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COMPOSITES

What is a composite?

May ask himself who arrives in this web page and has no idea at all about it.

Alot of things, used everyday, could be a first answer. A biker's helmet, a fishing rod, the chassis and the body of a Formula 1 car, a lighting of design, the mast of an oceanic racing sailing boat, the frame of some very expensive laptops, ventilation pipes of airplanes, the fairings for racing motorcycles, a golf shaft, canoe and rowing paddles, ski poles, the mast of a wind surf, the driving shaft of a paper machine which runs at 600 meters per minute, a silencer for motorcycles, flippers for diving, the fuselage of the new 787 Dreamliner Boeing, plate holder rollers for flexography, fume evacuation pipes of marine engines, and much, much more.

How is it made?

Well, basically **composites are made, are composed of 2 elements: a fiber** which gives the structural features, and **a thermosetting resin**, incharged of keeping together the fibers permanently. Carbon fiber, fiberglass and kevlar are the most known fibers, but others less known are available, epoxy, polyesther and phenolic the most used resins, but here too the choice can be very wide.

As a matter of fact the working principle is very old. Mankind has discovered many centuries ago that a fiber and a binding-hardener element, could be put together, could be combined, getting in this way a light and resistent material. Perhaps one of the first examples of this combination are bricks, used since ancient Egyptians, made of clay (the binder) and of straw (the fiber). And coming very close to present times, and remaining in buildings, reinforced concrete is not composed of iron (the fiber) and of cement (the hardener)?

And what is the advantage of a composite?

The **advantage is that it can be designed, can be build up, starting from the structural requirements of the item to be obtained.**

And what does this mean?

Metals have the same properties in all directions. A steel rod has the same mechanical strenght on the 3 directions of his volume, and the strenght is given basically by the composition of the steel, that is to say by its chemical-phisical composition. In composites, on the opposite, fibers could be conveniently oriented, and obtain thus an increased strenght in the desired direction, all this with a great weight reduction. For example, if a tubolar item has to be produced, some fibers could be oriented lenghtways to give the rod a good flexure resistance. Other fibers are placed horizontally, to get compression resistance. The tubolar will not bend (or better, it will bend exactly how much has been forecasted by engineers) and

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it will not squeeze. In this way 16 metres roubasienne fishing rods, weigthing approximately one kilograms are obtained, as well as the Dreamliner body, weighting some 20% less than an aluminium airplain.

I find all this fascinating, don't you? With metals man has done wonderful things, combining, melting, forging, shaping and working them, but he was always compelled by the chemical-phisical features of what he had in his hands. **With composites he has much more degrees of freedom**. At first because he decides where structural features are necessary and where not. Then because the shapes are unlimited, not bound to operations such as melting, moulding, folding, milling, welding, but with a simple operation of cooking of the item.

Cooking?

Well an expert will turn up his nose, and will discuss instead of **polymerization**, other people may laugh at this term. As a matter of fact it is exactly what happens. A mould with the form of the item to get is prepared, then fibers with the requested orientation and the thermosetting resin are put. The whole is placed in special ovens (or autoclaves) and exposed at a controlled heating cycle. The resin is thermosetting: before the polymerization cycle is in a viscous, sticky stage. With heat at first becomes liquid, and then "freeze", it becomes solid, in a permanent and irreversible way. In other terms whereas plastic materials could be melt and pass from the solid to the viscous state many times (and for this reason are called thermoplastics), once thermosetting resins have hardened they cannot soften any more.

MANUFACTURING TUBOLAR COMPOSITES

This web page describes the manufacturing of composite materials, in particular of tubolar items. The first basic concept is that **to produce items in composite materials is quite simple, to make it very well is much more complex**.

In the production of composites, in particular for tubolar items, to get very good results first of all you need to know some basic theory. Then good starting advises, some good suggestions from skilled persons, and alot of experience on your own are necessary. There are still so many variables to handle, that are not properly considered by the theory yet. Having access to a consolidated experience can help you immediately to arrive at the best.

But let's start from the beginning. The first question is:

how a tubolar composite is made?

