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THE MARKET ORIENTED IMPROVEMENT OF THE ENVIRONMENTALLY FRIENDLY COLLECTOR TRAY OF THE GREEN TRACK SYSTEM FOR FULL SCALE RAILWAY AND ROAD TRAFFIC APPLICATION

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Abstract

We have carried out a research regarding the collection of materials escaping into the environment during the process of draining and filling of liquid carrying container devices. We found that at the moment the collection of liquids getting into the environment is not always managed properly. Therefore we conducted a study in which we took account of the present issue and we are looking for the solution to have a collecting device made.

A mobile collector tray would be a solution in these cases. To be able to define the physical and chemical characteristics of this tray we must be acquainted with the liquids presently being delivered. It is important to note that we can collect only such liquids which do not become combustible when mixing with air and do not produce toxic gases.

Keywords

environment, composite technology

1. Introduction

Firstly, we examined two main areas. On one hand we looked into the container devices currently being used for carrying liquid and considered their sizes in order to match the tray in size. On the other hand we examined the transported materials to find out what materials the tray should be resistant to.

A significant aspect is that the collector tray should be as light as possible and as easy to fit as possible during the process of application.

Presently the liquid materials are transported/moved by rail or by road or within agricultural areas. Filling and emptying is generally done on fixed locations.

As for the physical setup the tray must be placed between the tracks. In public traffic or in agricultural areas it must be placed on the ground in such a way that the wastage would flow into the tray.

The collector tray must fulfil the following physical and chemical requirements:

- physical size (width, length, height)
- mechanical straining (pulling, pressing, clipping, beating)
- weather (durability, between -20°C +40°C, humidity (oxidation) resistance to UV effects)
- resistance to fossil liquids
- resistance to acids and alkali solutions
- skid-resisting property
- easy and quick cleanability (in order for materials not to react between two emptying processes)
- flame resistance
- protection against static charging

Obviously many conditions must be fulfilled for a tray like this to be made which is a seemingly easy task. With one type of material we would not be able to fulfil all the requirements, therefore we came to the conclusion that the collector tray must be made of composites.

Polymers have less mass volume than metals therefore they are lighter. Since the trays must be able to be moved by people, we made the decision to use lighter polymer materials. We design the collector tray to be made of composite polymers. This is how we can ensure to have a material which fulfils all criteria.

Composites are heterogeneous systems which are formed by connecting (laminating) two or more materials. Oftentimes the chemical properties and shapes of the elements are different. Composites can provide such characteristics and property combinations which the different elements on their own would not be able to provide. Composites are often made in such a way that they are in their final form (Figure 1).

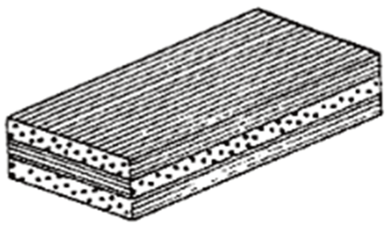

Figure 1. Composite Layers

2. Empirical session

According to the morphology of the composites regarding their structures they can be particulate, fibrous or laminated [1].

The top layer of the layered composite must be abrasion-resistant, skid-resistant and it must have chemical resistance and UV resistance as well. The layers underneath must have reinforced fibres which are resistant to mechanical strain, flash point and build-up of statics. The bottom layer must be adhesion free for the purpose of making the moving and cleaning easier.

These layers must be well connected to each other for a longer period of time because if they lack this quality then their primary characteristics are lost and they will be useless.

The layers on top of each other also must be made of composites, for example reinforced-fibre matrix polymer, metal, ceramic etc. The material of the matrix determines the strength of the layer-composite and the maximum composition of application. The preparation of composites greatly depends on the composite material [1, 2].

The layer structure suggested by us is the following:

– top layer: resin
– adequate adhesive material which connects the two layers on a big surface
– 1st laminated composite(s)
– core on which the laminated composites are applied
– 2nd laminated composite(s)
– bottom layer: adhesion-free layer

The materials of this layer structure can be diverse. Naturally, the order of the final layer structure might differ due to professional reasons. It is imperative to examine the chosen materials in light of their producibleness and connection to each other.

