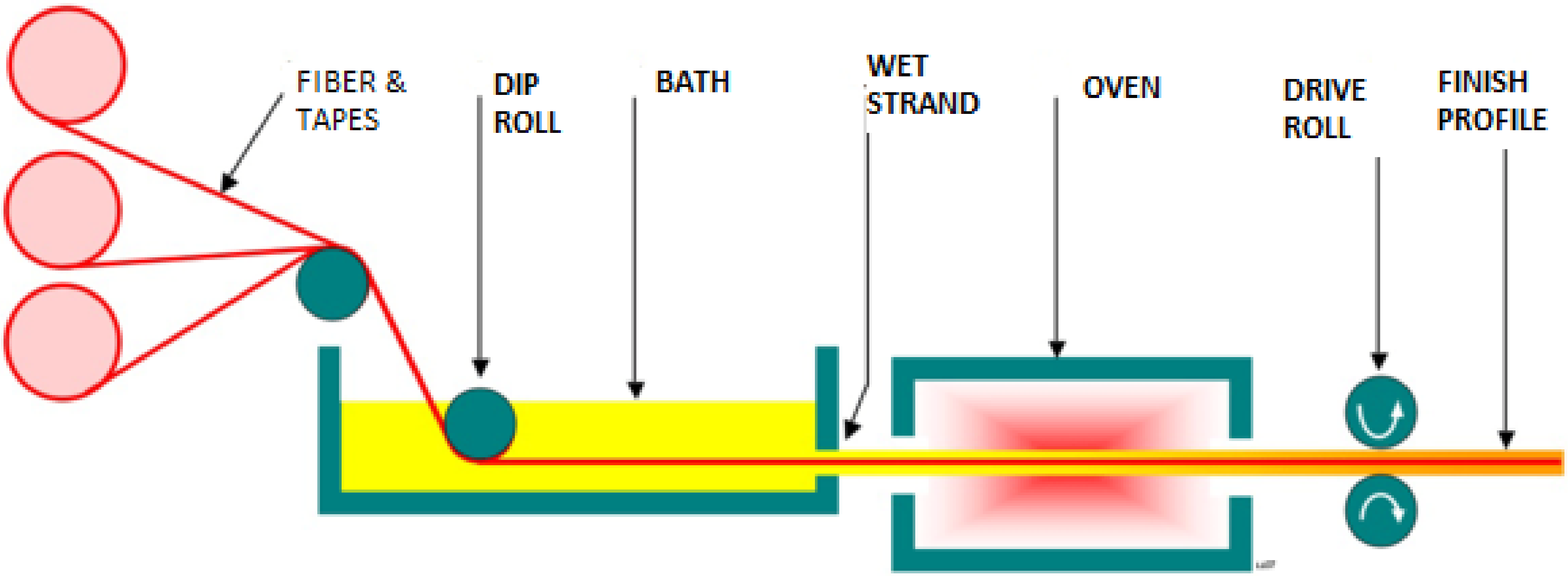
- Delamination can occur and can be catastrophic. Delamination is separating of adjacent layers.
- The layers of laminates are adhering to each other through weak forces which can deteriorate because of heat, water absorption or because of fatigue.
- The process is labor intensive. Human error can cause defects in composites.
- Destructive and non destructive inspection using many modern techniques is required to be carried out before certifying the component.
- The prepreg UD fabric is very costly and is imported.
- Prepreg is required to be stored in sub zero temperature.
- It has shelf life of few months.
- Layup operation has to be done at low temperature.
- Prepreg wastage to the tune of 40 % is common.

Reinforcements in SARAS Aircraft



- Composite components made from prepregs and Autoclave moulding
- Over 30% composite in Air Frame
- Use of UD carbon Prepregs

