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# Quantifying the relevant time-quality trade-off of the curing process for wind turbine blades manufacturing

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## Introduction

### Challenges in composite manufacturing:

- Quality compliance due to unexpected process induced defects
- Reducing cost due to long process time and failures
- Sustainability due to large amount of scrapped materials

### Wind industry current solution

- Overdesigning

### Issues:

- Process cost
- Blades efficiency
- Sustainability



Figure 1: a) Wind turbine farm in Netherlands b) Manufacturing of wind turbine blades

## Research methodology

Three threads of research can be identified to generate the necessary science based background allowing optimisation of the process:

### New material characterisation methodology

- **Chemical-thermal properties**
  - Cure kinetics
  - Specific heat
  - Thermal conductivity
- **Mechanical properties**
  - Mechanical modulus
- **Thermomechanical properties**
  - Coefficient of thermal expansion
  - Shrinkage

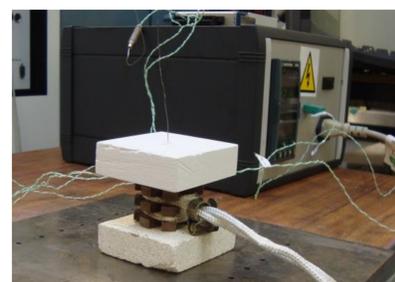


Figure 2: a) Thermal conductivity test set-up b) Mechanical modulus samples manufacturing

### Cure process simulation

- **Heat transfer model**
  - Degree of cure evolution
  - Overshoot temperature
- **Coupled thermo-mechanical model**
  - Residual stresses generation
- **Model validation**
  - Temperature measurements
  - Residual stresses measurements

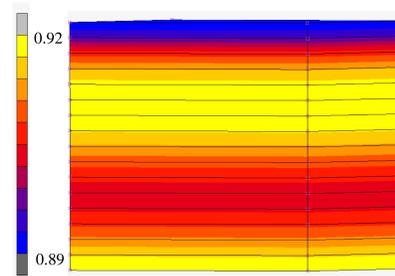


Figure 3: a) Degree of cure results for a 47 mm thick laminate b) Sampled manufacturing for mechanical performances and validation

### Multi-Objective optimisation methodology

- **Quality/Cost Pareto front**
  - Set of optimal design points
  - Significant reduction in process time (78%)
  - Overshoot temperature (60%)

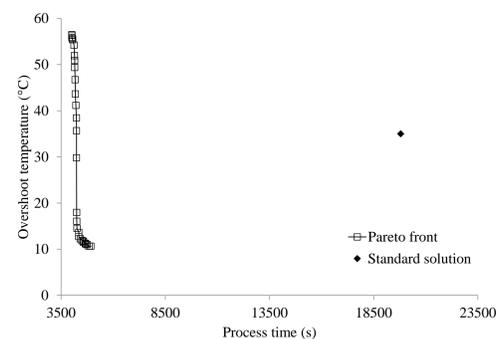


Figure 4: Comparison between standard results and Pareto front

## Conclusions

- The optimisation methodology is able to unveil relevant quality/cost trade-off
- The material characterisation will provide accurate material properties evolution due to novelties in characterisation
- Infrastructure for measuring temperature and residual stresses will validate models predictions.

## References

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