Producing sandwich structures:

Sandwich-structured composites can be made with various methods:

– The two reinforced composite cover layers are made in a form and then the core material is glued between.
– The cover layers are made the same way as described in the previous point and by using a spacing tool the core material is expanded between the layers.
– On the composite plate which is still soft, not cross-linked yet and is in the mould, the core material is pressed, then the laminate is cured and cross linked so the core material sticks to the plate. Then either in the mould or taken out of the mould the other plate is sandwiched on the free side of the core material.
– On the pre-cut, bent or combined core material which is a firm structure the composite cover layers are sandwiched on both sides [3, 4].

It is important that all layers have their own role and all these will make up the basic material of the collector tray which has the characteristics needed.

The design can be approached in various ways.

We chose the approach based on the materials of the layers:

The top layer is the resin. This layer must be abrasion-resistant, well-adhering and it must resist chemical materials, must be non-thermoplastic, as well as heat and UV resistant. Such a resin type must be chosen here which has all these qualities. Non-thermoplastic resin types are illustrated in Table 1.

Table 1. Non-thermoplastic resin types [5]

Plastic	Epoxy	Phenolic resin	Polyeste r	Vinyl ester
Density [g/cm^3]	1,2-1,3	1,2-1,4	1,1-1,4	1,1-1,2
Tenacity [MPa]	50-130	35-60	40-90	70-90
Tensile modulus [GPa]	2,5-5,0	2,7-4,1	1,6-4,1	3,0-4,0
Breaking strain [%]	<9	-	<5	<6
Bending strength [MPa]	110-215	-	60-160	120-140
Compressive strength [MPa]	110-210	-	90-200	-
Operating temperature which can be applied continuously [°C]	80-215	70-250	60-150	-

The epoxy resin has good resistance against corrosion and chemicals but has a breaking tendency which for us would be problematic since due to the continual handling this layer might break (crack) therefore the structure itself would lose these properties in a short period of time.

Phenolic resins are resistant to heat, friction and chemicals, nevertheless their mechanical properties are quite bad so this type is not useful for our purposes.

Polyester resins are widely used due to them being cost effective, easy to handle and they are fast to harden. Furthermore, resistance to atmospheric effects, good mechanical, electrical and chemical properties make them useful. This seems acceptable to us.

Vinyl ester resins are varieties of the poly (vinyl-alcohol)-based polyester modified by epoxy resin, novolac resin or epoxy-novolac resin. They are basically different from polyesters in that the reactive places are at the end of the chain. They contain less ester groups therefore they are less sensitive to degradation caused by water. The long carbon chains make them more resistant and they have a better load transferring property.

Better mechanical properties, higher heat resistance and excellent resistance to chemicals cause these resins to be different from polyester resins. There are less possibilities for cross-linkage in the vinyl ester polymer therefore it is more flexible and it strings better.

Based on the above properties we will choose the vinyl ester resin with the characteristic of 470-300 which is resistant to chemicals and has a high heat resistance quality. The disadvantage as opposed to the polyester resin is that this type of resin has higher costs but on the other hand it is less sensitive to the degradation caused by water (humidity). This aspect is also important and this is why we choose the vinyl ester resin.

The composites with inside plates are on top of each other in a multi-layered structure. The layer order of the composites with plates is described by starting from the core towards the boundary layers.

The core material is the material on which surface we apply the composite layers (Table 2).

Table 2. Properties of composite sandwich core materials

Alveolar structures	Plate thickness [µm]	Density [kg/m^3]	Resistance to Compression [MPa]
Aluminium alloy 5052	25,4	36,8	1,20
Aluminium alloy 5024	38,1	44,8	1,72
Glass fibre fabric/phenolic resin	–	56,0	3,45
Glass fibre fabric/polyester	–	64,1	3,86
Glass fibre fabric/polyimide	–	64,1	3,03
Aramid/phenolic resin	50,8	48,1	2,65
Kraft paper/phenolic resin	–	80,1	2,76

When choosing the core material it is important that the feeder layer would be well connected to it. The layer thickness of the core material is determined by applicability. The thinner it is, the more flexible it is and the thicker it is, the heavier and the firmer it is. This layer is protected the most from outside effects and it is important that its mechanical properties would be good. The core material must be chosen according to this aspect. Producibility aspects also must be considered.

The core material has two sides therefore we should choose the same material for both sides. On the bottom part the adhesive free layer can be put on and on top, if necessary, other adhesive layers can follow, then on the top layer comes the resin.

The material on the two sides of the core material can be different but in our case the same composite material is satisfactory. The reinforcing fibres greatly influence the properties of the composite.