Pultrusion process



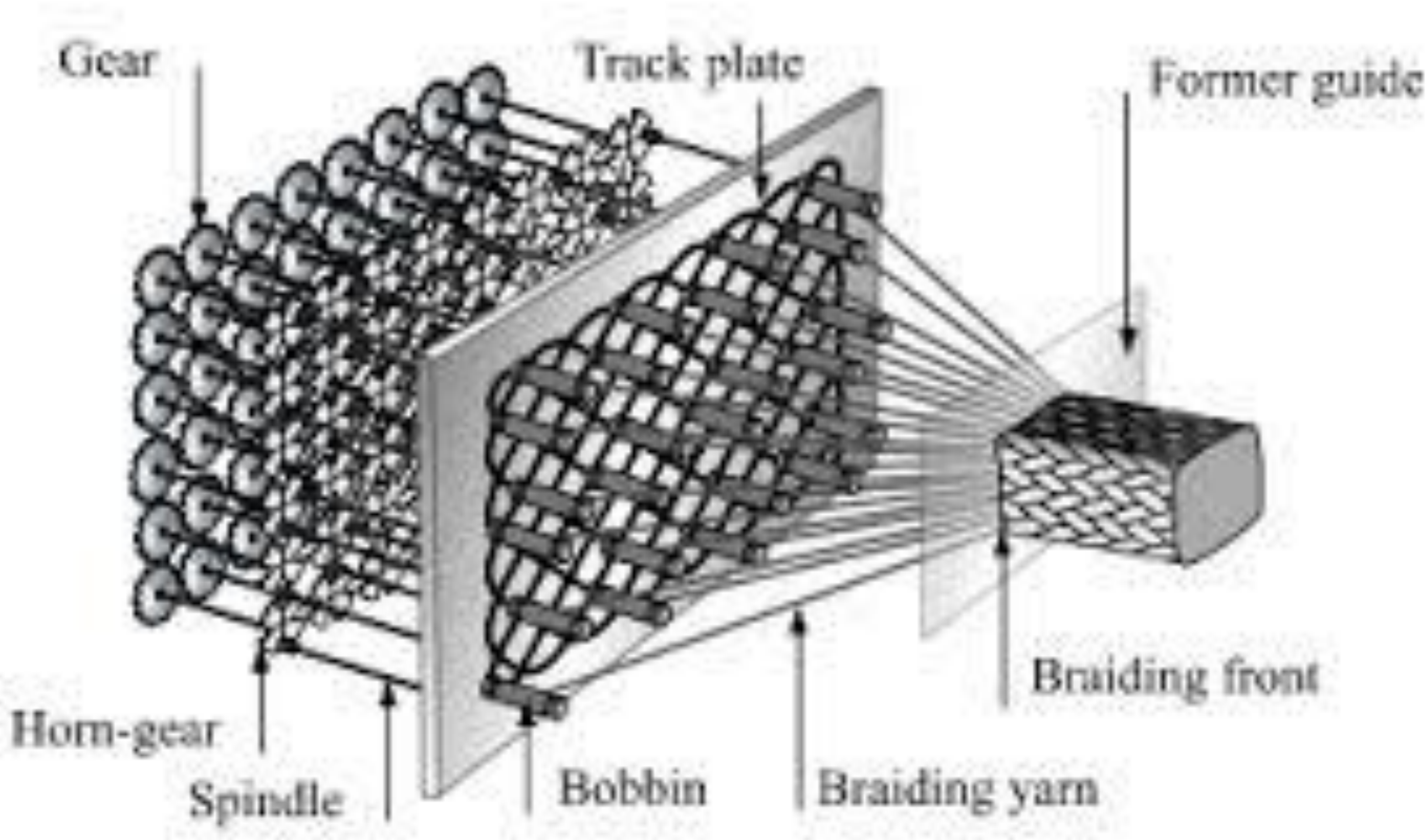
Pultruding

- This a continuous process.
- The fiber strands and tapes are impregnated in monomer of resin and passed through extrusion die and simultaneously cured to give continuous sections like channel, tubes etc.
- They are used in non structural items like cable passages.
- They are also used in construction like railing of bridges etc.

Fiber /tape winding

- This is used for cylindrical sections like gas cylinders.
- Fiber strand/tape is immersed in monomer bath and laid on rotating cylindrical mandrill.
- The strand/tape can be at different angle to the axis of rotation thus covering the mandrill area as may be required.
- The lay up is cured along with the mandrill. The composite is recovered either by destroying the mandrill or having a collapsible reusable mandrill.
- This technique is used for storage cylinders, rocket engine casing etc.

3-d Braiding

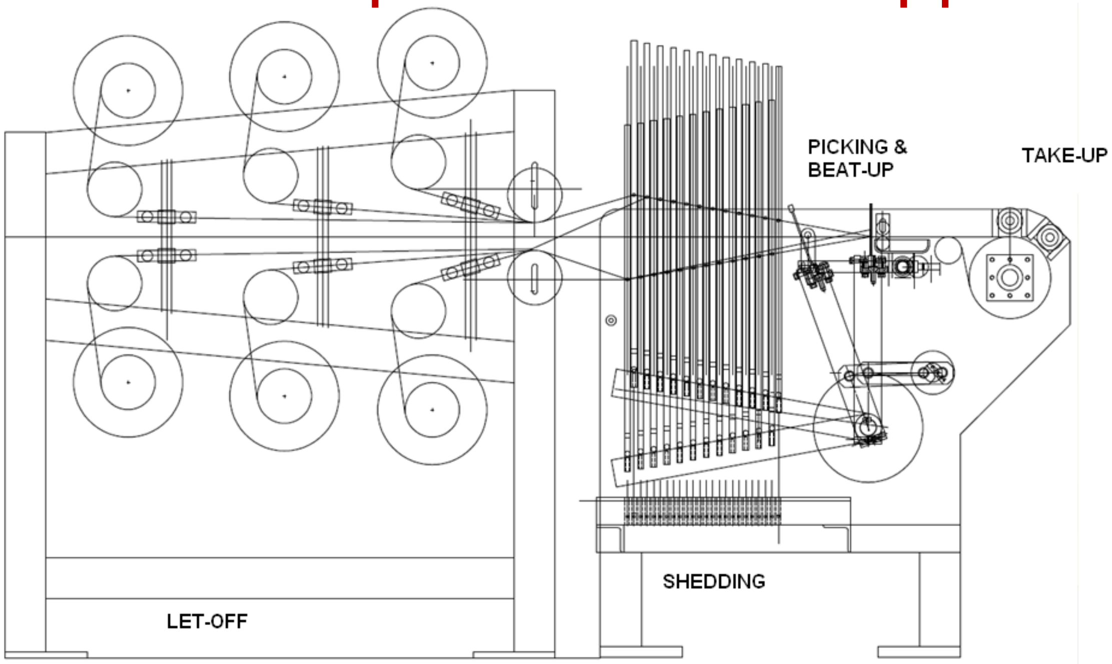

Gear
Track plate
Former guide
Braiding front
Horn-gear
Spindle
Bobbin
Braiding yarn

Typical braided structure

Advantages/ disadvantages of 3-d braiding

- 3- braiding machines are developed by modifying braiding machines
- This can give nearest to the size preform minimizing machining afterwards.
- It has through thickness fibers to give high performance strength. Chances of lamination is eliminated.
- It has a drawback of high crimp.
- Lower in plane strength. Good through thickness strength.
- Stress concentration points can not be avoided. This causes reduction in strength.
- This reduces labor required. This reduces wastage of fiber.
- There is a heavy fiber damage in weaving especially in heald frame, in shuttle/rapier passage and in beating. This reduces the strength of the preform.

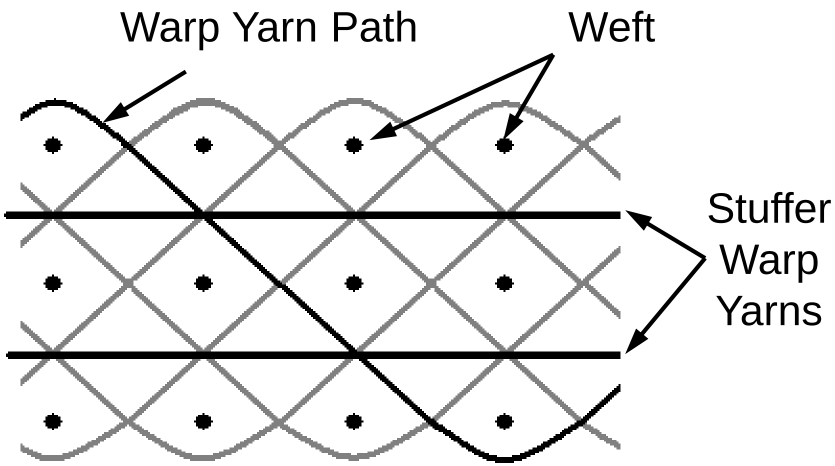
Angle Interlock Weaving Activities at NAL
With help of machine supplied by KALE TEXNIQUE



Weaving machine
with
6 warp beams

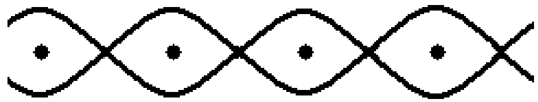
Angle-interlock Weaving

- Several layers of longitudinal threads (**warp**) will be arranged one over the other.
- They will be interwoven with several layers of transverse threads (**weft**) such that one thick bulk preform will be produced.