Well, it is not very difficult. You first take a metallic cylindrical mandrel (that could also be elliptical, or conical), on that you put some layers of the selected prepreg (made with a fiber and a termosetting resin), you wrap both over with a plastic tape, put the whole in the oven,

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and cook for, say one hour at 130 °C. After the cooking you take out the whole, unwrap the plastic tape, pull out the tubolar from the shaft, and you have a tubolar composite.

So **to manufacture a tubolar composite is very easy**, you just need an oven, a mandrel, some meters of prepregs and a plastic release tape. The technology is not impossible, and does not require huge, complex plants with sophisticated and expensive machines. A technical school with a tight budget could well imagine to start for teaching purposes. Exactly as driving a car can be done by the majority of us, also making composites is possible to many. But if you have reached this stage you are in the same conditions as the beginnner in driving: you can manage all the parts of the car, but you will hardly be a skilled driver, not to say a racer.

To make very good tubolars requests much more. The point is that tubolar composites are made, are requested, are sold for the performances they can give in comparison with non composites alternatives, in particular when expensive fibers (carbon fiber, arammidic fibers and others) are used. Lightness, designed rigidity, stiffness, high resonance frequency, very good pressure and flexural resistance and many others are some of the features a composite can offer in comparison with metal or plastic products.

How to achieve this? Exactly as in driving. **One needs to reach an higher level.** Just driving is not enough, it is necessary to drive as racers. In races most people make the biggest effort they can stand to win. Normal car is not enough: it is very likely that as a minimum you make changes in the chassis, in the brakes, in the engine, and you change your tires with special ones.

In the manufacturing of tubolar composites is the same: **you want to make very performant items.** You calculate the structure's characteristics, you design carefully the fiber orientations, you take sophisticated prepregs with special resins and fibers, you put many different layers, the oven became an autoclave, processing parameters (temperature, ramp, pressure and so on) are tightly controlled.

THE FUNCTIONS OF FILMS FOR TUBOLAR COMPOSITES

And the film?

Is "a plastic narrow film" still enough for you?

In our experience the answer is **a VERY BIG "NO", also wrapping has to be sophisticated in order to get the best performances.** A generical plastic film bought because it is cheap, it releases, and it has been wrapped somehow, could ruin a big part of your efforts. To go further in the arguing, today, most of the times a single film is simply not enough. For a **number of technical reasons a combination of films is necessary**, and to get the top **the proper combination of film** for each specific tubolar item is a must.

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We have to explain, to justify these statements. To do this and for completely unexperienced persons who read these web pages for curiosity we have to describe **the functions of the tapes** for manufacturing tubolar composites.

- The termosetting resin in the prepreg is in a viscous, sticky stage. With the temperature the resin first becomes liquid (sometimes very liquid) to fullfill all the space between the fibers, and after hardens permanently (for this reason it is called termosetting, because the process is irreversible, whereas in termoplastics the material could melt, pass from the solid to the viscosity state many times). This **liquid stage** (called **gelification**) lasts for a while (say 10-20 minutes, sometimes much less, sometimes more, depends on resins' characteristics). During this period **you have to keep the resin (all the resin) where you want it to be, in the composite body.** For this purpose you have to prepare a proper container for this liquid. In tubolars the container is made of 2 parts: in the inner part the containment is made by the metallic mandrel, in the outer part a narrow plastic tape wrapped around is the most common, effective, cheap and handy solution (as an alternative one could well imagine to have an outer metallic mould, made of 2 parts; or to dress a sleeve, a tubolar plastic shrinkable film. Both are possible, but much more complicated, expensive, and much less effective). So **the first, basic, function of the plastic tape is the CONTAINMENT OF THE RESIN during the liquid phase.**
- Since plastic film, once cooked, has often a bad look, it weights, and it is not necessary for the tubolar, it is very common to take it away after the cooking (by the way, cooking is also called polymerization). Here we find the **second function** hystorically requested to the plastic film: **to have RELEASE CAPABILITIES after polymerization.**
- Any composite is well done only if resin and fibers are mixed, glued together very tightly, without any space left between them. No air bubbles should remain inside, no holes on the surface. To acheive this **it is very important to give alot of pressure on the composite during polymerization** and vacuum and/or autoclaves are often used for this purpose. For tubolars it is even simpler because **the wrapping with the tape can MAKE A SPECIFIC PRESSURE** (often much bigger than vacuum or pressure) **EVENLY APPLIED in all the parts of the tubolar.** This is made in two ways:
  - since it is very likely that more than one layer of prepreg is put on the mandrel **if the plastic tape is tensioned alot during the wrapping it will press each layer to the others.** We call this function **COMPACTION OF THE LAYERS obtained through heavy tensioning of the tape;**
  - then there is the polymerization with the resin passing through the liquid stage described above. If the plastic film has heat shrinkable properties **the tape will shrink with the temperature** and make extra compression on the tubolar exactly when we need it, the liquid phase. This is called **EXTRA**

