PARAMETRIC STUDY AND FABRICATION OF A COMPOSITE TABLE TENNIS BAT

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

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UNDER THE ESTEEMED GUIDANCE OF

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DEPARTMENT OF MECHANICAL ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (AUTONOMOUS)

(Permanently Affiliated to Andhra University, Approved by AICTE, and Accredited by NBA & NAAC with 'A' grade) SANGIVALASA BHEEMUNIPATNAM (MANDAL) - 531162,VISAKHAPATNAM (DIST.), ANDHRA PRADESH, INDIA.(2017-2020)

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SANGIVALASA, VISAKHAPATNAM (District) – 531162

CERTIFICATE

This is to certify that the Project Report entitled **"PARAMETRIC STUDY AND FABRICATION OF COMPOSITE TABLE TENNIS BAT"** being submitted by DHANISETTI SAI PAVAN (317126520073), SIDDDHABATTULA DHEERAJ (317126520115), GAVARA AJAYBABU (317126520081), BHUSHI DIVYA TEJ (317126520066), ANKAMREDDY MANOJ KUMAR (317126520064) in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING**. It is the work of bona-fide, carried out under the guidance and supervision of **DR.RAJESH GHOSH**, Associate Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2017-2021.

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Last but not least, we would like to convey our thanks to all who have contributed either directly or indirectly for the completion of work.

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ABSTRACT

This study is concerned with the composite materials used in the fabrication of Table Tennis Racket.Table tennis racket blades are made of an assembly of several wood layers (3, 5 or 7). The layers are of different wood essences, and other fiber orientations of successive layers are perpendicular most of the time. Hence, the blades appear to be made of a composite material.

The performances of a table tennis racket can be qualified with several adjectives like: fast, slow, stiff, adhesive, controllable, etc. These qualifications are subjective since they are relative to the sensory analysis made by each player.

The best suited wood layers are combined with the adhesive glue to form a composite paddle. Different materials used for paddle and sponges and their effects are studied.

The results obtained permit to clearly state the effectiveness of these design parameters on the impact sound and materials for producing a bat.

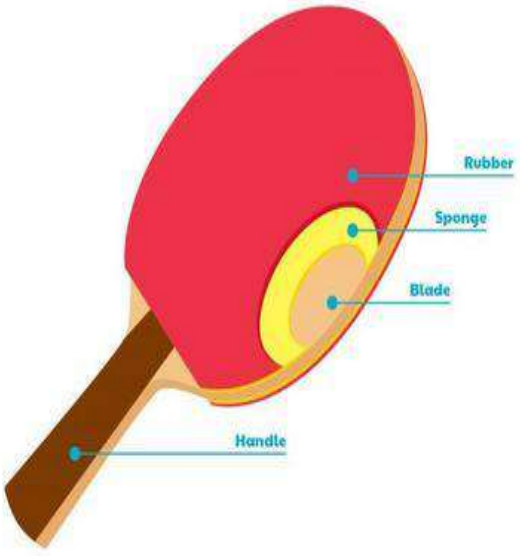

Fig 1:Table tennis bat and its parts

INTRODUCTION

The performances of a table tennis racket can be qualified with several adjectives like: fast, slow, stiff, adhesive, controllable, etc. The influence of the blade plywood composition is studied. The study presented here is concerned with the parametric of table tennis racket at ball impact and more specifically on the influence of the racket blade plywood composition: type of woods, thickness of the plies. The blade plywoods tested differed by the thickness of the plies and/or their wood essence

Table tennis racket blades are made of plywood that can be composed of at least 3 to a maximum of 9 layers. . The central ply has usually the largest thickness, and then the other plies have similar thickness values.

Our study is based on composites used in table tennis bat. Composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents. Weight of the bat, stiffness, balance ,speed, number of layers, types of woods used play a major role in table tennis bat .

The term keeps changing depending on the country where it is played. As for Britain, it is a bat; in the USA, it is called a paddle. The term followed by ITTF is racquet.
The racquet is laminated and covered with rubber on either side or on both sides depending on the player. The player based on his/her grip decides whether they need the rubber on either or on both sides.

The handle of the racquet is called a blade. This blade could be made of many different materials varying from glass fiber, cork, carbon fiber, Kevlar to aluminum fiber. But ITTF recommends that at least 85% of the pThe term keeps changing depending on the country where it is played. As for Britain, it is a bat; in the USA, it is called a paddle. The term followed by ITTF is racquet.

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Table tennis-terminology

Many terms are used in a table tennis game to describe points, fouls, etc. A list of some of the frequently used terms is given below.

Heavy — Used to describe a strong spin.

Blade — Wooden part of the racquet.

Anti-spin — A defense spin used to confuse the opponent or even as a reaction to one strong spin. Top-level players rarely use this technique, but it is very famous among amateurs. Player uses the pimple side of the rubber of the racquet.

Inverted rubber — Smooth side of rubber which is used to play and the pimpled side is glued to the bat. The smooth side gives more spin as there is a larger contact area.

Pimples (Pips) — Rubber side of the racquet that gives different spin effects unlike inverted rubber. There is not much contact surface on this side of the racquet.

Crossover — Change of stroke from forehand to backhand. A player needs to change his/her stroke as this is often an easy target for attack. It is not easy to return a service in this area.

Tight — A strong return which is difficult for the opponent to handle. It is usually a combination of spin and strong stroke.

Loose — A weak return that has insufficient spin or stroke or both, and is easy for the opponent to play.

Early — This is to refer to raising the ball.

Late — The fall of balls bounce.

Loop — A strong stroke that usually overpowers the spin of the incoming ball.

Multi-ball — A ball robot or another player continuously feeds another player in training. This method is used to reduce time waste.

Penhold — This is a style used to hold the paddle. This resembles t-holding a pen.

Shakehand — Holding the paddle with index finger perpendicular to handle. This is the most common way of holding the racquet and it resembles the holding of racquet in tennis.

Sandwich rubber — This is to describe inverted rubber with sponge

Speed glue — As the name implies, it is a glue with high volatile solvents, used to glue a sponge of rubber to the blade (the wooden part of the racquet). It increases the speed of stroke.

Third ball — This is a stroke that's hit by a server in response to the opponent's stroke after serve. This is the first attacking stroke in a table tennis rally.

Concerning the table tennis racket, the sport engineering community has mainly focused its studies on the ball-racket impact analysis and prediction . For the player, the performance of a racket depends highly on the performance of the rubbers glued on each side and characterized by a restitution coefficient.

Another factor to appreciate a racket is the sound produced at the impact. This sound is directly related to the racket blade vibrations and therefore it depends on the blade plywood composition. The tennis table racket blades are made of plywood composed of several plies of different woods. Each blade on the market has its proper composition defined by the number of plies, their woods and thickness. Recently some carbon plies have been introduced in the plywood to increase the blade stiffness and therefore the
racket speed. These types of blades address competitors which are expecting precise characteristics and performances for their rackets. The rackets can be qualified as: fast, slow, controllable, soft, stiff, flexible, powerfull, precise, easy to play, tolerant, dynamic, etc. All these adjectives qualifying the racket performances are subjective and related to the player feeling. It appears that the blade performances are closely linked to its dynamic behavior.

About ping pong paddle

A Table Tennis blade is the core of a table tennis racket and there are various types of wood that are used in designing table tennis rackets.
These days table tennis blades consist of various layers of wood and carbon to improve strength of the racket and reduce vibrations.
Table tennis in general is considered a lightweight game but the right amount of strength is also important with the right amount of control to hit spins within a table.