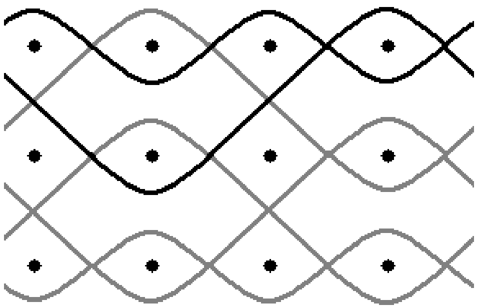


- The warp yarns criss-cross through the thickness in a pre-defined pattern.
- There would be possibility of including non-interlacing stuffer yarns to improve strength as well as fibre volume fraction.

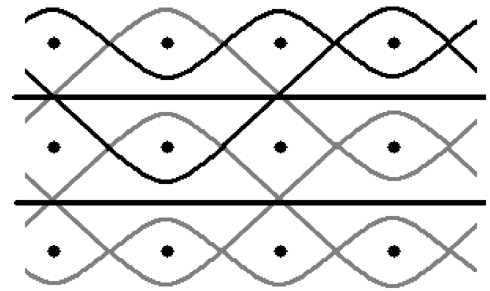
Angle-interlock Structures



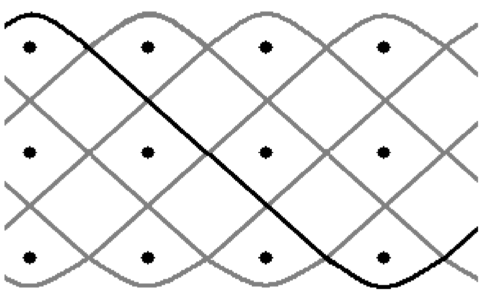
Bi-Directional
Cloth



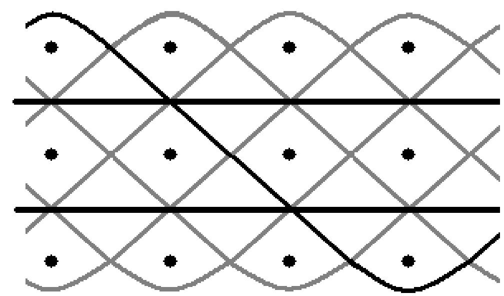
Layer-to-
Layer



•Warp layers need not travel through the thickness of the fabric



Through-
Thickness



•The warp layers travel through the entire thickness of the fabric

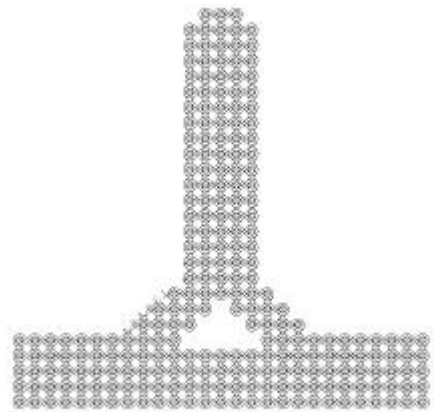
Note: Dot represents Weft and Line represents Warp

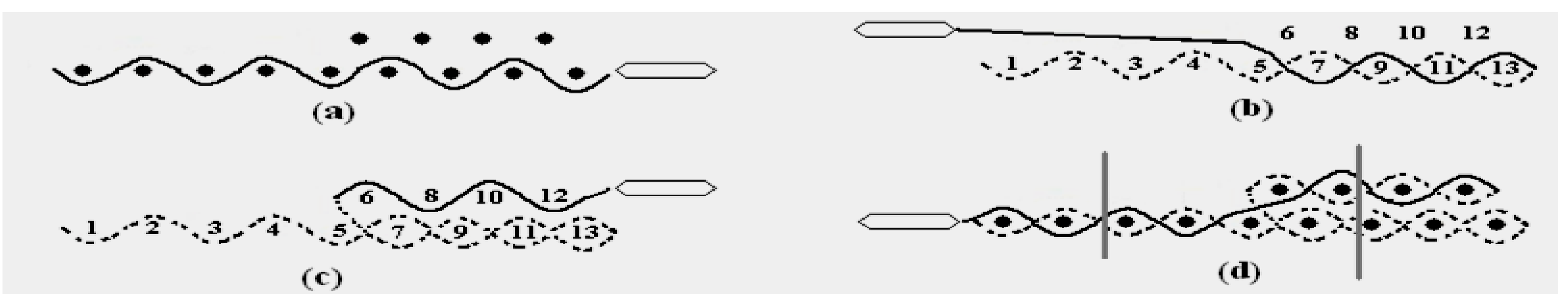
Near-Net Preforming – T Inserts

One Woven continuous layer linking the different sections of the joint

- Bridges the sections & acts as a deterrent for failure

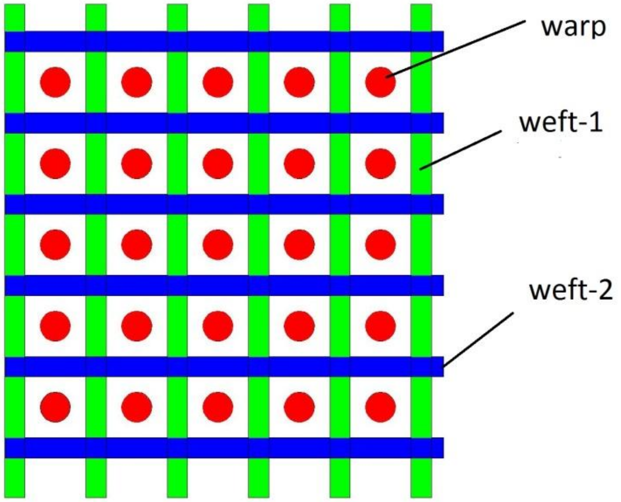
- Requires shuttle weaving loom as the shuttle binds the edges



