EFFECT OF SURFACE COATING ON THE CHARACTERIZATION OF THE PROCESS DYNAMICAL BEHAVIOUR DURING MOLD FILLING IN LIQUID RESIN INFUSION

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20th International Conference on Composite Materials
Copenhagen, 19-24th July 2015

INTRODUCTION

Resin Infusion (RI) is increasingly used in **aeolian energy systems where low weight and high mechanical performance materials are demanded**. It can be operated in low cost open molds with vacuum bags due to its low-pressure conditions. Moreover, in many applications like **wind turbine blade manufacturing the in-mould coating plays a key role in the product performance**. It is often required an optimum interphase adhesion and surface finish for mechanical performance or durability reasons. Since the coating is usually painted or sprayed onto the mould tool before the dry preform is laminated, it is also necessary to address measurement of part quality in terms of different reasons such are: **completed filling, proper resin impregnation, and also, interphase coat-laminate** mechanical characterization. Distinctive testing are shown in order to assess the **macroscopic flow behavior of the resin laminates and its relation with the coating and the manufacturing conditions**.

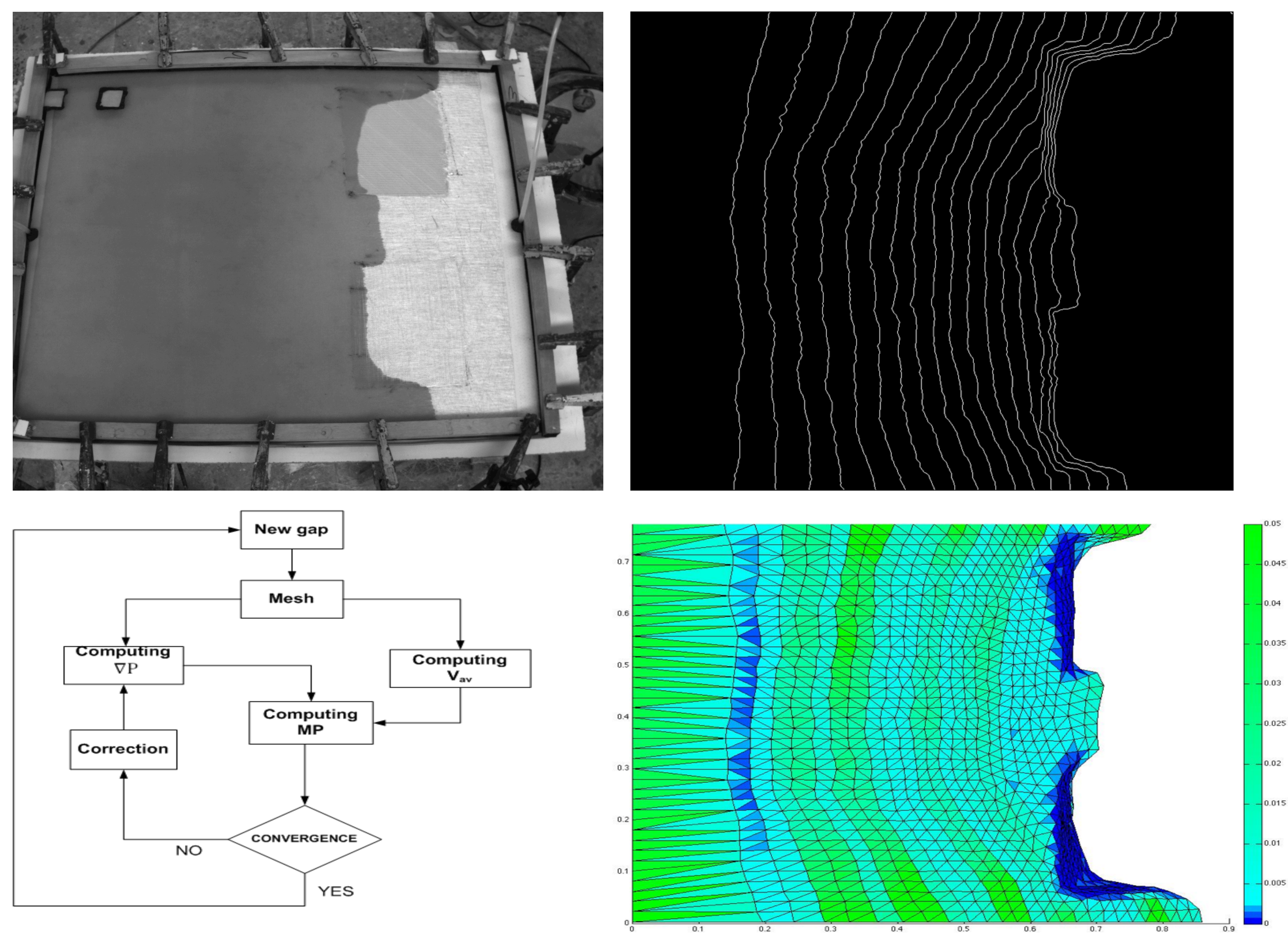

Figure 1: A Mixed numerical/experimental technique (MNET) based on A.V. for the dynamical behaviour characterization during filling

ESTIMATION OF MATERIAL PROPERTIES