There are various types of blades with different layers and properties. Most commonly used blade are-

- 1 Layer all-wood Blade
- 3 layer all-wood Blade
- 5 layer all-wood blade
- 7 layer all-wood blade
- 3 Layer wood + 2 layer Carbon

Dimensions for table tennis bat

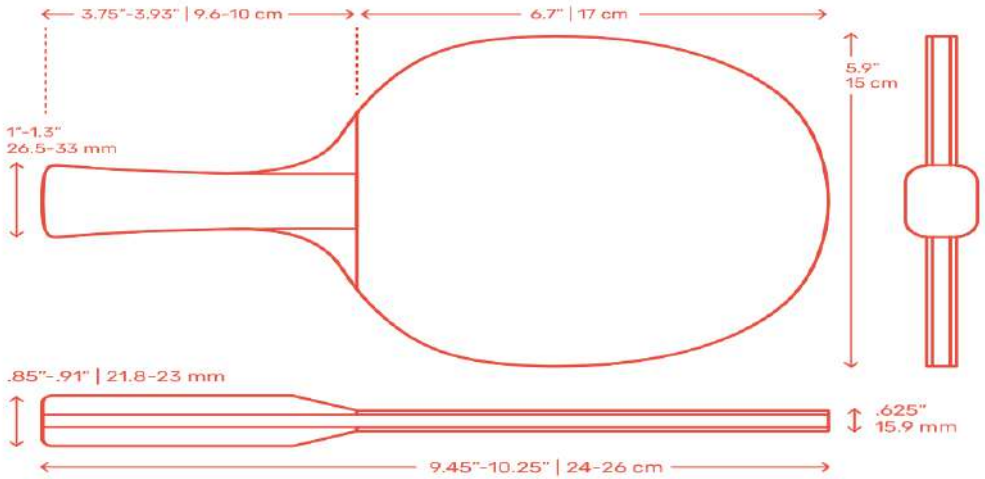

FIG.2:Dimensions and contour of tt bat

Composite material

A composite material is a combination of two materials with different physical and chemical properties. When they are combined they create a material which is specialised to do a certain job, for instance to become stronger, lighter or resistant to electricity. They can also improve strength and stiffness.

(0r)

Composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents.

Classification of composites

There are two classification systems of composite materials. One of them is based on the matrix material (metal, ceramic, polymer) and the second is based on the material structure.

Classification of composites I(based on matrix material)

- Metal Matrix Composites (MMC)
- Ceramic Matrix Composites (CMC)
- Polymer Matrix Composites (PMC)

Classification of composite II (based on reinforcing material structure)

- Particulate Composites
- Fibrous Composites
- Laminate Composites

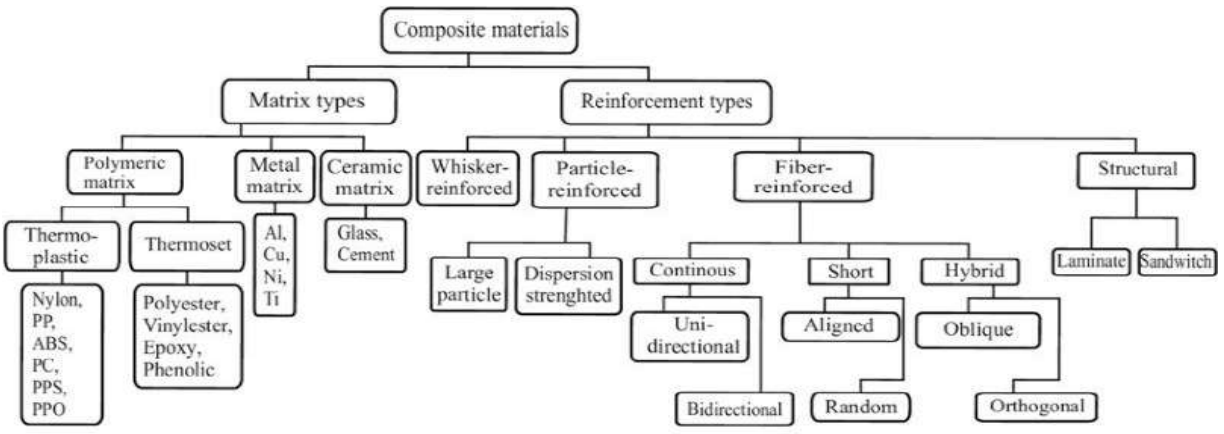

Fig.3:Classification of composite materials

Different types of composite materials:

Reinforced concrete and masonry.
Composite wood such as plywood.
Reinforced plastics, such as fibre-reinforced polymer or fiberglass.
Ceramic matrix composites (composite ceramic and metal matrices)
Metal matrix composites.
and other advanced composite materials.

Constituents in a composite material

Matrix phase

The primary phase, having a continuous character, is called matrix. Matrix is usually more ductile and less hard phase. It holds the dispersed phase and shares a load with it.

Dispersed (reinforcing) phase

The second phase (or phases) is embedded in the matrix in a discontinuous form. This secondary phase is called the dispersed phase. Dispersed phase is usually stronger than the matrix, therefore it is sometimes called the reinforcing phase.

Functions of a reinforcement:

- Contribute desired properties
- Load carrying
- Transfer the strength to matrix

Functions of a matrix:

- Hold the fibres together.
- Protects the fibres from the environment.
- Protects the fibres from abrasion (with each other).
- Helps to maintain the distribution of fibres.
- Distributes the loads evenly between fibres.
- Provides better finish to the final product.

Desired properties

- Strength Stiffness Toughness
- Corrosion resistance Wear resistance Reduced weight Fatigue life
- Thermal/Electrical insulation and conductivity Acoustic insulation
- Energy dissipation

Advantages of Composite Materials:

Design Flexibility
Low cost per cubic inch
Lower material costs Improved productivity Corrosion Resistance
High Flexural Modulus to Carry Demanding Loads Durable
Lighter Weight than Metal

Disadvantages of Composite Materials:

Technique sensitive.
Placement takes longer than amalgam and other restorative materials.
Risk of microleakage and secondary caries. Meticulous oral hygiene maintenance needed.
Lower fracture toughness, cannot be used in areas of high occlusal stress.

Applications

Aerospace Automotive/Transportation/Farm/Construction Civil Infrastructure
Corrosive Environments Electrical
Marine

Hand lay-up technique

The manufacturing **process** known as '**hand layup**' involves manually laying down individual layers or 'plies' of a form of reinforcement known as 'prepreg'. This consists of thousands of fibers, which are pre-impregnated with resin and bundled into tows and arranged either in a single unidirectional ply or woven together.

The **layup process** involves manipulating each ply into shape by **hand** and then firmly stuck to the previous layer or mold surface leaving no air pocket between plies. This can produce high-quality complex features, has relatively low start-**up** costs, and is highly adaptable to new parts and design changes.