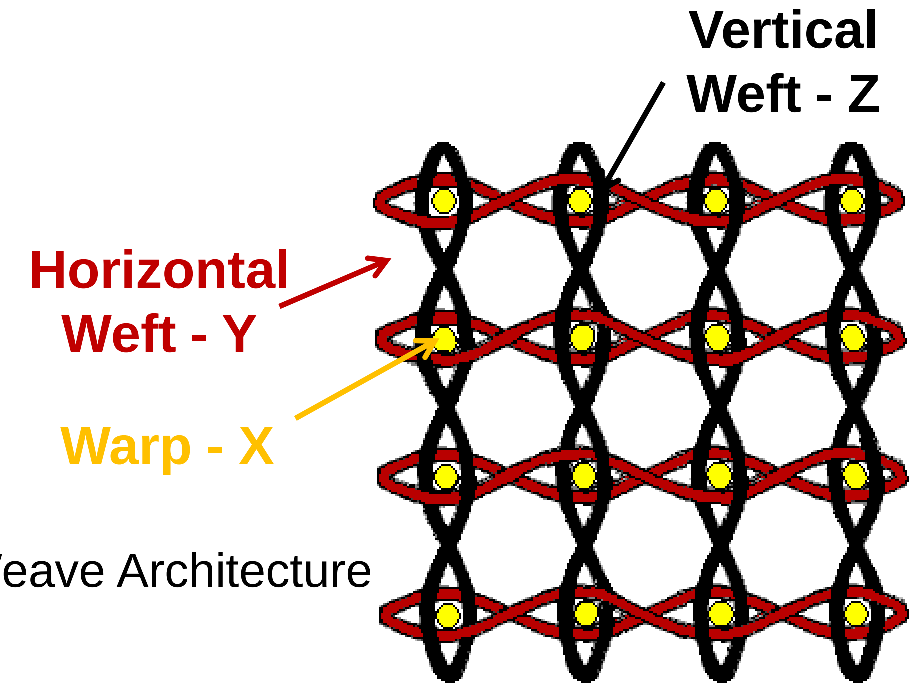


What is 3-d weaving

- 3- d weaving has warp in number of layers. Number of wefts are inserted simultaneously in both orthogonal direction.
- If wefts interlace with the warp it is called woven 3-d fabric. If it does not interlace it is non interlaced (NOOBED)