It is important for us that the reinforcing fibres would be of great firmness that they would bear the demands of everyday transporting and it would withstand the environmental changes in temperature. Since it is not directly subjected to UV light or humidity therefore it must not necessarily comply with these. However, in case of the top layer being damaged, these properties might be useful but necessarily needed.

Since the tray can be subjected to the same amount of stress from all directions therefore the cut glass fibre (Figure 2) mat structure or the glass fibre fabric can be the right solution.

The glass fibre mat is made up of various different grain directions among which gaps can be found and these lessen its firmness but its mechanical properties are of equal distribution in all directions of the plane. Due to its short thread length the unique production is easier and it is suitable for making complicated structures as well.

The glass fibre fabric structure is made up of long stranded threads which are distributed equally in the two main directions of the plane. It has great resistance to shear stress but in case of felter this property deteriorates. During the production technology process thread stretching can occur which cannot be corrected and this greatly influences its properties [6, 7]

We chose the glass fibre mat because the stress effects in regular circumstances are not very strong but in our case they can occur in any direction during usage and in regular circumstances it will not be subjected to great stress.

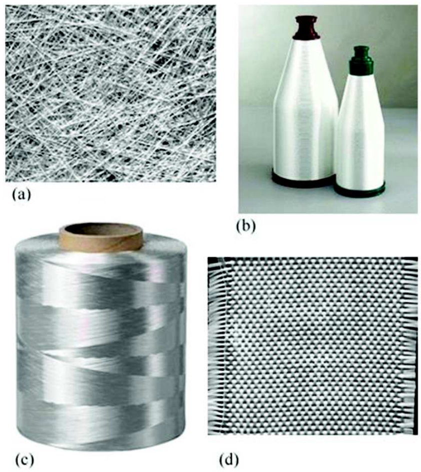

Figure 2. Typical forms of glass fibre made for composite [4]
a) cut glass fibre mat, b) glass fibre thread, c) roving,
d) glass fibre fabric

We chose the glass fibre mat because the stress effects in regular circumstances are not very strong but in our case they can occur in any direction during usage and in regular circumstances it will not be subjected to great stress.

The bottom layer of the composite tray under the fibre glass mat should be a material with low adhering property in order to avoid the contaminants adhering to it and when in use the tray would be easy to slide and keep clean. In this case vinyl ester resin can be used with added paraffin or cheap polyester where the aspect of choosing is the low adhering property.

Above the core material we choose the fibre glass mat and we choose a glue type which can be used for connecting this with the outside resin layer. The chosen glue must adhere well to both the fibre glass mat and the vinyl ester resin. We chose the Vlies veil.

The thickness and arrangement of the composites must be optimally defined which can be checked during the testing process of the prototype. If necessary, we can change the order of layers and their thickness (Table 3). By doing this we do not lessen the chemical properties but rather enhancing the physical properties of the tray and the result is that we will have a durable, easy-to-handle and good quality tray (Figure 3) to go into production.

Table 3. Layers chosen by us

Figure 3. Installed element of the GREEN TRACK collector tray

Vinyl ester gel coat	Derakane 470 resin +Aerosil 202 + colouring paste (10%)	800 micron thickness	1-1,2 kg/m^2
1 layer veil	D77-60 vlies		1 m^2 vlies 0,2 kg/m2 resin
2 layers 450 g/m^2 fibre glass mat	450 g/m2 fibre glass mat + Derakane 470 resin	1,6 mm layer thickness	1,8 kg/m^2 glass fibre mat 3,6 kg/m^2 resin
Core material	Coremat 3 mm thick	3 mm	1,8 kg/m^2 resin
2 layers 450 g/m^2 fibre glass mat	450 g/m2 fibre glass mat + Derakane 470 resin	1,6 mm layer thickness	1,8 kg/m^2 fibre glass mat 3,6 kg/m^2 resin
Top coat layer adhesion free	Can be the vinyl ester gel coat from above + paraffin or polyester, coloured VUP 960 BE	800 micron thickness	1-1,2 kg/m^2

3. Conclusions

As engineers we must not be satisfied with just discovering the problem but we must find a solution and we have to correct it and eliminate it. In this case the issue of the liquid escaping during the filling and emptying processes could not be eliminated therefore the goal was to collect the liquids. In this situation our aim was to collect and prevent harmful materials (e.g. petroleum fractions) or valuable materials (e.g. water) getting into the environment. This way we can ensure the protection of the environment and recycle these materials. We feel we are on the right track, the aim is clear for us and we are working on the stages of realization.

Acknowledgements

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