" Consumables or Reusable – a case for a more ecological and economic approach"

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ABSTRACT

The use of film infusion techniques to manufacture composite parts is a well established process and is widely employed in the industry for a vast range of products including large marine and wind power applications. A large infrastructure of supply companies for infusion consumable films, sealants, peel ply, breather cloth, etc is now established to meet this manufacturing need and yet the industry appears to make little effort to develop a less consumable approach for the infusion films and associated materials which are discarded after each production cycle.

With the development of silicon reusable films, their method of production, ancillaries and advances in techniques for infusion, a change now appears possible bringing significant wastage reduction and thus a more acceptable ecological impact with the bonus of greater economic benefits to the producer.

The paper discusses and sets out to show how cost savings can be realised with silicon reusable infusion membranes and also the advances in resin delivery and management resulting in zero consumable wastage per part, which are now possible in this manufacturing sector.

Details of new innovative low cost membrane connections for resin feed, seals and resin runners are illustrated. Cost analysis of the new reusable approach verses traditional infusion is also provided.

Conference attendees presently involved with infusion will find the presentation an eye opener to a potential new approach offering cost savings and improved impact upon environmental wastage issues that cannot continue to be ignored.

Introduction

In the field of worldwide manufacturing there are few industries that produce parts employing systems that involve consumable tooling for each production cycle. Exceptions like metal foundry production using sand casting techniques are amongst the minority whereby the mould is destroyed after each cast but industrial waste, for obvious reasons of cost and environmental impact, are kept to a minimum. It therefore follows that in the field of composites we observe an industrial production process whereby B face film infusion moulds are disposed of after each production cycle.

In essence the presentation proposes an alternative method to consumable tooling waste by employing a reusable flexible tooling system and describes the benefits of these together with sound economic reasoning to its application.

1.0 Economics

Conservative estimates of cost between 5 -6 Euro per square meter for composite film infusion material consumables are accepted as unavoidable due to the nature of this well established composite film infusion technique. However, this translates, by way of example, that for a 10 M2 composite part moulded 20 times will result in a total material waste cost of 1,200 euros ! Add to these costs the labour time for bagging up sealing and resin and vacuum connection preparation followed by removal and waste management per production cycle it soon becomes significant concern to seek less costly and wasteful alternatives.

Reusable films are a natural alternative as they offer identical technical performance and, although more expensive at the outset, do offer an economic viable alternative. The chart below (Fig 1) illustrates the cost break-even point for the mould material cost consumption for the two systems for a small 2 m^2 mould