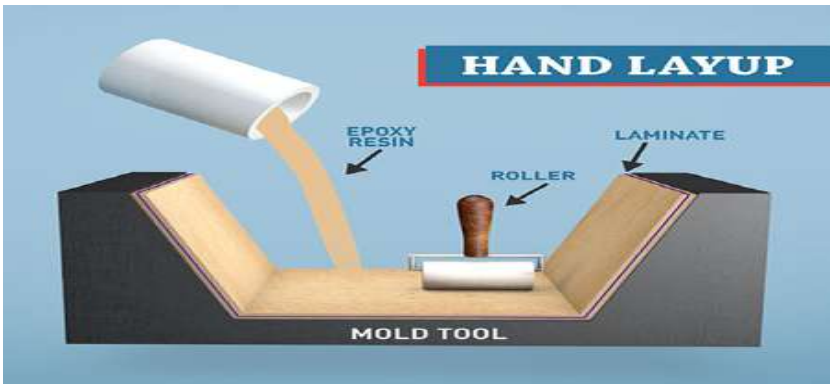

FIG.3:Hand lay-up process

This process is used to make both large and small items, including boats, storage tanks, tubs and showers. **Hand lay-up** is an open molding method suitable for making a wide variety of composites products from very small to very large.

Composite lay-up

Composites are engineered materials composed of a matrix material (e.g. polyester or epoxy resins) and a reinforcing material (e.g. glass mat or woven fabric). The process of making a composite is termed Composite Layup, which is derived from the original method of making these materials.

Curing method

Mixing **epoxy resin** and hardener begins a chemical reaction that transforms the combined liquid ingredients to a solid. The time it takes for this chemical transformation from liquid to solid is called cure time. As it cures, the **epoxy** passes from the liquid state, through a gel state, before it reaches a solid state.

Fig.4:Curing process

Epoxy resin systems consist of two parts, an “A” and a “B” side. The B side, also known as the “**hardener**”, is the **epoxy curing agent**; the **curing agent** is responsible for reacting with the **epoxy** groups contained in the **epoxy resin** A side. Reaction of **curing agents** with **epoxy** resins results in hard, thermoset materials.

The **resin** reaches 95% of its full **cure** within 24 hours, and 100% of its **cure** within 72 hours.

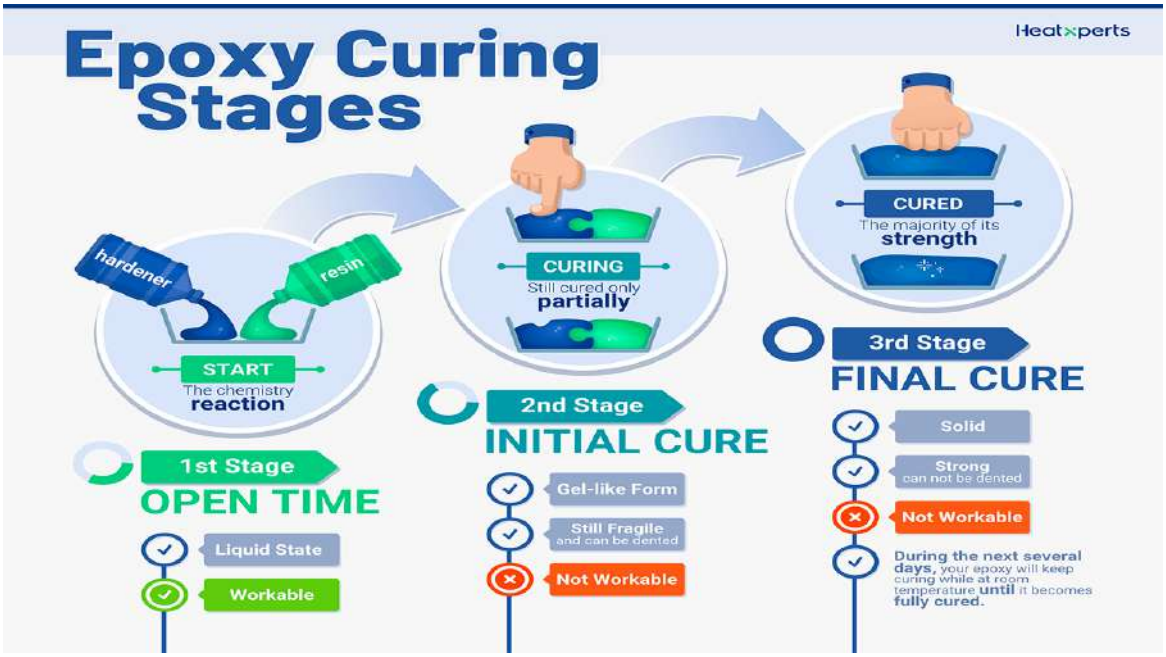

Fig.5:Epoxy curing stage

Literature review

1.Vibrations of table tennis racket composite wood blades

Lionel Manin,(2012)

This study is concerned with table tennis rackets used in competitions. Table tennis racket blades are made of an assembly of several wood layers (3, 5 or 7). The layers are of different wood essences, and the fiber orientations of successive layers are perpendicular most of the time. Hence, the blades appear to be made of a composite material. A finite element analysis was conducted on the modeling of the racket blade. The questions relative to the detailed modeling of each wood layer is discussed versus the modeling of only one homogenized layer. The model considered orthotropic properties for the wood material. The comparisons between vibration modes and frequencies obtained by simulation and experiment permit to validate a FE model for the racket blade. It takes into account the orthotropic property of the composite wood that constitutes the blade.

2.A pilot study on characteristic of table tennis bat rubber

Zhang Wei-bing,(2014)

This study is concerned with the characteristic of table tennis bat rubbers.The blending ratio of styrene butadiene rubber and natural rubber was very important to table tennis bat's rubber. The purpose of this study also investigated the performance of rubber rackets due to the material changing. The results reflected that natural rubber and styrene butadiene rubber blends had best compatibility at a ratio of 82/18. Considering the performance and cost synthetically, the amount of calcium carbonate should be moderate. The aim of this research is to explore the influence of the proportion of adhesive, accelerant and gross dosage of filler calcium carbonate on performance of NR SBR blend rubber.

3.Prediction of Table Tennis Racket Restitution Performance Based on the Impact Analysis

Yoshihiko KAWAZOE* and Daisuke SUZUKI**

This paper investigated the physical properties of the racket and the ball, and predicted the impact force, the contact time, the deformation of ball and rubber, the coefficient of restitution and the racket rebound power associated with the frontal impact when the impact velocity and the impact location on the racket face are given. This study is based on the experimental identification of the dynamic characteristics of the ball-racket- arm system and an approximate nonlinear impact analysis, where the contact time is determined by the natural period of the whole system composed of the mass of the ball, the nonlinear stiffness of the ball and rubber, and the reduced mass of the handled racket at the impact location on the rubber face. Also considered is the energy loss during the impact. It was found that the racket rebound power peaks when the hitting point is 16 cm from the grip end of the racket and then decreases because of the mass distribution of the racket. The racket rebound power decreases remarkably with increasing impact velocity.

4.Vibro-acoustic of table tennis rackets at ball impact: influence of the blade plywood composition

Lionel Manina*, Florian Gaberta, Marc Poggib, Nicolas Havardc

This study has shown experimentally there is a correlation between the vibration and acoustic behaviors of a table tennis racket blade at ball impact.Two vibrations modes are mainly responsible for the racket acoustic, there are the chips and membrane modes. The influence of the rubbers on the frequency spectrum was analyzed, they add some mass and damping to the racket and therefore the frequency peaks are shifted toward low values but the mode shapes are the same. Each racket tested has been characterized by its acoustic and vibratory signatures. Modal analysis was performed on the racket blades to clearly identify the vibration modes. The composition of the plywood has a great influence on the vibro-acoustic spectrum and on the modes' shape. A sensory analysis, implying players, has been conducted.