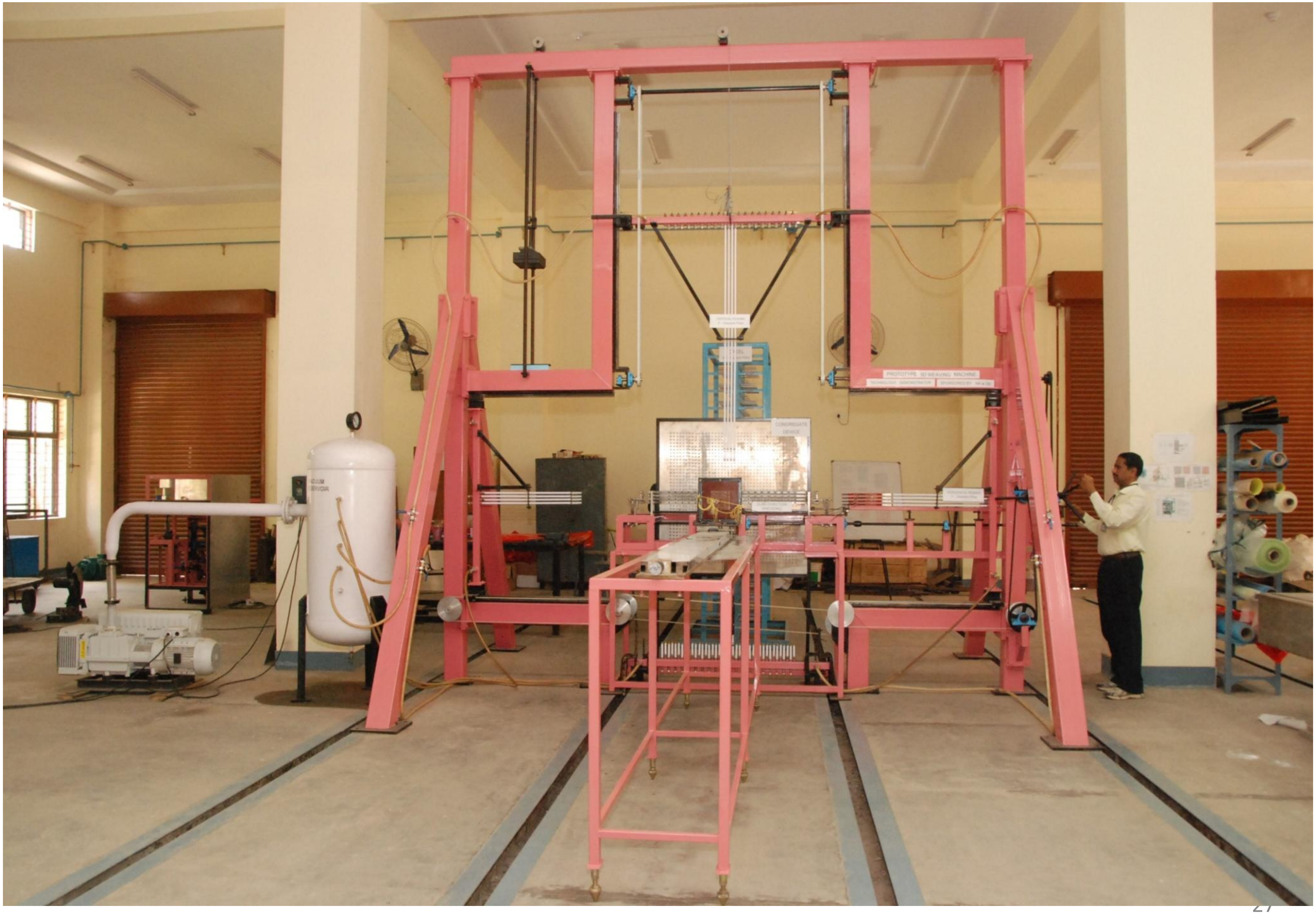


NOOBED STRUCTURE

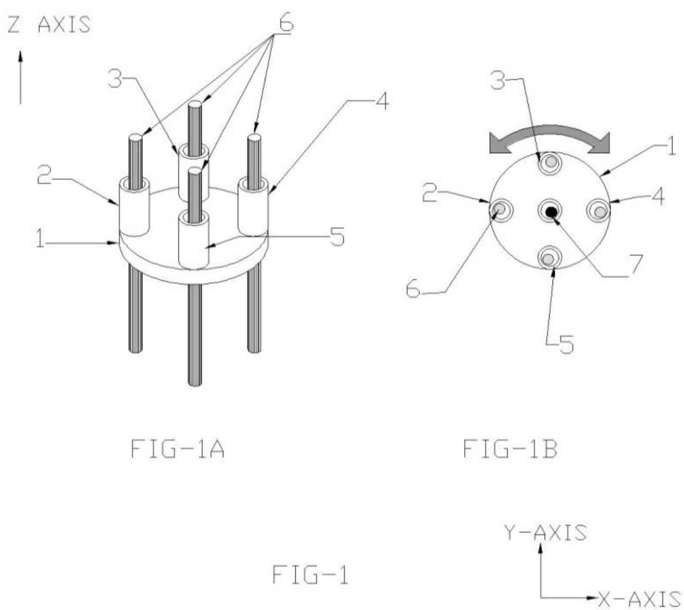


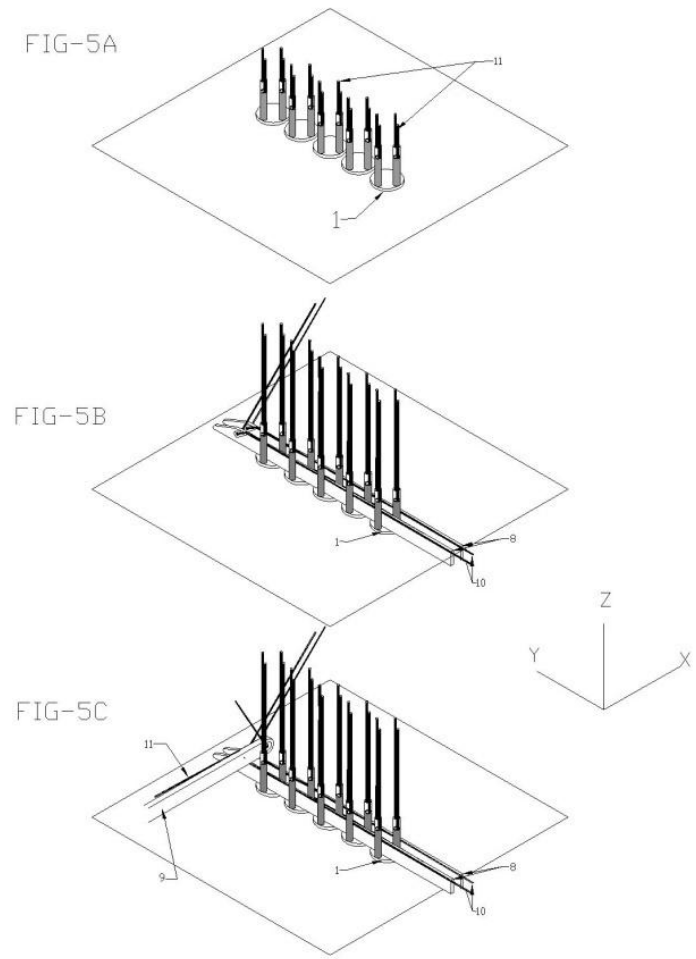
3D Weave Architecture

Prototype 3D dual direction Weaving Machine – Developed by NAL



The machine patented by KALE TEXNIQUE- innovative rotating disk

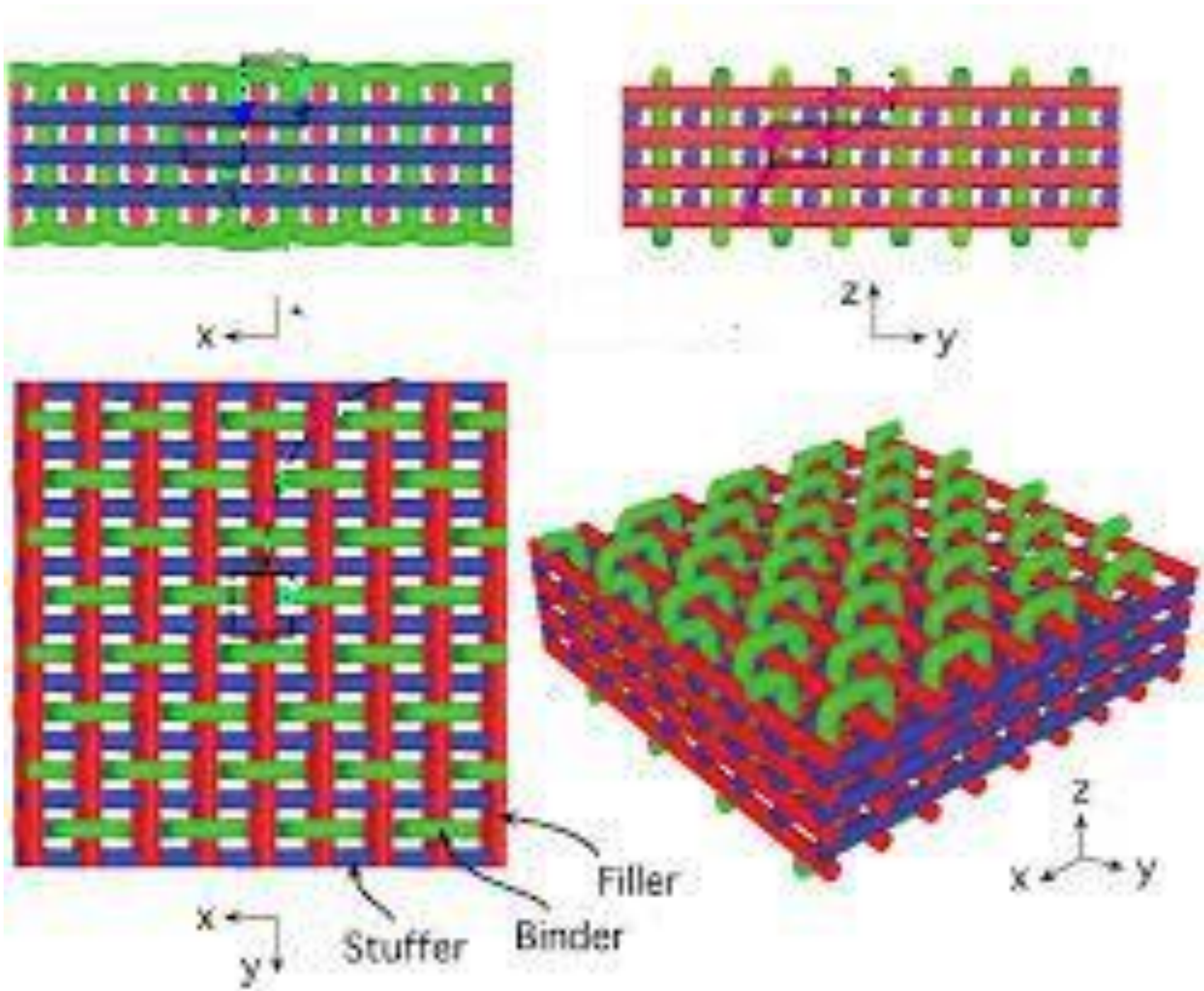




Benefits of our rotating disk principle over the system developed elsewhere

- The size of our machine is 1/20 th of the machines elsewhere. So cost of our machine is also much lower.
- The shed opening causes yarn damage. Our shed movement is only 5 mm as compared to 30 mm.
- Weft rapiers in our model do not touch the warp. It passes through the guides. This further eliminates chances of warp damage.
- In our machine the angle of convergence is minimum.
- In our machine, beating is easily possible. In other machine positive beating is very difficult.
- Our machine can produce woven interlaced and non interlaced (NOOBED) fabric on same machine. Others have different machines for interlaced and non interlaced fabrics.