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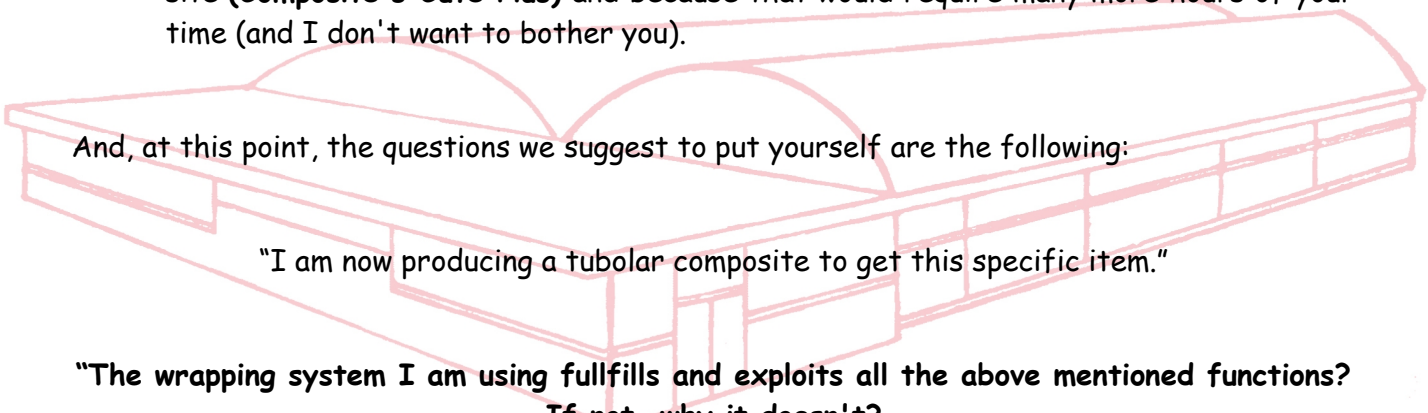
COMPRESSION THROUGH HEAT SHRINKING. (And if you think about it, it is very hard to get these two functions in the same time with 2 moulds or a tubolar sleeve).

- In addition plastic film has to **withstand quite high temperatures without collapsing**. Sometimes it is necessary to use even higher temperatures both to shorten processing times or to use particular termosetting resins. This function of **the film is to act as an HEAT SHIELD**.
- Since the weight of the paint is inacceptable for light structures often tubolar composites are sold as they are, without any additional paintings. In that case **the plastic film makes also the external look of the tubolar**: glossy, matt, heavy matt, satinated looks are possible in this way. And this is another function of plastic films: to give the **EXTERNAL LOOK**.
- Finally a plastic film could be prepared in a peculiar matter **to TRANSFER TO THE COMPOSITE BODY AN ADDITIONAL, EXTREMELY THIN, SKIN**. This is another function of the film, and opens a whole new set of opportunities. I don't go any further on this subject since you can find something more in another web page of this site **(Composite's Cute Plus)** and because that would require many more hours of your time (and I don't want to bother you).



And, at this point, the questions we suggest to put yourself are the following:

"I am now producing a tubolar composite to get this specific item."