Table Tennis Bat:

It's made up of multiple layers of compressed wood, and sometimes includes layers of carbon fibre, glass fibre, texalium, titanium, aluminium, synthetic, arylate, aramid, and kevlar.
According to the International Table Tennis Federation (ITTF) regulations, at least 85% of the blade must be of natural wood.
A Table Tennis Bat Consists of 3 parts:

- The Blade
- Rubber
- Glue

Fig.6:Table Tennis bat

THE BLADE

The wooden portion of a table tennis bat is referred to as the “blade”. It's made up of multiple layers of compressed wood, and sometimes includes layers of carbon fibre, glass fibre, texalium, titanium, aluminium, synthetic, arylate, aramid, and kevlar.
According to the International Table Tennis Federation (ITTF) regulations, at least 85% of the blade must be of natural wood.
Blades consist of a flat paddle area for striking the ball, and a handle to hold the bat. The weight and materials of blades influences the desired style of play — such as attacking/offensive, defensive, or all-around. Changing the blade enables players to adapt their levels of power and control over the ball.

Fig.7:Blade

Types of Table Tennis Blades:

The type of blade you choose will depend on your play style, so you need to select a combination of wood layers for your blade.

Table tennis equipment suppliers have different categories of the blade so you can be able to choose a blade that fits your game.

There are three main types of ping pong blades:

- Defensive blade
- Offensive blade
- All-around blade

Defensive Blade

The defensive blades are for players that play defensive games. It is a slow kind of blade and heavy in weight.

Offensive Blade

The offensive blades are used by players who use the attacking kind of play. It is a very fast blade and light in weight.

Allround Blade

The all-round blade is used by intermediate players who play the not too fast and not too slow game; they are in between the offensive and defensive kind of gameplay. It is perfect for beginners

EFFECT OF BLADES

Weight

Generally lighter blades tend to be slower and suit all-round or defensive playing styles. Heavier blades tend to be faster and suit offensive attacking players. Lighter table tennis blades can usually be swung more quickly, but heavier blades have more mass to use when hitting the ball.

STIFFNESS

The stiffness of the blade refers to the amount of elasticity or flex the blade has. A stiffer table tennis blade will generally be faster but less spiny than an elastic blade. It is very important to consider which table tennis rubber you use when choosing your table tennis blade. Our equipment experts at Topspin find that a very effective combination is with soft sponge rubbers to choose a stiff fast blade and with hard sponge rubbers to choose a more elastic blade.

BALANCE

The balance of a blade refers to whether the centre of gravity of the blade is closer to the handle or the top of the head. Topspin and counter attackers tend to prefer head-heavy blades which help them generate that little bit of extra spin and speed, while blockers and defenders often prefer blades with the centre of gravity towards the handle, which can increase the feeling of the ball. Bear in mind that the weight of your rubbers can also affect the centre of gravity of your table tennis blade - heavy rubbers will tend to move the centre of gravity out towards the top of the racket head.

SPEED

It is very important to choose the right speed of your blade to suit your playing style. Generally faster blades tend to be used by the more aggressive players and slower blades by the more defensive. Each blade is graded for speed and control on our website - the higher the number rating the faster the blade. Players often like to choose the fastest blade possible but don't forget that with an increase in speed you also sacrifice control. You may be an offensive player who likes to hit the ball very hard but if you find the ball shooting off the end of the table tennis table you may want to choose a slightly slower blade. For example many of the best players in the world hit the ball incredibly hard but don't use the fastest possible blades — Dima Ovtcharov current world no. 7 uses the DONIC Ovtcharov Senso V1 Blade which is only 7th fastest in our range of blades.

HEAD SIZE

The difference in air resistance between large headed table tennis blades and smaller headed blades is very small. The main difference is that larger rackets require more rubber to cover the surface, which makes the bat heavier and also tends to move the centre of gravity of the blade away from the handle.

LAYERS/PLIES

There are two things to consider when talking about the layers of your table tennis blade. The first is the number of layers in the blade, and the second is what the layers are made from. The number of layers in the blade can vary from 1 to usually a maximum of seven. Three and five ply blades are also popular.

According to rules of table tennis at least 85% of the blade thickness must be natural wood. The other 15% of the blade can include layers made of such material as carbon fibre, aralyte, or glass fibre.
The effects of these materials are that:

- Carbon strengthens and stiffens the blade, while also increasing the speed and the size of the sweet spot of the blade.
- Aralyte is meant to also increase the size of the sweet spot, but is supposed to dampen vibration and give a softer feel than carbon.

TYPES OF WOODS

- LIMBA
- BALSA
- HINOKI
- KOTO
- AYOUS
- KIRI
- SPRUCE
- LIMBA

A large tree in the family Combretaceae, native to tropical western Africa. The wood is either a light (white limba) or with dark stripes (black limba or korina) hardwood. Limba has excellent acoustic properties, and so good vibrations which make this wood excellent for table tennis blades. The thinner veneers of limba that are being used in table tennis blades are popular for topspin games. The wood gives good acoustic click sound when used with softer rubbers and its vibrations or flex is liked by topspin players. The more the thickness, it increases the hitting ability.

BALSA

Fig.8:Balsa wood

Forest tree of lowland Central America. As it is low-density but high in strength, balsa is a very popular material to use when making light, stiff structures. It has a typical density of about 160 kg/m³. In blades Balsa is often combined with carbon + 2 outer plies of plywood, to make the blade light and fast at the same time.

HINOKI

Fig.9:Hinoki wood

A species of cypress native to central Japan. The wood is lemon-scented, light pinkish-brown, with a rich, straight grain, and is highly rot-resistant. Hinoki has the property of being very soft with a nice soft touch in short, but very fast when hitting.
The biggest drawback is probably weight, that is apart from its scarcity and cost.

KOTO

Fig.10:Koto wood

The wood is tight and rather solid. It has a nicely striped, decorative design and therefore is often used as surface veneer (with a thickness of 0.7/0.8 mm.

AYOUS

Fig.11:Ayous wood

The high elasticity of this African wood gives quite a nice bounce effect when inside the blade. It is not that great a top veneer wood as it is not very pliable. Seemingly ayous is more often used in Asian blades, whereas Limba is used in European blades. There are exceptions though.

KIRI

Fig.12:Kiri wood

A light weight, soft but very tight and torsionally stiff type of wood, mainly used as core veneer. Almost every Butterfly table tennis blade that is made in Japan has a Kiri core. More durable, heavier and harder than balsa. This is one of the main reasons why Butterfly blades are heavier than other manufacturers' blades.

SPRUCE

Spruce is an amazing ply that results in good feedback and generates a unique sound when the ball is hit.
Some of the rackets use hybrid wood such as:

- ARYLATE
- ARAMID

Fig.13:Spruce wood

- CARBON
- FIBERGLASS
- ZL CARBON

Physical Properties of Wood:

Color,luster,texture,macro-structure,odor,moisture,shrinkage,internal stresses,swelling,cracking,warping,density,sound-electro-thermal conductivity.
Color,shine,texture and macro-structure determine the appearance of wood.
Wood of different breeds are different from white-aspen,spruce to black-ebony.Tannins,resin and pigments,found in cell cavities, make wood more colorful.

Plywood

Plywood is a material manufactured from thin layers or "plies" of wood veneer that are glued together with adjacent layers having their wood grain rotated up to 90 degrees to one another. It is an engineered wood from the family of manufactured boards which include medium-density fibreboard (MDF) and particle board (chipboard).