NOOBED structure



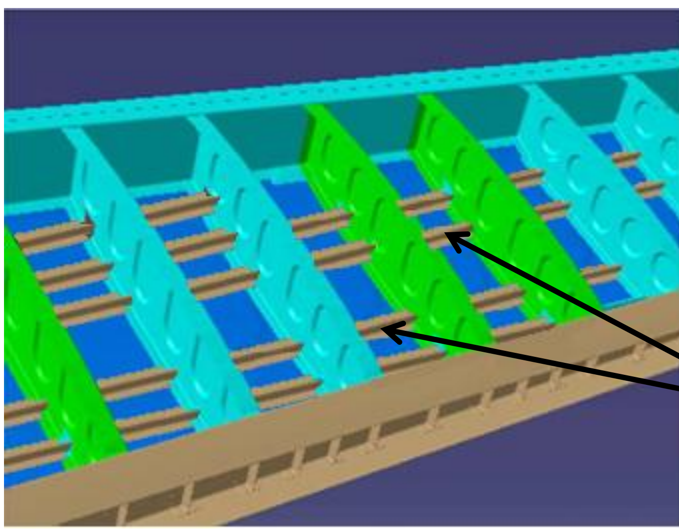
Non interlaced orthogonal woven preforms

- This is a latest system of fabric formation.
- There is no interlacement of threads.
- The third axis threads bind the fabric together.
- All the drawbacks of the previous systems are eliminated.
- All the fibers are straight so no crimp.
- Penetration of resin is easy and complete.
- Fatigue life is increased many folds.
- Orientation of fibers along the axis of load is easy.
- Being dry fiber system, it has all the advantages of dry fibers .
- Self developed holes for clamping are possible which will avoid strength reduction.

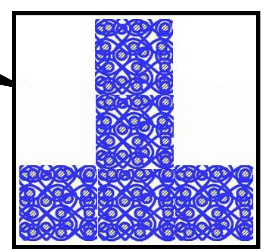
Need for 3D Composites…

- Laminated composites have good in-plane properties but poor out-of-plane properties due to lack of reinforcement in the third direction.

- A fine balance of in-plane with the out-of-plane properties would be required to address the complex and multi-directional loads in components such as T sections, I sections, Links, fittings etc.,



Typical Skin Stiffener Joint

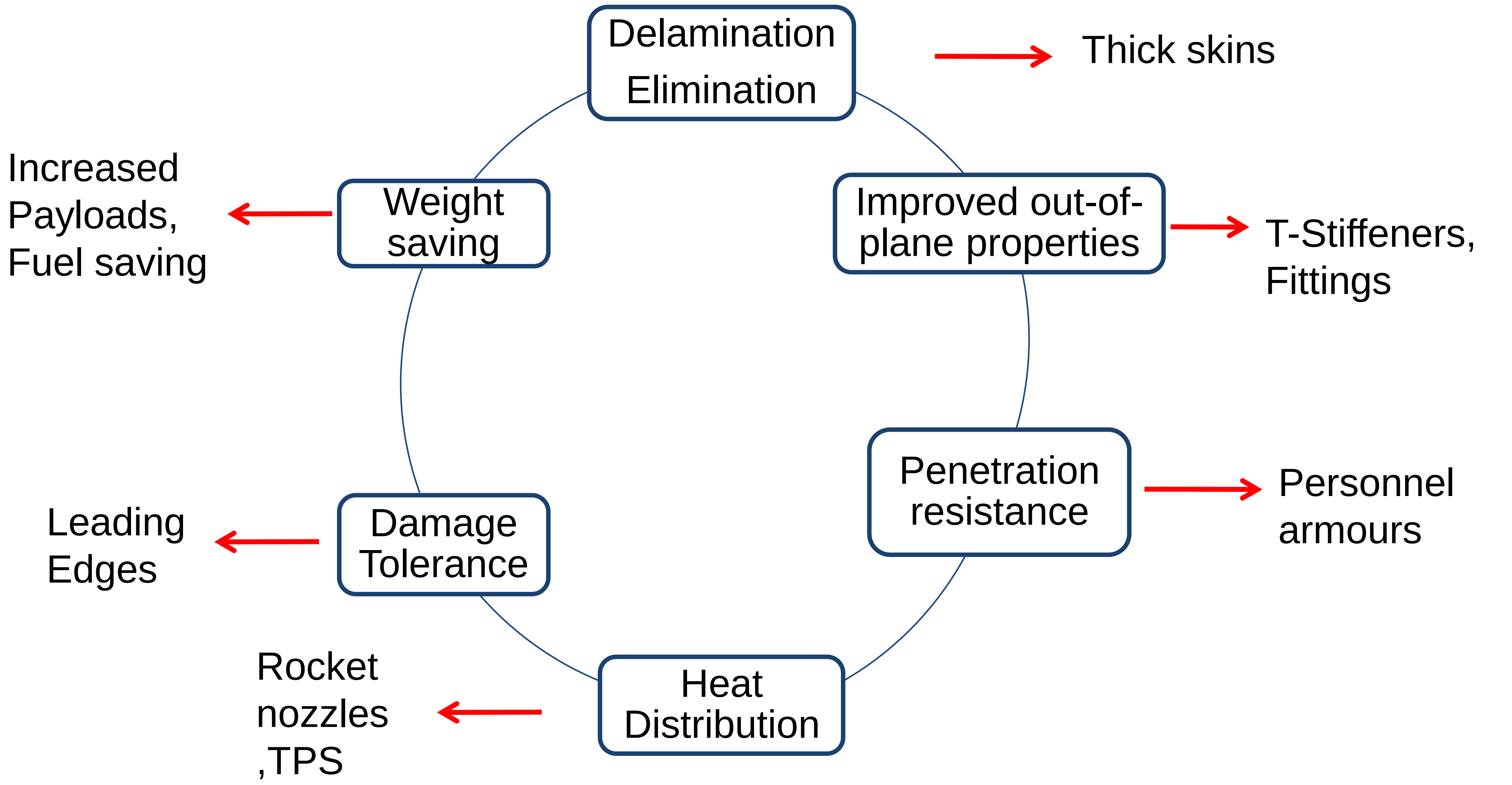


Magnified view of ‘T’

… Need for 3D Composites in Aircraft

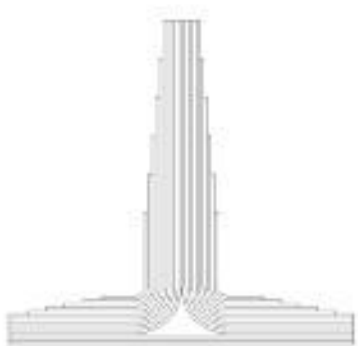
- The complex profiles can be produced as one unified coherent structure with yarn interlacements in X, Y and Z directions using 3D reinforcement technologies.
- Complex Components with integral tapers, curvatures, bifurcations, holes, stiffeners, flanges etc., can also be developed using 3D composites
- 3D composites can improve damage tolerance, impact resistance, resistance to crack growth, reduce part count, enhance process automation and reduce manufacturing cost