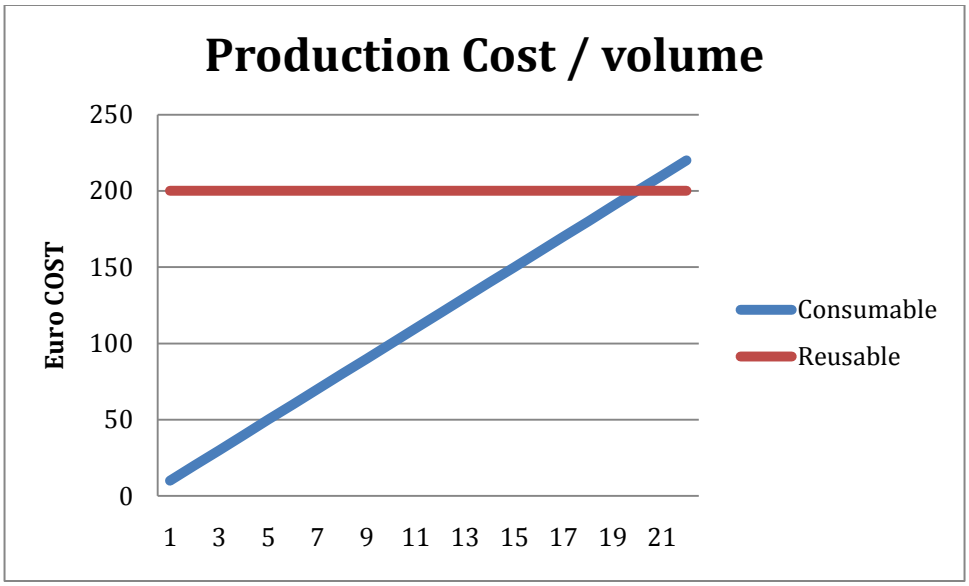

Figure 1 Cost / production for a 2m2 infusion mould

The chart clearly shows that although the reusable silicon bag material cost is fixed at 200 euro throughout its life the consumable material cost equals this after only a series production of 20 parts.

It follows therefore that after 30 parts the moulder has saved 100 Euro and continues to save a further 100 Euro so for every 10 further parts produced. This argument is true for ester based resins as a silicone membrane bag has a life expectancy of over 500 production cycles. However this is greatly reduced when using epoxies where a silicon membrane bag has a useful life of only 30 cycles. Even so there is still a significant saving of over 30% in membrane costs if the silicon membrane is employed in material costs alone.

When labour costs are compared there is further saving of greater significance. For example, consider the time to bag up using conventional film infusion materials for the 2 m2 part in the preceding example. Labour time starting from a point at which the fibre has been accurately placed upon the face mould the operators tasks include cutting from role and placement of peel ply, infusion mesh and film. Further he must add tacky tape to the mould border, in this case approximately 7m peripheral run and attach and sealing of injection and vacuum take off tubing. Thereafter careful tacky tape attachment to the film edge and pleating before vacuum is applied and leak tests are carried out. An estimated time of 40 minutes per production cycle for these tasks is reasonable which also includes the post moulding clean up work and disposal of the consumables.

The above labour tasks carried out 20 times amounts to 20 x 40 minutes = **13.4 hours**

Compare this to the time to actually manufacture a reusable silicone membrane, in the example, would be approximately 2 hours plus 20 x 10 minutes for placement and removal of the finished reusable silicone bag.
The sum of these times = 120 + (20 x10) = **5.3 hours**

Again it becomes obvious the labour cost is significantly reduced by well over 50% when employing silicone infusion membranes.

It must also be emphasized that silicone bags are moulded to fit even the most complex mould geometry whereas the use of conventional film infusing bagging materials require further time to set up and lead to many pleats and B surface of the part post moulding time to clean up.

2.0 Silicone bag production

With the introduction of liquid Platinum cure Silicone membrane materials in recent years the need for efficient methods of handling and meter mixing the 2 component silicone material has led to the developed of simple dispense/spray machines to ensure rapid and high quality membrane manufacture.

The trend has been to use double acting positive 1;1 air driven pump systems where the material is fed from on board tanks and pumped out from a hand held spray head. Figure 2 illustrates a typical Silicone dispense/spray machine of this nature. Although some material suppliers do offer the 2 pack silicone material in more costly small 0.3 to 1.0 kg cartridge form the use of twin 15 - 20 kg twin bulk tank (total 40 kg) packaging is considerably more economic. The lightweight gun with highly flexible feed hoses allows the user to rapidly manipulate the spray direction with ease. The dispense rate from a gentle 0.3kg to as high as 2.0 kg/min can be infinitely varied with the ability to simply dispense or spray from the hand held machine's gun.

The machine operation needs only both tanks topped up and is ready to use. Platinum cured silicones can be formulated to react within 90 seconds however when making an infusion bag it

is preferable to use 20 -30 minute gel time material as this allows the operator time to place reinforcing mesh within the sprayed skins to give robust handling features in the final bag. The SiloCon II model machine above has also the feature of a 3 tank model so the user can switch the nozzle output quickly between a slow and fast silicone system. Or if a more thixotropic version is to be used this can be as easily switched on for quicker build up on vertical surfaces without material draining /sagging downwards.