Types of plywood

Softwood plywood Hardwood plywood Tropical plywood Aircraft plywood
Decorative plywood (overlaid plywood) Flexible plywood
Marine plywood

VARIOUS CARBON FIBERS PLIES USED IN TABLE TENNIS BAT

CARBON KEVLAR:

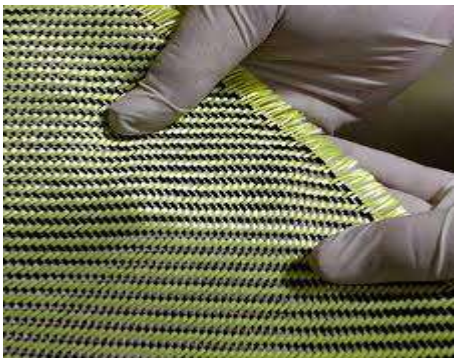

Fig.14:Carbon kevlar

Kevlar fiber has a tensile strength comparable with that of carbon fiber, a modulus between those of glass and carbon fibers and lower density than both. Kevlar aramid is used for high-performance composite applications where lightweight, high strength and stiffness, damage resistance, and resistance to fatigue and stress rupture are important.

CARBON GLASS FIBER:

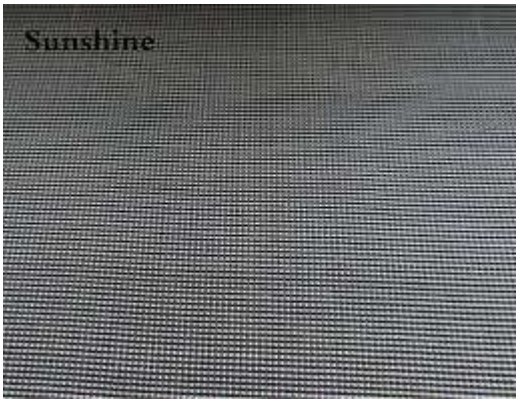

Fig.15:Carbon glass fiber

As the names imply, fiberglass is made of small strands of glass that have been melted down, while carbon fiber is made of small strands of carbon atoms. Both materials can then be combined with an epoxy resin to create a stiff product that can fit any shape or mold.

RX CARBON:

RX Carbon is a company with many years of experience manufacturing products from composite materials and plastic. We are working with one time projects as well as bulk orders producing moulds and parts from fiberglass, Aramid and Carbon. The company has a lot of experience in the automotive industry as well as non-standard projects.

MELIORATE CARBON:

The carbon meliorate is a harder lightweight carbon variation of the popular Arylate carbon. The carbon layers are close to the surface of the blade giving it an extra large sweet spot.

ZYLON CARBON:

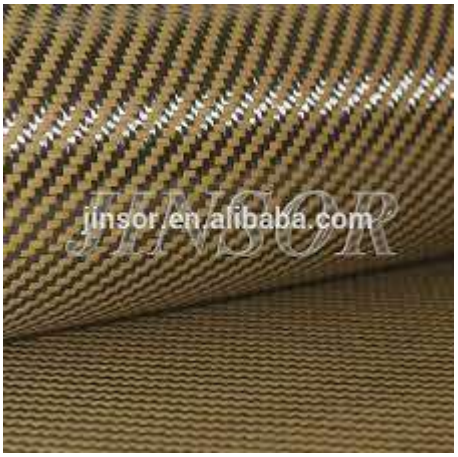

Fig.16: Zylon Carbon

Zylon is an exotic super fiber that is actually stronger and stiffer than most carbon fiber with a toughness similar to Kevlar. Combining materials such as Zylon and Carbon Fiber result in composite materials with unique and useful physical characteristics. Epoxy: PRO-SET INF-114, INF-213. Glass Transition Temperature Tg Onset: 177°F (81°C).

ARAMID FIBRE:

Fig.17:Aramid Fibre

Aramid" is formed from "aromatic polyamide".Aramid fiber is produced by spinning a solid fiber from a liquid chemical blend. This causes the polymer chains to orientate in the direction of the fibre increasing strength.Para-aramid fibers such as Kevlar® and Twaron®, which are slightly different, have outstanding strength-to-weight properties, and have high tenacity which makes it difficult to cut or fray.High Rigidity Young's modulus (stiffness): 130-179 GPa compared to carbon Fiber 300 GPa and glass 81 GPa, low elongation to Break (does not stretch much).

BALSA CARBON:

Fig.18:balsa Carbon

The unique carbon/balsa design makes our ping pong paddle both lightweight and thicker for improved striking. This gives you the best of both power and control. These rackets are great for kids, amateurs and professionals alike, making them ideal for home play, practice, tournaments, and all-around use.

Handles for table tennis bat

Table tennis handle is a very important part of a blade since this provides the connection between your palm and the blade. This is what delivers the signal of ball touch into your hand and it makes it possible to get the feel. We devoted as much time as possible to the blades' body laminating to provide maximum collaboration. Handle is not a piece of wood that is glued onto the laminated wood. It is a far more important part.

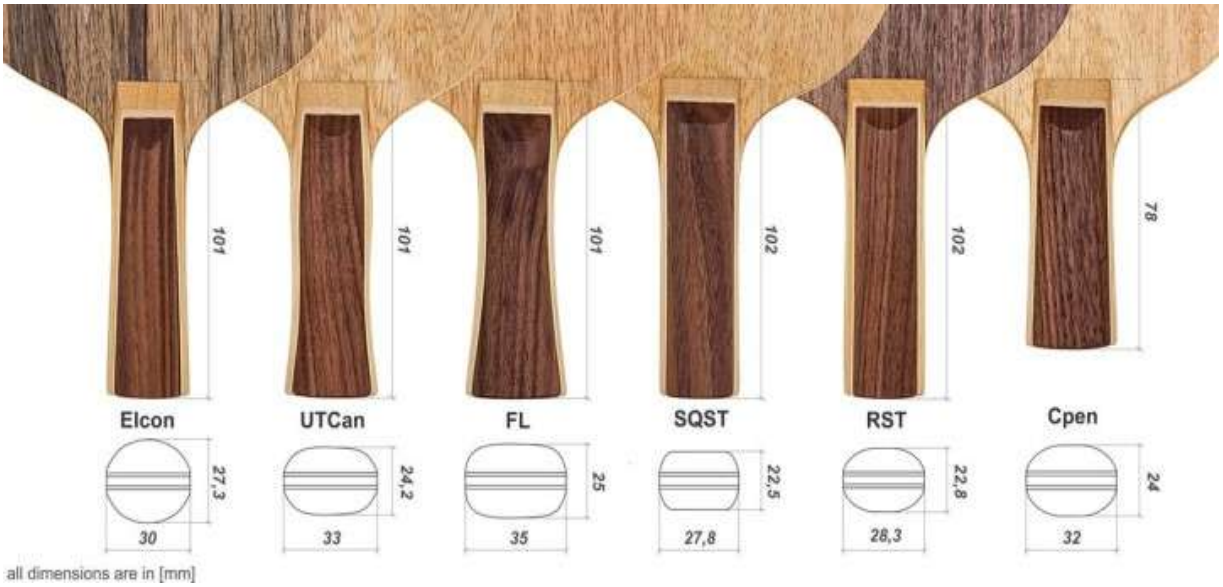

Fig.19:Handles with measurements

Fig.20:Types of handles

Flared

The flared handle has a gravity center that is closer to the grip and the blade fits in the palm of a hand. This handle provides confidence in your hand. That's why the Flared handle is great for a forehand dominant player, who prefers using powerful strokes at mid-distance.