The **material characterization and measurement of fibre preform** permeability allows predicting the flow behaviour in porous media with numerical simulation. A **mixed numerical/ experimental technique** based on artificial vision is used for estimating the induced effect of the surface coating curing in the laminate impregnation and the flow front advance during filling. The procedure **iterates the value of the estimated local material parameters M in the simulation until it matches the evolution of the experimentally measured flow front data.** Computation of **velocities at flow front** can be estimated by means the distance and time between consecutive flow fronts. In this work **a level set approach is employed to compute the vent distance field.**

Darcy's Law: $\underline{v} = -\frac{\underline{K}}{\varphi \cdot \mu} \nabla P \quad \Rightarrow \quad \underline{v} = -\underline{M} \cdot \nabla P$

Artificial Vision+LevelSet Velocity computation

Assuming Isotropy $\quad M = \frac{\|v\|}{\|\nabla P\|}$

FEM Simulation of Velocity field

$$M^{est} = \frac{\|V_{AV}\|}{\|\nabla P(M^{est})\|}$$

$$M^{est}_{K+1} = \frac{\|V_{AV}\|}{\|\nabla P(M^{est}_K)\|}$$

Figure 2: Estimation of Material Properties M

EXPERIMENTAL RESULTS

The described proposal has been applied to both simulating and real mold filling. The experiments have been **conducted by filling a 2D rectangular mold using 2 different curing conditions for the gel coat** in order to generate **differences in the impregnation and flow advancement of the resin in the dry preform during filling**. Coat 1 and coat 2 are characterized previously by performing a measure of the degree of conversion of the polymerization reaction of the polymer matrix.

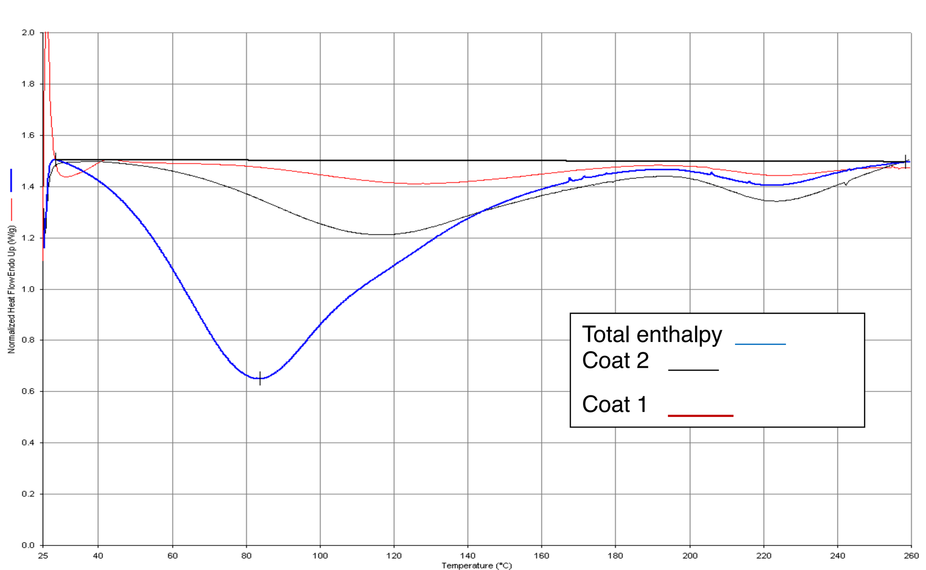

Figure 3: Coat reaction entalphy measured with DSC.