"The wrapping system I am using fullfills and exploits all the above mentioned functions?
If not, why it doesn't?
I don't need for this tubolar,.....
.....or I am not exploting all the functions because I didn't think about it,.....
.....or the functions have not been explained to me.....
.....or because my tape supplier does not have the availability of all the necessary films?"

Well, if you decide that your tubolar does not need alot of sophistication, keep on producing as usual and sleep easy. Otherwise if you have the doubt you are not working at the best, and that some improvements would be possible, we suggest you as a minimum to inform you.

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STATEMENT'S EXPLANATIONS

Above we have described the various functions of the wrapping tape.

The key issue is that a single film cannot fully accomplish all these features together.

For example one film could be very good for tensioning and compact thus the prepreg layers, another to make heat shrinking, another to give a matt look etcetera. So far no film is available that could do the 3 jobs alltogether.

Luckily it is possible to put one film over the other and get sinergies, "sum up thus the advantages" of each tape.

Hence it is explained why today a combination of film is very often used.

Since racing in rallies is quite different from racing in F1, and both are different from Endurance one needs an impostation specific for the type of race he is found of. In tubolar composites it is exactly the same: one thing is to manufacture light tubolars, another story structural tubes, another are conical rods or elliptical pieces. Roubasienne rods are different from windsurf masts, and both are different from industrial cylinders, golf shafts, sailing masts, etcetera.

That is why each product needs a specific combination of films.

And what happens if you use the wrong film or the wrong combination of films? In the word of races everybody are in the same place at a certain time. Some form of learning from others is possible, just by imitation, stealing with your eyes your competitor's behaviour. That helps also to avoid big mistakes: if you use winter ice rally tyres on a F1 car everybody will see it, will laugh of you, and you are tought the lesson.

In manufacturing this is very hard: everybody stands in its own factory, it maybe that your competitor is hundreds of chilometres far, you are not certain if your production process is correct or awful, if wrapping is proper and well done. Meeting in trade fairs teaches you very little: you will certainly see the finished products (may be wonder how the hell your competitor has done such a wonderful product, yours is just mediocre), for sure not the manufacturing method.

It is difficult/impossible to learn the procedures from the others.

And there is still another issue to consider.

If you start from the wrong point it is very difficult that you arrive at a good result.

If you drive the car and your seat is too distant from the wheel, from the brake and from the accelerator, it is very difficult that you have a good drive. You are clever and you learn from the experience, but anyway sometimes it is hard to realize oneself that there is a basic error, which can compromise the whole.

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Your experience could mislead you and take you very far from the correct way.

It is much easier if somebody else looks at you and tells: "Move ahed that seat, and you will drive better and more comfortably".

We write these things because we still see big basic mistakes, also made by very important companies, which lead to poor composites performances. My though in this case is: "I would never suggest to use this system, this production method, these processing procedures, this plastic tape, neither to produce a toothpick, imagine a structural composite tube (or an airplane)."

"So, I am now convinced that a combination of film is better."
"How do I get the best combination for my composite?"

You have 2 choises:

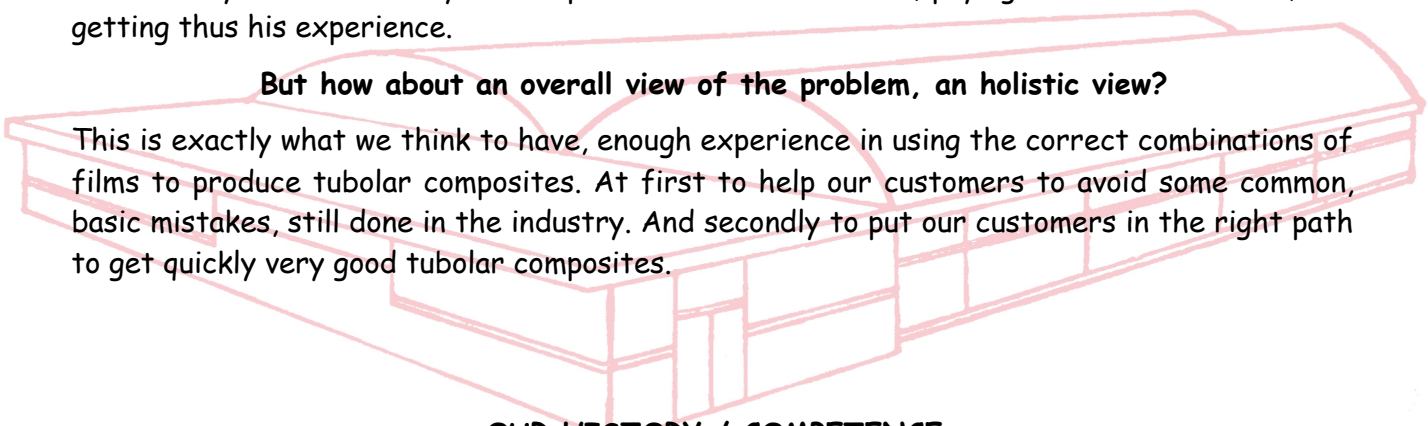
1. You make yourself alot, alot, alot, alot of experience (in many years time).
2. You get advises from an expert.