Anatomic

An anatomic handle is like the flared handle but with an extra widening region in the middle. Some players prefer this handle for better grip to fit the contours of the hand.

Straight

Straight handle (ST), both Round Straight Handle (RST) or Square Straight Handle (SQST), good for control style. Smooth backhand-forehand transition. European players prefer using this type of handle. It provides Balance between Backhand and Forehand Power.

GRIPS

Competitive table tennis players grip their rackets in a variety of ways.The manner in which competitive players grip their rackets can be classified into two major families of styles; one is described as penhold and the other shakehand. The Laws of Table Tennis do not prescribe the manner in which one must grip the racket, and numerous variations on gripping styles exist.

Penhold grip

The Penhold grip is named this way because of the similarity to the way pens are held. Penhold grip styles have suffered in recent years due to their inherent weakness on the backhand side. This weakness makes it much harder for penhold beginners to perform well against their shakehand counterparts. However, this has not stopped the top penhold players from winning the World Championships, the World Cup and the Olympic Games regularly, as the backhand weakness can be covered adequately with excellent footwork, or supplemented with the recent reverse penhold backhand loop innovation.

Shakehand grip

Possibly the oldest surviving grip since the table tennis racket took its current shape. This is similar to a tennis grip with the index finger extended over the racket head perpendicular to the handle. This grip allows almost even power distribution over forehand and backhand shots, but has a wider crossover point in between.

Virtually all European players and roughly two thirds of Asian players use this grip.

Unusual grips

Although the vast majority of the players grip the racket in one of the two styles above, there are some curious grips that have not proven their effectiveness in the higher level yet, and are very rare.

V-grip

An experimental style being developed in China, it is held by forming a "V for victory" sign and gripping the blade between the forefinger and middle finger while having the other fingers rest under and on top of the handle; it requires a modified blade to grip successfully. This grip produces a noticeable spin benefit due to the longer lever and mechanics utilized in the forehand and backhand (much like those found in the Western grip in tennis).

Seemiller grip

A grip that was made famous by Dan Seemiller, an American champion. This grip is a variation of the shakehand grip, but closely resembles the western grip used by many tennis players. In the Seemiller grip, the tip of the forefinger is placed so it reaches near the edge of the bat (or, in the case of another American champion, Eric Boggan, actually wraps around the edge of the bat). This enables Seemiller-grip players to get tremendous snap on their forehand strokes. However, it also makes it awkward to hit shots using a traditional backhand, using the opposite side of the racket. So, instead, Seemiller-style players hit their backhands with the same side of the racket as they hit their forehands, turning their wrists over the way a baseball player would to make a backhand catch, and typically blocking or counter-hitting the ball. Since they would otherwise use only one side of their racket to hit all their shots, Seemiller-style players often put a rubber with very different playing characteristics on the other side of their bat, commonly a low-friction "anti-spin" rubber that they use to return spinny serves or to abruptly change the pace of the ball during a rally. Seemiller, in fact, is credited with virtually inventing the combo bat, a racket with different types of rubber on each side. This grip also has the nickname "windshield wiper" due to the motion of the backhand and forehand.

Penhold styles

Looper

Penhold loopers utilise the forehand topspin loop as their primary shot. This type of player usually exhibits excellent footwork, trying to use the forehand to cover the entire table. Compared with shakehand loopers, penhold loopers have a shorter reach and try to stay close to the table even during power exchanges. Notable penhold loopers are 1981-83 World Champion Guo Yuehua, 1988 Olympic Gold Medalist Yoo Nam-kyu, 1992 Olympics Men's Doubles Gold Medalist Lü Lin, 1992 Olympics Bronze medalist Kim Taek-soo, 2001-03 World Men's Doubles Champion Yan Sen, 2004 Olympic Gold Medalist Ryu Seung-min, 2008 Olympic Gold Medalist Ma Lin, 2009 World Champion Wang Hao, and 2015 Men's and Mixed Doubles Champion Xu Xin.

Counter Driver

The penhold advantage of a small crossover is fully utilised in this style. Staying close to the table, counter drivers block and drive the opponent's topspins back across the table at speed, trying to force them out of position or look for the opportunistic forehand kill. Counter drivers usually have a safe forehand loop as well, in case the opponent is a chopper and doesn't give topspins or easy kills readily.

Pimpled Hitter

The traditional penhold style. Pimpled hitters play over the table, hitting the ball as soon as it bounces off the table with the pimples taking care of most of the problems caused by the opponent's spin. The aggressive attacking can win points easily in the first few returns, but the lack of a topspin Magnus effect means that the attacks are less effective when the opponent is forced back.

Shakehand styles

Looper

Shakehand loopers apply pressure and win points primarily with speed and spin loops from the forehand. After the opening exchanges, when the first attack has been made, loopers will attack with a variety of topspin shots varying in speed and spin, maneuvering their opponents around the table and looking for outright winners. The power and reach of a shakehand looper means that they can counterloop even when forced back from the table, which can be quite a spectacle when a lobbying looper forced back by smashes suddenly attacks in an attempt to regain initiative.

All-round Attacker

Like a looper, the all-round attacker uses the loop as a primary weapon. In addition, an equally effective backhand increases the chances of having the first attack, and the number of angles that could be attacked. While this potentially means that the player could get confused whether to attack using the forehand or backhand, most players tend to use the more powerful forehand, making all-round attackers not that different from loopers.

Counter Driver

The shakehand counter driver blocks and drives various attacks back at the opponent, forcing errors through changing angles and rhythm. A series of quick drives and blocks between counter drivers can look quite impressive, with balls seeming to fly everywhere.

Attacking Chopper

The single most distinctive style in table tennis is the attacking chopper. While other styles look to attack and gain initiative, the chopper gives up the initiative, uses the chop to return an attack with backspin, making it necessary for the opponent to start the attack all over again. The defensive chopper returns repeated attacks with slow, floating backspin chops executed as late as possible, taking as much time as necessary to tire out and frustrate the opponent. Chops can vary in the amount of backspin (from no spin to floating), sidespin (curving into the table or away from the opponent), or position, making it hard to continuously attack. If the opponent refuses to tire out or starts to play defensively, the attacking chopper can suddenly mix in a spin or smash attack, catching anyone who isn't fully alert and prepared. Reversed rubber is usually employed in the forehand, but the backhand is usually reserved for long or short pimples, which is much easier to control. Some players reverse their racket in order to use the pimpled rubber on the forehand, notable examples include

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RUBBERS:

The rubbers cover the “paddle” area of each side of the blade. It provides grip on the ball (of varying degrees), and is instrumental in developing your own playing style.
Rubbers must be approved by the IITF to be used in tournaments. The IITF maintains a database of authorised rubbers and they update it with successful applicants (e.g table tennis brands) that pass their stringent tests. The brand logo must appear on the rubber.
In the interest of consistency and fairness, one rubber must be red, the other black. Both rubbers usually perform the same — but some players opt to use different rubber types on the red/black sides in order to combine attacking and defensive playing styles in their game.

TYPES OF RUBBERS

SMOOTH

The majority of modern players use smooth or “inverted” rubbers. The surface of the rubber is flat and often shiny in appearance, with a layer of sponge underneath. The smooth, tacky surface provides the most amount of spin of all rubber types, and is used by over 85% of tournament players. Hitters, loopers, all-around, and defensive players all opt for smooth inverted rubbers — hence why the Palio ETT range includes them.