Test 1: Unidirectional flow with an abrupt discontinuity in the curing degree of the gel coat: the coatings have been applied on the mold surface in 2 consecutive areas as outlined

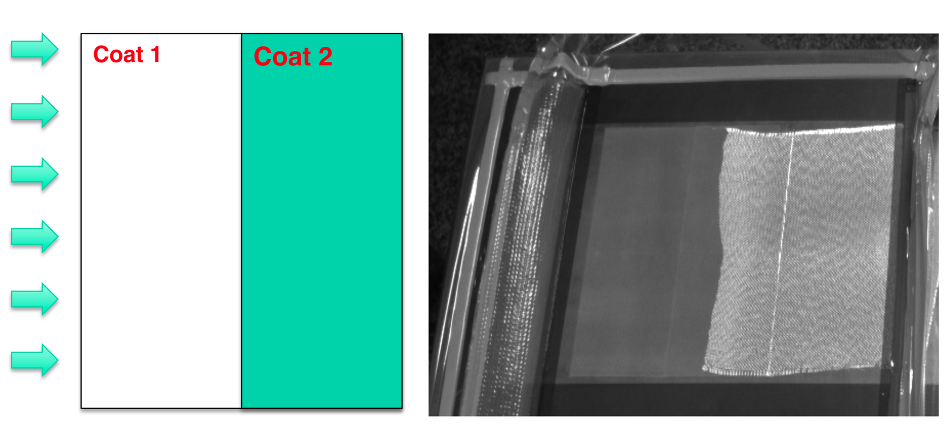

Figure 4: Experimental setup for 1D Material Properties estimation

The textile was preplaced in the whole domain with a constant isotropic permeability. The material properties are computed locally during filling using the above exposed methodology stated previously as $M = \frac{K}{\phi \cdot \mu}$

The **value of M is estimated for each flow front position** so it can be observed an abrupt change on it when the coating also changes. **This alteration on the coat curing yields a related change on the flow front velocity that the system identifies**