"Any other solution?"

Of course you can recruit your competitor's best technician, paying whatever he wants, and getting thus his experience.

But how about an overall view of the problem, an holistic view?

This is exactly what we think to have, enough experience in using the correct combinations of films to produce tubolar composites. At first to help our customers to avoid some common, basic mistakes, still done in the industry. And secondly to put our customers in the right path to get quickly very good tubolar composites.



OUR HISTORY / COMPETENCE

Now I have to talk of our history and how we have got our specific competence in the tapes for manufacturing tubolar composites. We supply special films for this process. We have started in the early 70ies with the first Italian producers of fishing rods.

"Fishing rods?
Are you kidding me?
I am in the aereonautical industry,
….or....

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I produce masts for transoceanic racing sails.
Your ridicolous fishing rods are nothing to me"

Well, many times I have read these thoughs in the eyes of my interlocutor. Then I argue that our customers are now producing roubasienne fishing rods as lengh as 16 (sixteen) metres, as light as 1300 (one thousand tree hundred) grams, with a flection on the top of less than 5 (five) centimetres. And if this is not enough to you consider that when the rod is fishing it could well happen that a carp of 4-6-8 kilograms is hooked.

Can you calculate the force in this situation?
How about the leverage at 16 metres?
Is still a fishing rod ridicolous to you?

Of course most of the performances of roubasienne rods are due to the skillness of their producers (our customers), but believe it or not, our films have for sure a very important part in the final result.

To go ahead with our history, at the beginning we have grown up with fishing rods. In the seventies rods were made with phenolic resins and fiberglass and they were very strong but quite heavy as well. Cellophane was used as (sole) wrapping tape.

But soon carbon fibers (and aramidic fibers) appeared in the market and polyesther and epossidic resins became available. Carbon fibers in particular has made possible the big development of the industry with enormous improvements in the performances of finished items. At first Polypropylene Speciale and Polypropylene Alto Modulo were used with the new resins, later on other films were added.

For years the functions the film had to fullfill were the first two described above (containment of the resin in the liquid stage and easy release after the cooking), and the application had very little content of knowledge, of knowhow. Then our customers have moved to differentiate their range, and new requests have come for new products. Motorcycle silencers, bycicles, masts for windsurf, industrial rolls, sleeves, cylinders for flexographic printing, lamps, masts for sails, golf shafts, are some of the products developed with time by our customers. To cope with the product features tubolars had to become very strong and light. **New composite structures has meant different, more tought, requests to the wrapping tapes.**

To tell the truth at that time we didn't know what to search for. Today I can tell you the story and say that new requests have forced us to improve our films giving them the **specific pressure and heat shield capabilities** described above. But if these new functions of the films are now clear to us, they weren't at all during the development of new films. Only with

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time, experience, daily discussion with our customers and alot of arguing on these subject it has been possible to identify all the functions and assign each its own value.

As a matter of fact with the time our know how has broaden both in films and in manufacturing processes, and the range of film has grown. Our films have gained consideration on the markets, first in Italy and later on abroad.

In 1998 we have launched in the market Polypropylene Satinato to make the matt look of the composite and the function to make the external look was invented.

