

Optimization of Assembly Processes by Heated Air Technology

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ABSTRACT

In today's assembly of large complex Carbon Fiber Reinforced Plastics (CFRP) components, e.g. vertical tail planes (VTP) of modern passenger aircrafts, liquid resin-based materials are used for several applications. Commonly, liquid resin-based materials are used to close gaps between the CFRP single parts during assembly (shimming) or to smoothen outer surfaces to fulfill aerodynamic requirements (aerodynamic sealing).

Curing times of standard resin-based materials vary between eight to twelve hours at room temperature under normal shopfloor conditions regarding air humidity. In running aircraft production such long curing times are definitely waste in the sense of lead time. By heating these resin-based materials the common curing time can drastically be reduced down to two hours. By using heated air - instead of e.g. heating lamps - the curing process can reliably be controlled, without any risk of overheating and destroying the sealant or shim material.

Both, the heated air technology as well as the newly developed dedicated heated air toolings are presented in this technical paper. The first example is the aerodynamic sealing of a VTP. Curing time of the aerodynamic sealant can be reduced by eight to ten hours using the newly developed heated air technology. The second example described in this paper is the shimming of gaps between a VTP center box and metallic parts attached to this center box.

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INTRODUCTION

In today's assembly of large complex Carbon Fibre Reinforced Plastics (CFRP) components, e.g. vertical tail planes (VTP) of modern passenger aircrafts, liquid resin-based materials are used for several applications. Commonly, liquid resin-based materials are used to close gaps between the CFRP single parts during assembly (shimming) or to smoothen outer surfaces to fulfill aerodynamic requirements (aerodynamic sealing).

Depending on temperature and air humidity, these materials generally require curing times up to twelve hours. From an efficiency and cost optimization perspective in running aircraft production such long curing times are definitively waste in terms of lead time.

By heating and/or air conditioning these resin-based materials the common curing time can drastically be reduced down to two hours. Due to the use of heated air - instead of e.g. heating lamps - the curing process can reliably be

controlled, without any risk of overheating and destroying the sealant of shim material.

In this technical paper two applications of heated air technology for the accelerated curing of resin-based shim and sealant materials will be described. At first, tolerance compensation using resin-based materials and also the resin-based materials themselves will shortly be described.

TOLERANCE COMPENSATION USING RESIN-BASED MATERIALS

CFRP is more and more used especially in the manufacturing of modern passenger aircrafts since, in general, it shows significant advantages compared to metals regarding weight, relative specific stiffness and corrosion resistance [1]. Anyhow, large and complex parts made of CFRP commonly show larger tolerances regarding form and thickness accuracy compared to metal parts since higher accuracy would directly lead to exponentially higher costs of

the single parts. Therefore, as a compromise, tolerance compensation has to be performed in the following assembly process steps, [Figure 1](#).

Shimming has to be performed to close gaps between the single parts which are caused by stack-up of thickness tolerances, to guarantee correct transfer of loads through the parts and the fastener elements.

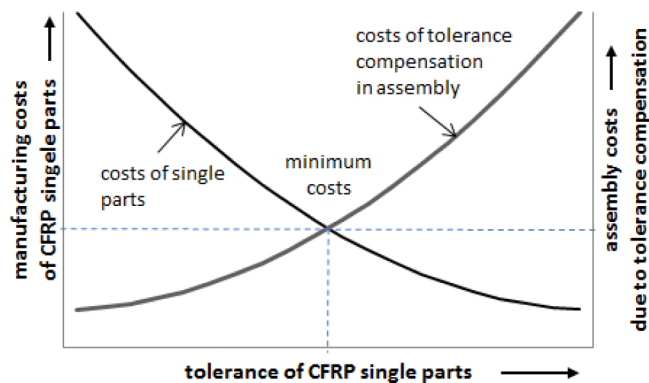


Figure 1. Optimum regarding single part manufacturing costs and assembly costs due to tolerance compensation

Closing of gaps on the outer surface of assembled components, so-called aerodynamic sealing, has to be performed to smoothen the surface and thereby to fulfill aerodynamic requirements. Following [Figure 2](#) schematically shows a vertical tail plane of a single aisle passenger aircraft exhibiting the gaps on the outer surface that have to be closed by aerodynamic sealing.

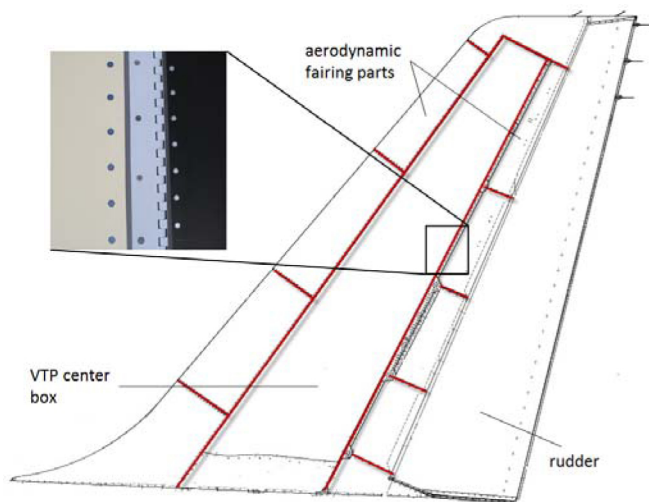


Figure 2. Example of a vertical tail plane of a single aisle passenger aircraft showing gaps on the outer surface (in red) that have to be filled by aerodynamic sealing.

GAP FILLING MATERIALS

Both, the shim and the sealant used for tolerance compensation are liquid resin-based materials. In the following only the main characteristics of these materials are shortly described which are relevant to understand the usability of heated air.

Aerodynamic Sealant

The sealing material is a two-component polysulfide-based compound from company Chemetall. With the current product variant the curing time is ≤ 8 h at 23°C to achieve a hardness of Shore A ≥ 30 of the cured material. By increasing the temperature the curing time can be reduced. Vice versa, a decreased temperature leads to longer curing times. Especially during winter time (with temperature in the shopfloor of less than 20°C) this could lead to curing times of up to 16h. [Figure 3](#) shows the curing time of the used sealing material in dependence of the curing/environmental temperature [2].

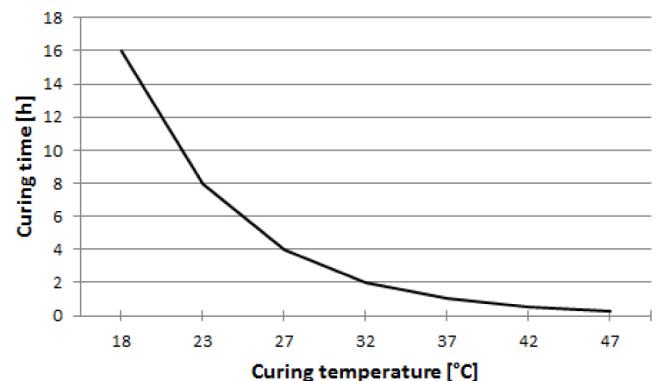


Figure 3. Curing time of the used sealant material in dependence of the curing temperature.

In addition, a minimum relative humidity is necessary for the initiation of the chemical curing reaction (vulcanization). Also, especially during winter relative air humidity could be less than 10% which leads to further extension of the curing time.

Shim Material

The used shim material is a two-component epoxy-based compound from company Henkel. The curing time at $20\pm 3^{\circ}\text{C}$ is 9h. By increasing the temperature the curing time can be reduced to less than 2h. [Figure 4](#) shows the curing of the used shim material in dependence of the curing temperature [3].