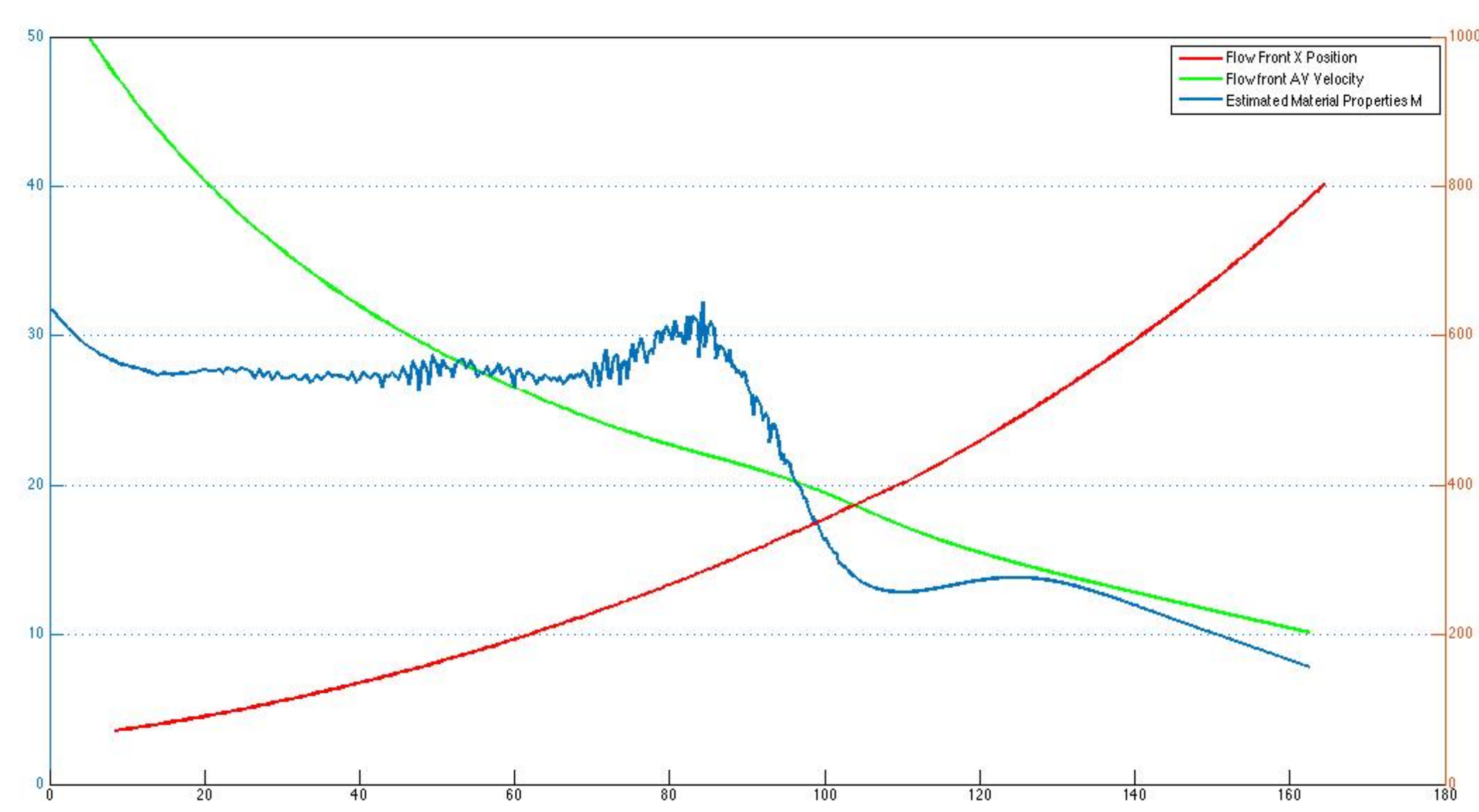

Figure 5 Material Properties Estimation during filling (blue), 1D Flow front position (red) and Flow front Velocity (green)

Test 2: Bidirectional flow with an abrupt discontinuity in the curing degree of the gel coat

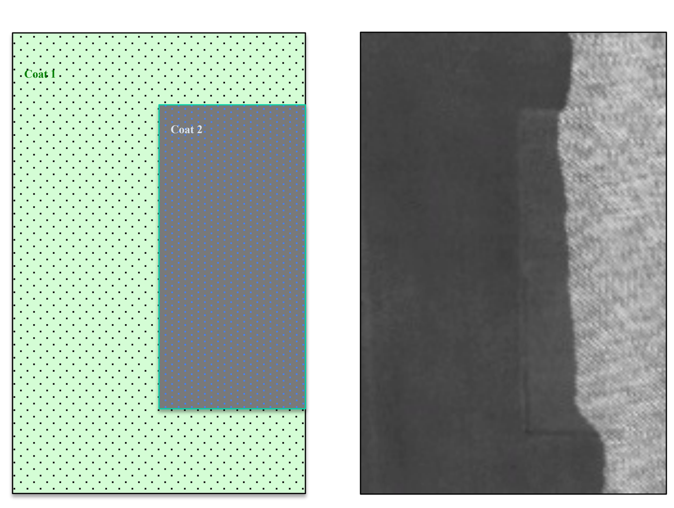

Figure 6 Experimental setup with two different coat areas (left) and intermediate AV image flow front (right)

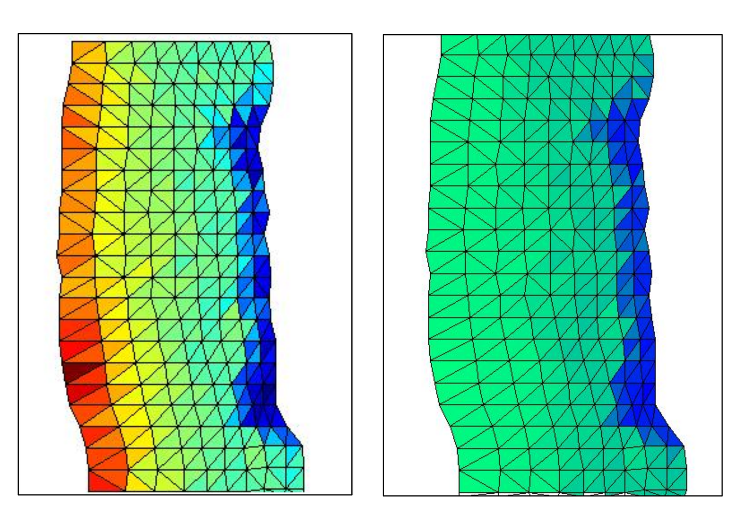

Figure 7 Estimation of Velocity field in elements (left) and Material Properties (right)

In this case, the 2D velocity field during filling is computed in a triangular mesh. The Material Properties estimation M is outlined in Figure 7. It can be observed **that the curing degree discontinuity of the coating areas** can be **identified by means of a deep change on the flow front velocity** and hence M can be characterized.

A deeper research is being done in order to establish the effect on the materials parameters separately (permeability, compaction, porosity, etc).