This was the turning point. Matt film makes very little specific pressure and needs at least one more tape for compacting and compressing. So, in addition to the new innovative look, this new tape has made us aware that to get the best results more than one film is sometimes necessary.
Until then everybody was looking for an unique tape capable of doing everything (and still today new customers sometimes ask for an unique, universal film). After Polypropylene Satinato we and soon our customers have realized that **to put 2, 3, 4, even 5 films one over the other is not that more complicated and expensive, but can improve dramatically the outcome of the tubolar.**

Found the way, in the first years of the new century our research has focused in **finding new tapes, that could be used in combination**, one over the other, **to get sinergies, to exploit this "sum up" effect.** Two more films for the external look have been added. Others have been launched to make pressure or as an heat shield. That has led us to have now a range of about 12 films, specifically designed to manufacture tubolar composites.

In the same time **another field of development has exploited the competence** we have in another technology: flexographic printing of plastic films. Composites and flexographic printing are apparently technologies, worlds, very far one from the other. That is true if you look at them from the outside. If you are in, the opposite is correct. As a matter of fact in the recent past with the use of flexographic printing we have invented printed films which have brought new important innovations in the tubolar composites world. I can't give any more details about that because these innovations are still used (and kept secret) by our customers.

And we arrive at **2009**, when we have filed the **Patent** application for **Composite's Cute Plus**. With flexographic printing it is now possible to prepare a special (patented) film which gives an additional skin to composites (for instance also the manufacturing method for making tubolars is patented).

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HOW TO TRANSMIT OUR COMPETENCE TO OUR CUSTOMERS?

So, how can we transmit our customers good advises to improve their tubolar composites?

Let's consider various approaches.

"Look, I am an aereonautic engineer, have a PhD in composite materials, I have worked with the best international companies. To make good composites the key issue concern the type of fibers and resins, fiber orientations, engineering and designing, not certainly the plastic film".

Well if you think this I suggest you to go back some screens and read again the functions of the film. Specific pressure on the tubolar surface is, in particular very important, and in same cases is overwhelming. You can make a wonderful project, but if you don't give the correct specific pressure to your tubolar part of your potential is lost. And if you still don't believe, make a simple test. Hit softly with a wrench your tubolar composite to make it resonate. The sound you will get will be deep if you have made a strong specific pressure, much more acute if you haven't done that.

The point is that the production process (wrapping and polymerization together) is not neutral.

Let's make another example. You have invited some friends for dinner and you want to prepare the food. You have decided you will cook a dish in the oven. So you go to the market and buy the best piece of meat, or the best fish from the sea you have ever seen. The quality of the raw material is, for sure, at the top. If you cook it properly, you will get a wonderful dish, if you are a mediocre cooker the food will probably be not disgusting, but simply poor. In tubolar composites that means that starting from raw materials of top quality, from the best project, the polymerization process can give you 100% of the potential only if it is perfectly done, but it can also ruin everything when it is carried out badly.

"We have the most updated and performing autoclaves in the market. Every item is produced under high pressure. With these conditions wrapping tape is of little help".

We think that for sure autoclave can help, but it makes a generical pressure on the item, on every directions. A well done wrapping on the contrary, **makes a specific pressure, exactly where it is needed, on the tubolar walls.** And often the specific pressure we manage to obtain is bigger than the autoclave pressure.

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Another approach we often have faced is:

"Please send me your product data sheet, and we will evaluate your films"

This approach is correct if you decide to use only a single film to wrap. You make comparison between all the films available in the market and you choose the best. This decision is still the right one for some composites. For light, cheap tubolars one film (the right film, properly tensioned and wrapped, in 2 passages) is still the best choice. But if you intend to make structural tubes and you decide for a single film it means that your development stage, concerning film for tubolar composites is remained 10-15 years behind. You are fixed ages ago.

Our experience tell us that with a single film it is very hard to get all you can have from a combination of tapes. For example you could decide you want a matt surface, but you need also a very good structure and hence you need alot of pressure through compaction of the layers and compression by heat shrinking. With a single tape you will never get all these all together. You need to put at least 2-3 tapes. So the approach through data sheets is wrong if you use many films.

