

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Gliders are today capable of achieving performance values that were only dreamed of a few years ago. This is the result of careful aerodynamic refinement, leading to reduced profile drag that is, in turn, achieved by the extensive use of laminar flow on the glider surfaces. Laminar flow is very sensitive to the surface quality and can only be achieved if the surface contour is accurately manufactured and smoothly polished (Gliding Federation of Australia, 2001).

Such smooth surfaces are comparable to the Class A surface finish standard of the automotive industry. Figure 1-1 shows the JS1 Revelation glider finished to this standard.

The requirement for a smooth high-quality surface finish is therefore a performance requirement for gliders, but it is also a customer requirement since consumers are typically unwilling to accept scratched, warped, or otherwise damaged goods with imperfect surface finishing (Gaunle, 2012).

A Class 'A' finished surface can be defined as a flawlessly polished high-gloss surface, free of any kind of porosity and scratches. This classification originated in the automotive and marine industries. These two industries, interestingly, achieve the same finish using two different processes (Fibreglast, 2012; Raja, 2005).



Figure 1-1: A polyurethane paint, Class A finished JS1 Revelation

Automotive panels are finished with primer and paint systems that are sprayed over metal surfaces with a medium quality. The paint flows into a self-levelling thin film, after which it is polished to a true Class A surface process (Fibreglast, 2012; Raja, 2005).

In the context of marine production, the boat hull (or, in aviation, any composite structure like the fuselages and wings of gliders) receives its finish directly from the mould in which it was built. (This process is therefore quite different from the process used for automotive panels.) The finish of the mould is copied onto the part, and therefore if the mould is finished to Class A requirements, the part will have the same finish. This last method discussed here is used for most composite structures (Fibreglast, 2012; Raja, 2005).

Although the finishing of all composite structures, such as the examples of the boat hull or a glider fuselage, mainly depends on the quality of the mould finish, the application of surface layers also plays a role in the finished product. Surface layers (paints) are defined by their resin type, namely Acrylic, Epoxy, Polyester and Polyurethane. Polyester resins have enjoyed a wide spread use due to their low cost, wide spectrum of colours and applicability. The Polyurethane paints, on the other hand, have better UV resistance and does not crack as easily (Haddock, 2002). Surface layers on modern gliders are either simply polyester based gelcoats or polyester based gelcoats with an additional urethane topcoat (Dirks, 2012).

The purpose of the surface layers is twofold. Firstly, it provides the glossy final finish layer of the product; and secondly, it protects the underlying composite structure from UV damage. The UV protection usually proceeds in a manner that can be described as self-sacrificial; the surface layer therefore has a limited life (Dirks, 2012).

A polyurethane finishing is more expensive than a gelcoat system because the former requires large spraying facilities, but it offers an increased life-span compared to gelcoat finishes (Dirks, 2012).

The increased life-span of the polyurethane paint makes it a superior choice. Gelcoats, being polyester-based paints, are less UV resistant, so that it yellows over time. However, the main reason why polyurethane paint systems are preferred is because polyester paints (gelcoats) are more likely to crack and flake due to the difference in expansion between the polyester paint and the underlying reinforced epoxy plastic. Polyurethane paints, on the other hand, are more flexible and will not crack even if the filler/gelcoat underneath it shows hair thin cracks. Both of these finishes can be applied by means of two different manufacturing processes (Dirks, 2012)

These manufacturing processes used for both the composite surface layers are known as “in-mould”- or “post-mould” processing. The most commonly used process is “post-mould”, where the finish is applied to the product after it has been demoulded. This normally entails a primer and paint system similar to those in the automotive process.

In the mid-1970's, however, polyurethane moulders began to produce primed or coloured items by spraying a thin film of paint into an open mould and then placing the casting system onto the coating. This process became known as the IMC (in-mould coating) process, illustrated in Figure 1-2 (Sunbelt Materials, 1998).