3.0 Method of making reusable Silicone Infusion Bag.

The following method to spray up a silicone bag is provided as a brief guide, more detailed information is necessary for the user to utilize the benefits however there is no black art to the technique.

Apart from the need to produce a robust reusable silicon membrane bag it is most important to design in effective seals, vacuum channeling and resin input runners.

To begin the face mould is normally calibrated with an offset thickness equal to that of the final part thickness. This is normally achieved using thickness wax or wax / cork combination. Some use an original part placed back into the face mould and having a relatively smooth rear face onto which the silicone is spray applied.

To produce an effective seal at the edge some have attempted to bond by various means a separate seal profile to the liquid sprayed silicone however a simpler and more cost effective method is to use a seal profile section pre positioned on the mould flange so that the silicone spray forms the correct seal shape (figure 3 illustrates)

Figure 3.

Racing car seat pre calibrated for offset thickness of final part and seal profile fixed to mould flange edge.

A range of *fi*RST® inserts, seal profile and resin runners are available (2.)

Provision is made for a central resin runner gate running on the rear calibrated surface of 2 thirds the longitudinal product length. This runner is a pre made keyhole silicone section with a proprietary attachment method to engage with and fix to with the applied uncured silicone.

Figure 4 Silicone bag production by spray application

For the mould illustrated in figure 4 a spray up time of approximately 40 minutes is normal with slow cure silicone. Systems with full cure being achieve in 3-4 hours. During spray up fabric reinforcement can be embedded to provide extra strength. Also inserts with proprietary attachment systems are applied and bonded into the final membrane bag .

There is no need of any form of release agent, as the silicone will not adhere to almost any surfaces. Once cured the reusable bag is demoulded and edge excess is trimmed off leaving the bag for instant production use. The seal profile is totally reusable for further bag production adding further cost saving. If during manufacture spray up has to stop for extended periods it is possible to continue hours later without concern for layer upon layer of silicone delamination however absolutely no contamination must be allowed to affect the virgin surface between layers. For a 2 m2 mould it is possible to spray down the required thickness in less than 10 minutes but the 40 minute time previously mentioned allows for detailed spraying on this compound and complex shape and time to place fabric reinforcement and inserts.

Figure 5

Demoulding the finished reusable bag after spray and cure.

Note the central resin line gate and bonded in insert .

4.0 Infusion methods using silicone reusable bags

As already explained the finished bag incorporates all the necessary features to use for infusion production including the edge seal, resin delivery paths and inserts so all that remains to prepare is the corresponding fibre pack onto the face mould.

Due to the forgiving nature of the silicone flexible membrane fibre needs only to be placed within the moulding cavity without too much concern of over runs into the flange area. However it must be said that fibre placement must not encroach the seal edge path as this could interfere with the seal effectiveness allowing vacuum loss during production. Also the bag design allows cavity vacuum to be achieved from the edge seal region alone but prevent resin from exiting into the vacuum take off point.

Figure 5

Basic infusion under vacuum. Resin enters a central insert point and flows longitudinally through the key hole resin runner . Resin quantity is predetermined to ensure correct volume for the mould size and fibre volume fraction . Post moulding runner resin flash zero to 1 mm

Conclusion.

There exists today a totally viable alternative to wasteful consumable film infusion materials by adopting a reusable silicone bag. Further the time saving to bag up and improved quality of the part B surface needs little or no clean up. These features alone provide a strong argument for change. Not only does the moulder make more money but reduces the industrial waste associated with conventional film bagging.

1. SilCon II - Two component Silicone spray machine by AHC, UK.
2. *fi*RST is registered by AHC UK

** Alan Harper is a specialist in his field and has been involved in closed mould composite production techniques for the last 41 years establishing recognition in all aspects of closed tooling, equipment and advanced techniques in this field. Alan Harper Composites , harpers own consultancy and technology company was established in October 2010*

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