How to combine one tape with the others?

"I take product 3 from supplier XXX, then put film A from supplier YYY, and finally film "Super" from supplier ZZZ.

.....or.....

I take film "Thin" from supplier ZZZ, product 1 of XXX, and film C from YYY?

.....or.....

I take everything from XXX, and put 5, then 2 and then 3."

The number of combinations is very high.
Do you have time and money to test them all?
And beside this how different films interact one with each other?
And how about the sinergic effect?

Data sheets of course are important, but they are not exaustive, and none of them describes how one film can interact with the others.

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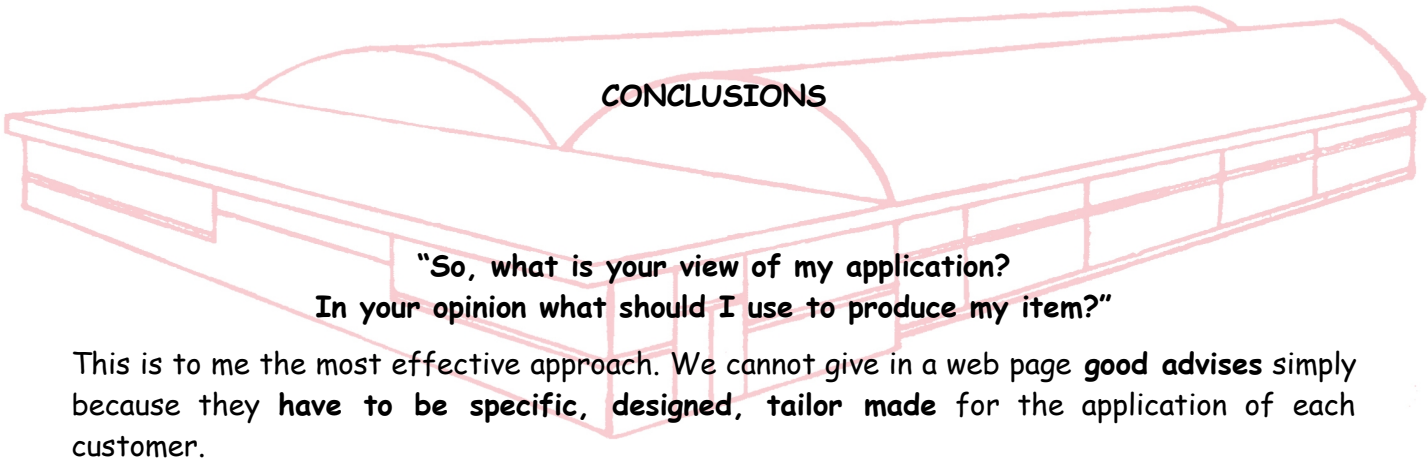
"You suggest to use more films to sell more"
"If I use one film instead of 3 I will save 66% of the film costs"

Well both statements are true, but consider that many times the cost of the film is a zeropointzerozerosomething percent of the total value of the finished item. Of course you save 66%, using only one film, but that means you have saved 66% multiplied zeropointzerozerosomething, and that adds at least another zero to the percentage.

And if this choice causes you ONLY A SINGLE ITEM REJECTED because faulty, how many times you will have to save the zeropointzerozerosomething to recover the faulty tubolar?

The use of 2-3-4 films one over the others in tubolars is not that complicated and expensive, can improve the quality of the composite, and reduce drastically the number of faulty pieces.



CONCLUSIONS

"So, what is your view of my application?
In your opinion what should I use to produce my item?"

This is to me the most effective approach. We cannot give in a web page **good advises** simply because they **have to be specific, designed, tailor made** for the application of each customer.