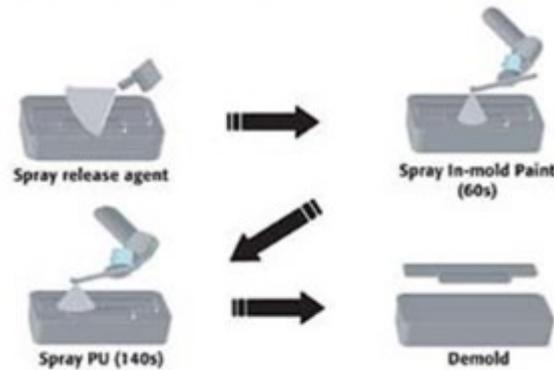


Figure 1-2: Illustration of an IMC coating process.

The JS1 Revelation, illustrated in Figure 1-1, is manufactured using a combination of in-mould and post-mould surface finishing processes to produce structures with a polyurethane surface finish. For all of these structures, the gelcoat part of the surface layers is applied in two female moulds. The two female moulds create the two halves of the outside of the structure, and these two are combined in a bonding process to create the final structure like a wing, fuselage or rudder. The final structure proceeds through various manufacturing stages before it is sent to the paint shop. Here the gelcoat surface layer is sanded, after which the polyurethane layer is also applied, sanded and polished (Coetzee, 2013).

The JS paint shop spends about 540 man hours to finish the surfaces of a glider. The entire production cycle of one glider is 2 470 hours, and entails seven production stages. Surface finishing therefore accounts for 20 per cent of the entire glider production cycle (Coetzee, 2013).

Of the 540 hours required for surface finishing, 80 hours are used to sand the surface with P600 sandpaper. P600 grit delivers a finish equal to a Class B finish (The Mould Polishing Co. Inc., 2012). This step is necessary for preparing the surfaces for further finishing steps towards producing the requisite Class A finish. Furthermore, the sanding step is required due to the poor quality of the surfaces that result after the demoulding and final assembly of the glider. If this step can be avoided, manufacturing time as well as material costs could be significantly reduced – with a concomitant reduction in cost. This can be achieved by

ensuring that all surfaces reach the paint shop already in a Class B, or even a better condition.

1.2 PROBLEM STATEMENT

The problem that this study wants to address is to explore ways of overcoming the time needed to prepare Class A surfaces, by developing a composite manufacturing process that will deliver Class A surface finished products straight from the mould. The process will need to adhere to the complete development process from mould and plug design up to the finished product, in order to solve the problem on a fundamental level by means of an applied approach.

1.3 AIMS AND OBJECTIVES

The main aim of this study is to determine a mould manufacturing method to deliver Class A surface finished part, using in-mould manufacturing processes. The objectives of this project are thus to:

- ◆ Provide a guideline for defining surface roughness and finishing of composite surface layers.
- ◆ Investigate the current mould status of the JS factory and determine the sections of the moulds that are more prone to damage and propose solutions for these.
- ◆ Determine the best surface type to use between tooling board and composite mould structures by means of a process of investigation.
- ◆ Propose and validate a process for achieving Class A surface finished plugs, with CNC machining of a tooling board as a baseline.
- ◆ Propose and validate a process for achieving composite Class A surface finished moulds.
- ◆ Propose and validate a process for achieving composite Class A surface finished parts within mould manufacturing.

1.4 LAYOUT OF THE STUDY

The body of the dissertation commences in Chapter 2 with the literature study which sets out to discuss the influences on the manufacturing of good surfaced plugs, moulds and parts for the composite industry. After the literature study has been presented, Chapter 3 provides a survey on a few JS moulds with a view to identify possible causes of mould damage. This

Chapter concludes with a summary that highlights typical mould areas that were subject to damage with the resultant refinish requirement.

Chapter 4 describes how these results were used to set up an experimental investigation for possible solutions. These solutions are presented in Chapter 5 to propose a possible method for manufacturing of Class A finished components. This process was then validated with a production part of the JS factory described in Chapter 6. The study is concluded in Chapter 7 where the objectives are revisited in light of the results of the study.