Need for 3D



Delamination Elimination
Thick skins
Weight saving
Increased Payloads, Fuel saving
Improved out-of-plane properties
T-Stiffeners, Fittings
Penetration resistance
Personnel armours
Damage Tolerance
Leading Edges
Heat Distribution
Rocket nozzles ,TPS

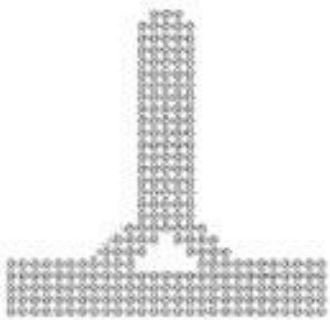
Compare the T form produced by different systems



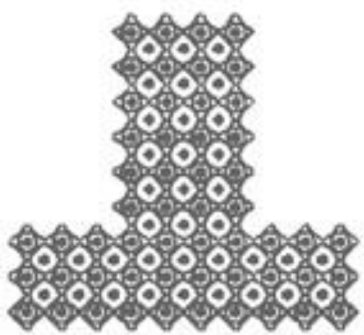
Laminated profile

Pultruded profile

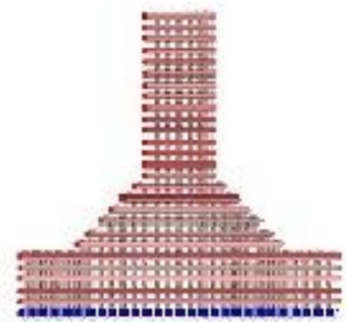
Braided profile



3-d woven on 2-d loom



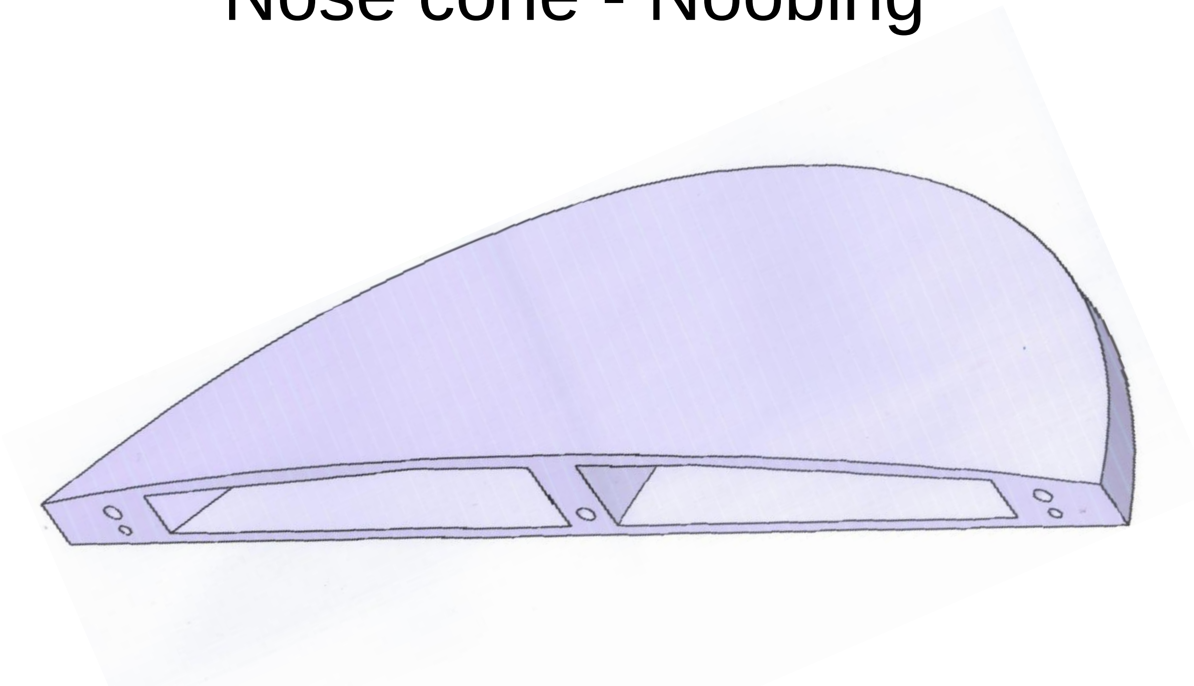
3-d woven on 3-d loom



3-d NOOBED profile

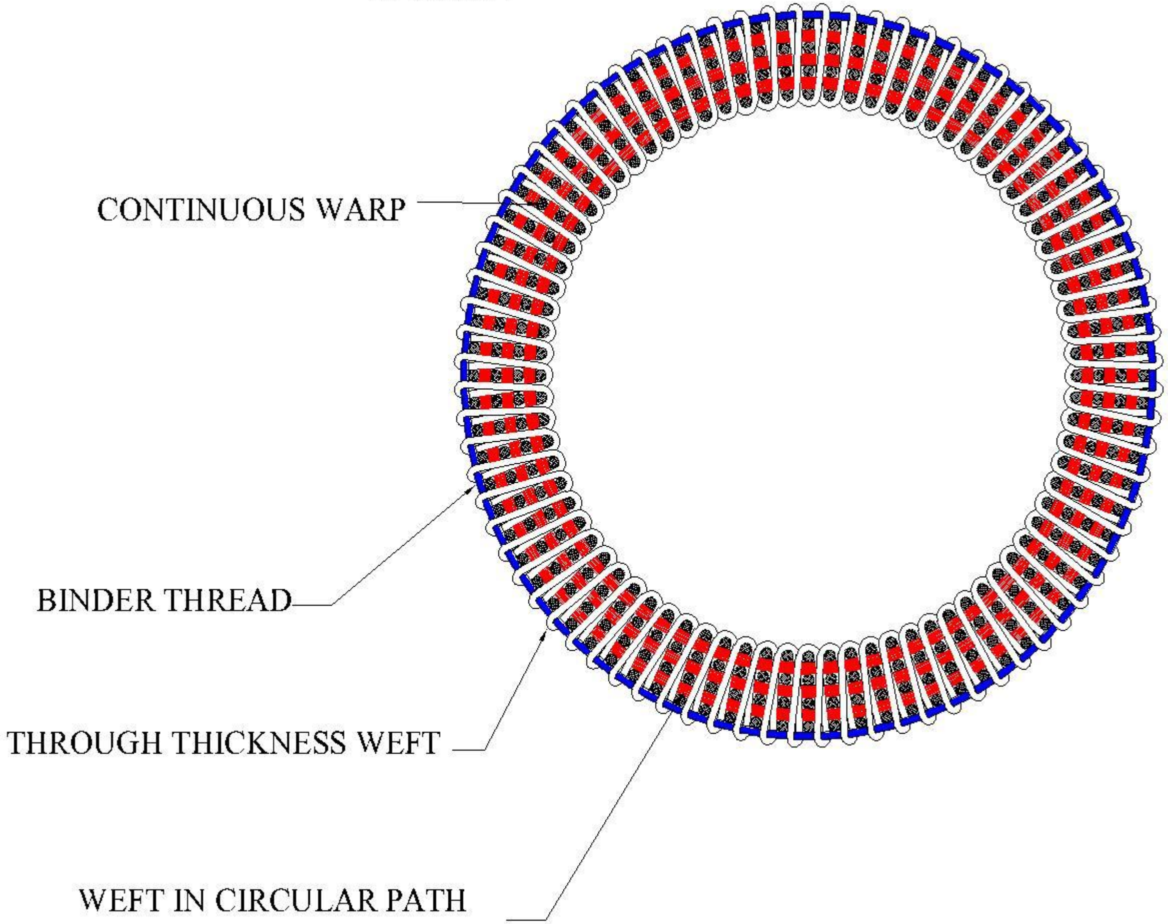
3D Near-Net Preforms developed by KALE TEXNIQUE