Consider that today the **list of the functions** we assign to our plastic tapes is this:

- full containment of the resin in the liquid phase;
- easy release of the tape from the composite after polymerization;
- specific and even pressure on every part of the composite tubolar body during manufacturing, achieved through:
  - compaction of the prepreg layers during the wrapping given by heavy tensioning;
  - extra compression of the structure during polymerization through heat shrinking;
- heat shield, protection for higher processing temperatures;

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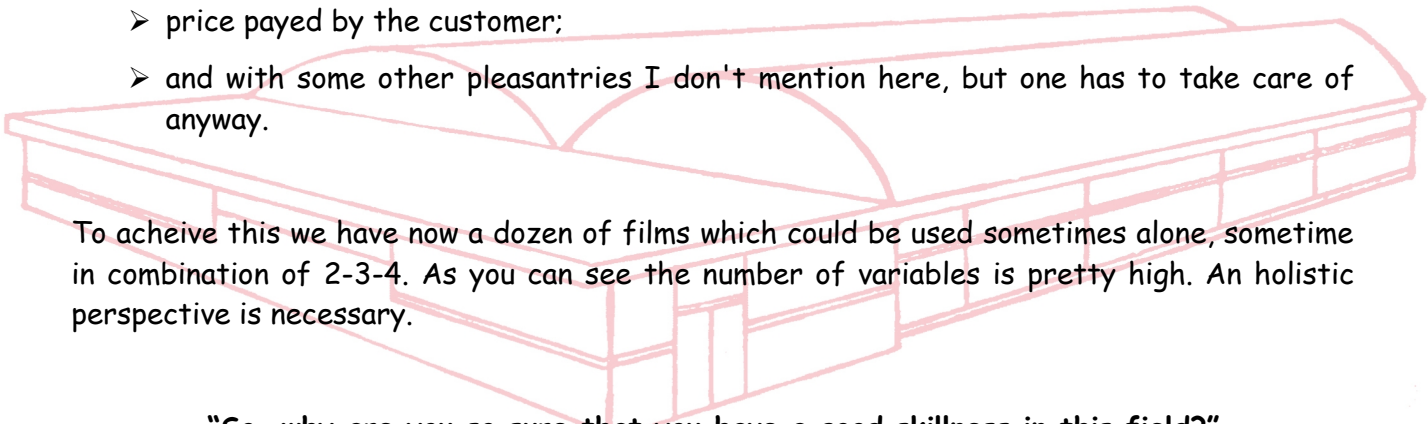
- external look: glossy, matt, heavy matt, satinated;
- transfer of an additional skin to the composite's body (Composite's Cute Plus).

All these functions **must fit well with all the other variables** we have in the process:

- diameter of the tubolar;
- possible conicity or elliptical geometry;
- number of layers of prepregs and thickness of the composite walls;
- lenght of the rod;
- types of termosetting resins;
- external look required;
- processing temperatures and conditions (different temperature ramps, presence of steam, pressure, autoclaves, cooking position);
- perfomance requested to the finished product;
- price payed by the customer;
- and with some other pleasantries I don't mention here, but one has to take care of anyway.



To acheive this we have now a dozen of films which could be used sometimes alone, sometime in combination of 2-3-4. As you can see the number of variables is pretty high. An holistic perspective is necessary.

"So, why are you so sure that you have a good skillness in this field?"

If you are still not convinced, please consider also these facts:

- when we start a business relationship in the composite the first contacts are always technical, the aim is **to identify and understand customer's requirements**. That usually requires minimum a couple of hours over the telephone or through emails or with a meeting. Once these needs have been identified one or more film or a combination of films is suggested and selected to start with prototyping. In this contact stage it is very common that the customer is not well aware of how to do the things with the films. In other words it is very common that the customer is learning, and our technicians will teach (by the way, technical assistance is for free, so far);

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- once the prototyping phase has been passed, the proper wrapping process identified, and the production process of the tubolar is set, the relationship follows on a standard business relationship. **The fidelity of our customers** (thanks them) in composite's applications **is pretty high**. Usually they keep on buying our films for very long periods. They are well aware that **they are not only buying the films but also the know how, and that they could have access also to further technical consultancy in case of problems, or to develop new products;**
- our films for composites are **sold in more than 30 countries worldwide, with no commercial structure at all**. This is possible only if the quality of the products is very good and the know how linked to the product is very strong.

So, for all these, in the production of tubolar composites, we think we have a word to say about tapes.

Want to listen?

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