SHORT PIPS

Short pips are also known as “pimpled” rubbers. They have a bumpy, tough surface, often including a layer of sponge underneath. “Hard rubber” is the name given to short pip rubbers without sponge, and they are used primarily for old-fashioned “classic” or “hardbat” play. Generally speaking, short pips are used by players that don't execute much spin in their game, and those that have difficulty playing against spin. Some
close-to-the-table hitters, all-around players, and defensive players opt for short pips.

LONG PIPS

Long pips rubbers have extra-long “pimples" that are capable of reversing the spin of an opponent. The spin produced from the long pips is hard to read — so it can give players an advantage over opponents that are unfamiliar in playing against this type of rubber. It is however difficult to play offensively with long pips, so it's usually used on only one side of the bat.

ANTI-TOPSPIN

Anti-topspin rubbers have a smooth surface — but do not generate much spin. They're also slow, meaning they are not offensive either. Anti-topspin rubbers are however effective in neutralising the spin of opponents, making them a good blocker. Some players combine the anti rubber with a more offensive rubber on the flip side.

Sponge and their effects

The high elasticity rubber sponge material consists of natural rubber 40-80 weight portions; cis-1, 4-polybutadiene rubber 20-60

weight portions; stuffer 20-100 weight portions; softener 5-20 weight portions; vulcanizing system 2-8 weight portions; and foaming system 2-10 weight portions.
The sponge lets the ball sink in and catapult out, which is what increases the spin and power of the rubber. The harder and thicker the sponge, the faster it is. The thinner and softer, the slower it is.

In table tennis there is some available sponge thickness for the rubber 15mm, 18mm, 20mm,22mm, 23mm or max 25 mm

The Role of Sponge:

The rubber's sponge contributes 2 advantages in table tennis.

Compressor

Energy storage

For any stroke you make in table tennis the ball must go through 3 stages

- The ball sinks into the topsheet and the pimples
- The ball push down the sponge (the sponge is now a compressor)
- The sponge springs back and releases the force (blade feeling and energy storage from the sponge)

That's the reason for the soft stroke (like service drop shot. the topsheet will generate spin But for the strong stroke (forehand attack topspin) that's the blade will generate a lot of power due to the stiffness) Or you will feel more your blade when you do a bigger stroke

Speed and Spin:

For any thickness and hardness of the sponge, there's some maximum amount of energy it can store during compression. If you hit hard and you pass this limit. then the bottom out" will happen You should avoid the bottom out effect you're going to lose energy on the shot

This is the main reason why professional players play with Max thickness sponge
Increase hardness. That's why the top Chinese player plays with hard to very hard rubber. To increase the limit of Energy storage to remove the bottom out effect and to increase the spin and speed.

Sponge Thickness vs. Speed

As you know that sponge thickness is measured in mm And thicker sponge can store a higher amount of Energy (or catapult effect). While control also depends on the blade the catapult speed depends mostly on the sponge thickness.

So if you hit harder play quicker you should choose thicker sponges, In general here is the guideline to choose sponge thickness which depends on your playing style.

Sponge Thickness	Rubber Rebound Speed	Playing Style
OX - 14mm	SLOW	Defence
15mm - 19.mm	MEDIUM	Allround
2omm - 2.2mm	FAST	Topspin Attack
23mm - MAX	VERY FAST	Power Attack

The Best Sponge Thickness is:
It depends on your hitting power. But don't choose too thin rubber or too soft rubber, even if you are a new player.

For the backhand side choose something between 2.0 mm (new player) to 22, or Max (intermediate player).

For the forehand side choose 2.1 mm or Max For the Chinese rubber you need to tune so choose 2.1 to 2 .15 mm. Don't select a max thickness for Chinese rubber Because boosting a Max thickness you will lose the feeling. I've explained how to boost Chinese forehand rubber here.
To improve fast you need to train like a pro with a similar set up of the advanced players.

GLUE

Custom bats require specialist glue to attach the rubbers to the blade. The preferred glue for table tennis bats is a water-based application, free of harmful volatile compounds. This ensures that the rubbers stay firmly attached without causing any long-term damage to the blade. Don't be tempted to use superglue
It's advisable that you purchase your own table tennis glue, as rubbers on any custom bat will need periodically changing. From time to time you'll also need to reapply your existing rubbers when any area becomes detached from the blade. Just note that different types of glue may affect the speed of the ball — so we advise buying a renowned brand, and staying with it.

TYPES OF ADHESIVES USED IN TABLE TENNIS BAT

VOC Glue (Prohibited)

VOC glues (which stands for volatile organic compounds) are banned for use in table tennis. They contain dangerous and poisonous chemicals that have been proven to be harmful so in 2008 the ITTF banned them. They make a different sound when striking the ball and tend to weigh more than other water based glues.

Water-Based Glue (Authorized)

The only glue that is authorized for official tournaments is water based glue. These glues don't contain any harmful chemicals and are used by professional table tennis players.

Speed Glue (Prohibited)

Speed glue is a type of table tennis glue that is also banned by the ITTF. It contains lots of harmful VOCs that are toxic and are thought to cause cancer . The reason players started using this glue is that the vapours in the glue cause the rubber to expand making it high tension and typically increasing the speed by as much as 10% and spin by as much as 20%.

Boosters (Prohibited)

Another type of glue known to be used by table tennis players are boosters and tuners. The ITTF also prohibits these from being used as they are harmful to players' health. Boosters cause the sponge to expand which then gives more speed and spin by around 10%.

Self Adhesive Sheets (Authorized)

Another type of glue used to glue table tennis paddles is a self adhesive sheet . These are rubbers that are pre-glued and as long as they use VOC-free glue then they are approved by the ITTF.

ITTF REGULATIONS FOR FABRICATION OF TABLE TENNIS BAT

•The table tennis bat may be of any size, shape, or weight but the blade shall be flat and rigid.

•At least 85% of the blade by thickness shall be of natural wood. An adhesive layer within the blade may be reinforced with fibrous material such as carbon fibre, glass fibre, or compressed paper but shall not be thicker than 7.5% of the total thickness or 0.35 mm, whichever is the smaller.

•A side of the blade used for striking the ball shall be covered with either ordinary pimpled rubber with pimples outward having a total thickness including adhesive of not more than 2 mm. or sandwich rubber with pimples inwards or outward having a total thickness including adhesive of not more than 4 mm.

•Ordinary pimpled rubber is a single layer of non-cellular rubber, natural or synthetic, with pimples evenly distributed over its surface at a density of not less than 10 per sq. cm. and not more than 50 per sq. cm.

•Sandwich rubber is a single layer of cellular rubber covered with a single outer layer of ordinary pimpled rubber, the thickness of the pimpled rubber not being more than 2 mm.

•The covering material shall extend up to but not beyond the limits of the blade, except that the part nearest the handle and gripped by the fingers may be left uncovered or covered with any material and may be considered part of the handle.

•The blade, any layer within the blade, and any layer of covering material or adhesive shall be continuous and of even thickness.

•The surface of the covering material on a side of a blade or of a side of the blade if it is left uncovered, shall be matt,bright red on one side and black on the other.

•Slight deviations from uniformity of colour or continuity of covering due to fading, wear, or accidental damage may be ignored provided they do not significantly change the characteristics of the surface.