Nose cone - Noobing

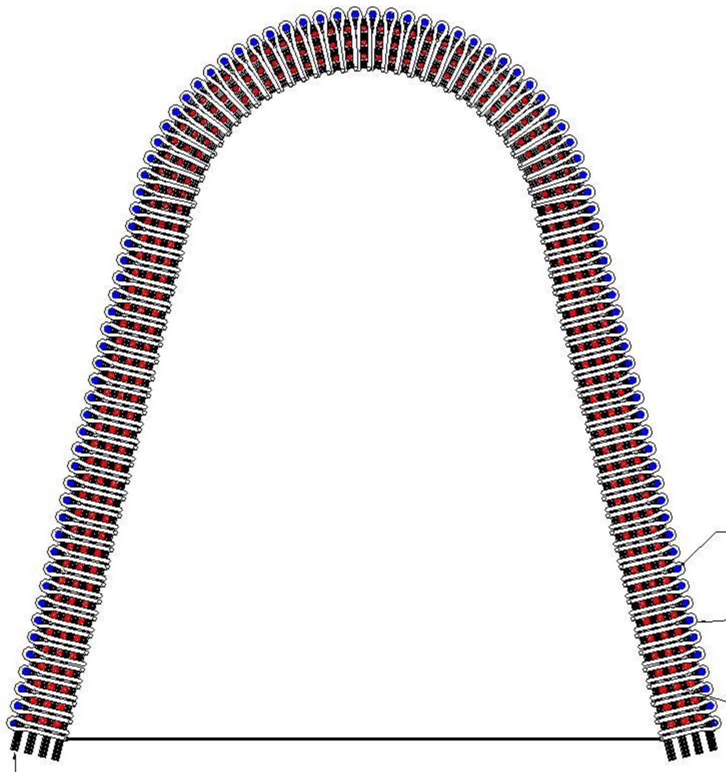


Fighter aircraft nose

HORIZONTAL SECTION OF HOLLOW CONE/ DOME

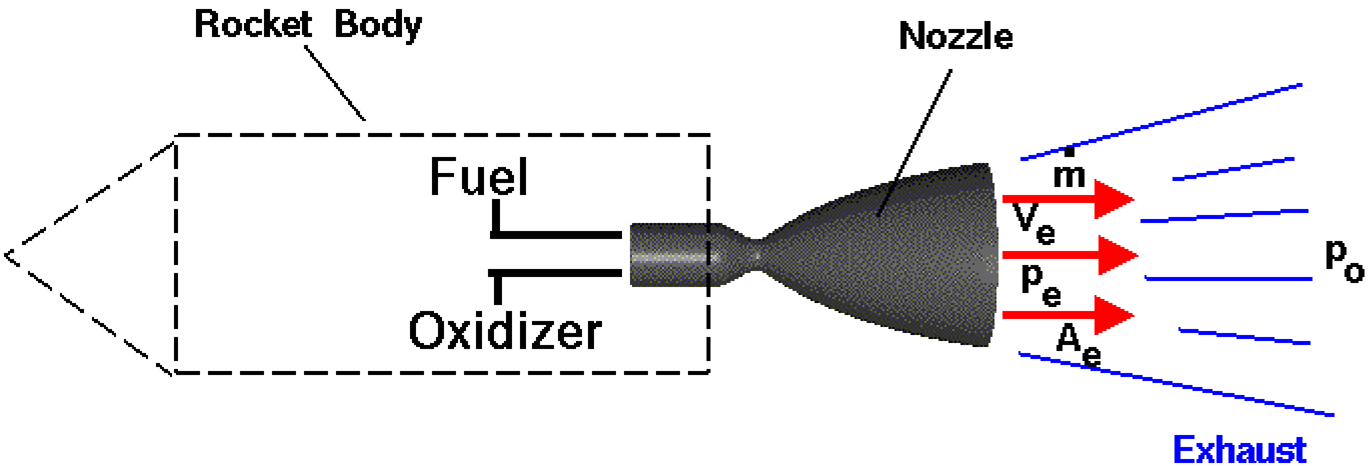


VERTICLE SECTION OF
HOLLOW CONE/ DOME



ROCKET NOZZLE SHAPE, 4 WARP LAYERS-12K, 3 WEFT LAYERS-12-K, THROUGH THICKNESS-3-K,NOOBED

Nozzle of the Rocket



BEND PIPE WITH FLANGES . FLANGES ARE WITH BUILT IN HOLES

Helmet

TUBE WITH 4 LAYERS ALL 3-K CARBON, 25 MM DIA , 4 WARP LAYERS,3 WEFT LAYERS, STITCHED NOOBED

SQURE TUBE WITH FILLATE AT THE CORNERS– IN 12K CARBON ,

8 LAYERD IN 3 K CARBON

THICK TUBE, 14WARP, 14 WEFT AND THROUGH THICKNESS- ALL 12-K, ADDITIONAL 2 LAYERS +/- 45 DEGREE THREADS , LENGTH CAN BE UP TO 1 METER

CONE- WARP-4 LAYERS 12 K, WEFT 12K 3 LAYERS, LOCKING THROUGH THICKNESS THREAD 3K

CONE IMREGNATED

KALE TEXNIQUE

THANKS

MACHINE DESIGNERS AND MANUFACTURERS

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