MATERIALS AND FABRICATION OF TABLE TENNIS BAT

RAW MATERIALS

1 . BALSA SHEETS

The reason behind using balsa wood is it is low in density but high in strength, balsa is a very popular material for light, stiff structures , model buildings, and construction of model aircraft; Ithas a typical density of about 160 kg/m³. In blades Balsa is often combined with carbon +2 outer plies of plywood, to make the blade light and fast at the same time.

Fig.21:Balsa wood

2. CARBON FIBER

The advantages of the carbon blade are a bigger sweet spot and a faster ball.Carbon blades have a larger sweet-spot due to the reinforced layers and harder feeling of the blade. This will give slightly more room for error if the player doesn't contact the ball in the center of the racket. The carbon blades have pretty good feeling as well so there are really no disadvantagesThis will allow the player to develop solid strokes because the ball has more dwell-time on the racket. A faster blade is better for an attacking player who contacts the ball at the top of the bounce

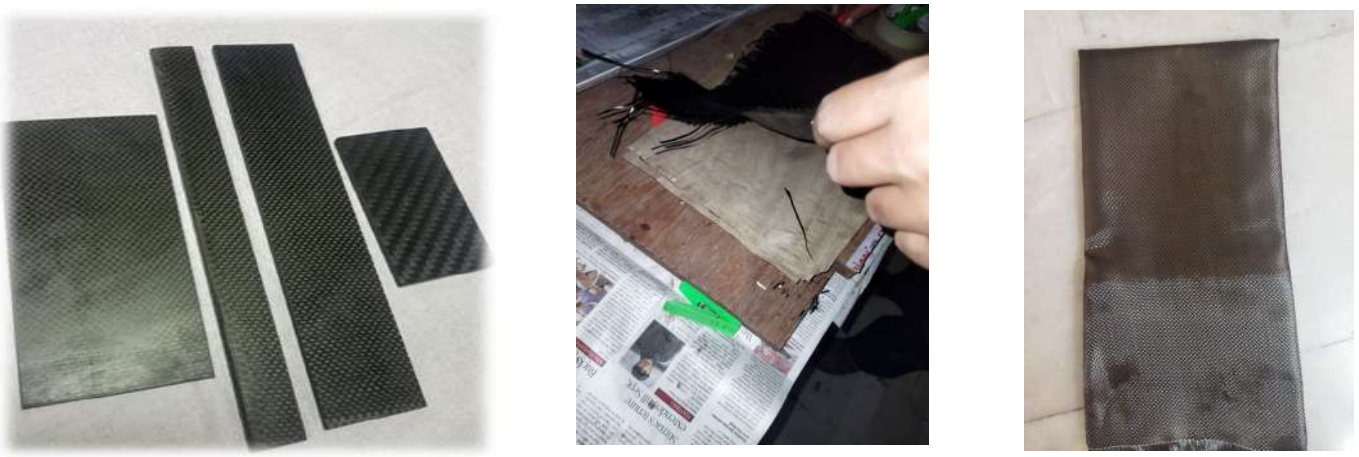


Fig.22:carbon fiber

3. Epoxy resin

We used the araldite glue for attaching the plies which are balsa wood , ash veneer , walnut veneer , carbon fiber, wooden handle.

Fig.21:Epoxy resin

4 . Ash veneer

Ash veneer is the cross between cypress and ayous .It is heavy and hard so it is best paired with lighter and softer core and outer plies. It needs hide glue for fully bringing out the playing characteristics . this is a wood best suited for fast all wood blades

5. Walnut veneer

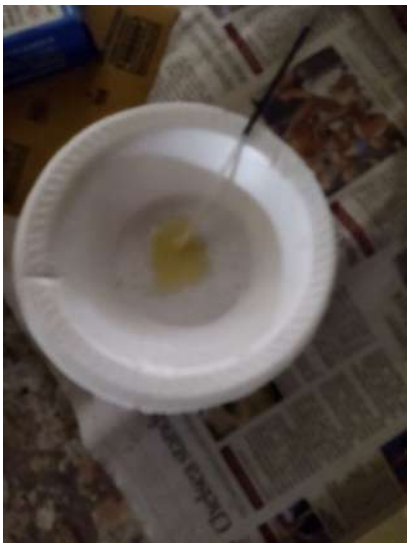
Walnut is a hard wood and has high repulsion and it is also light in weight , it has the ability to cope up with the specifications of the new plastic ball

FABRICATION OF THE TABLE TENNIS BAT

- ## Core balsa sheet

We have kept the balsa sheet as the core ply because of its high tensile strength and low density . we have attached the bala sheets side by side with a epoxy resin






- Ash veneer

After the core balsa sheet we have chosen the 2nd and 3 rd plies as ash veneer because it is well suited with the core ply . Similarly we have applied the epoxy resin and attached the ash veneer on the both sides of the core balsa ply.

- Carbon fiber

We have chosen the carbon fiber as the 4th and 6 th layer because this layer will allow the player to develop solid strokes because the ball has more dwell-time on the racket, simultaneously we have applied the epoxy resin and attache this carbon fiber on both sides of the ash veneer

- Walnut veneer

After attaching the carbon fiber we have taken the walnut veneer on both sides of the carbon ply . this walnut ply is the 1 st and 7 th layer of the composite ply.

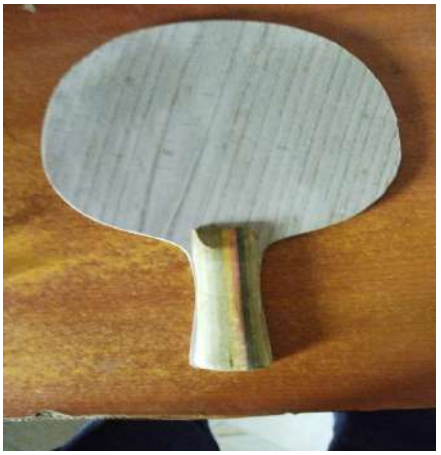
- Curing of the table tennis bat

After attaching all the plies together in order to cure the composite plies we have placed the weights and left it for 24 hrs

- Contour cutting

We have contoured the final laminated composite with the help of a band saw







Conclusion

In the course of fabrication of table tennis bat we have studied various wood and carbon fiber material properties

The right custom made wood veneers and carbon fibers were taken which met the desirable properties needed for the composite table tennis bat and used in this project work to fabricate a customised Table Tennis bat well suited for an all-round to offensive play.

Also studied the appropriate placement of the plies in the composite to gain the right amount of stiffness , tensile strength and controlling power over the ball.

The weight of the final fabricated composite table tennis bat came to be 65 gramsThe weight of the Table tennis bat paddle is 65gm (without handle), 85gm (with handle) and 175gm (with rubber) which is highly competitive considering 7ply Table tennis bat.

Result

A fabricated model of table tennis racket is obtained. After successful testing, the bat has good speed and bounce.

Discussion

The bat has been made up of 7 layers composed of balsa, ash, walnut, carbon fiber.These materials are chosen based on speed and weight for an All-round to offensive play. The glue used is an araldite standard epoxy adhesive which contains a resin and hardener.The bat can also be made using other different materials for obtaining defensive type bat for defensive players. Different type of composite material like ceramic material.Rubber can also be changed for spin and speed and different type of glue can be used to apply between the layers. By using these the properties of the bat will change according to our requirements.

Future Modifications

In the future, the bat rubbers can be changed based on our requirements.

We can change the rubber type for a defensive type of bat,and the composite material like instead of using a 200GSM carbon fiber we can use a different type like 300GSM carbon fibre.

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