

VIPV: Thermocompression Process Development and Simulation to Integrate Photovoltaic Cells in a Double-Curved Composite Structure

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SUMMARY

- Introduction & context
- **I**. Process development
- **III.** Numerical model of the developed modules
- **IV.** Conclusions and perspectives



STATE-OF-THE ART: VEHICLE INTEGRATED PHOTOVOLTAICS (VIPV)





module 40 cm x 40 cm

FROM A CLASSICAL FLAT PV MODULE TO A DOUBLE CURVED COMPOSITE PV MODULE



↑ Simplified exploded view of a "classic" flat photovoltaic module

Laminator \rightarrow

Source : Directindustry.fr

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 \uparrow Press + double curved mould



Introduction

Process development: thermocompression for PV module manufacturing





THERMOCOMPRESSION PROCESS ...



Geometrical tolerances

High production rate

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- Automatable
- Thermoplastic materials

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 Stresses resulting from thermomechanical loads

SOUTONS SOLARS

AND ITS ISSUES... Porosity Cells breaks Materials Springback processing & adhesion

Introduction

Conclusior

THERMOCOMPRESSION PROCESS DEVELOPMENT: MOULD DESIGN

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SYMME



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Under progress...

- → End up validation of the numerical model
- → Increase in maturity: ageing tests, optimisation of process parameters, industrialisation scheme, etc.



Introduction

Numerical model of the developed modules



AIMS OF THE MODEL		J: Test courbure Directional Deformation Type: Directional Deformat <mark>Max Y</mark> is) Unit: mm Global Coordinate System Time: 0,94737
Predict the stresses resulting from the process	 Simulate the different stages of the process Validate the numerical results 	03/12/2020 10:41 0.051437 Max -0,78918 -1,6298 -2,4704 -3,311 -4,1517 -4,9923 -5,8329 -6,6735 -7,5141 Min
		Rc=300 mm, p= 0.213bar Déformation delér _{ent} (82 _{cm} , 21.016 mm)
Ensure the integrity of the cells	• Define the double radius of curvature limit of a photovoltaic cell technology (see poster session 2CV.1.7)	
		See 2CV.1.7
Optimize the stack	 Minimise mass for a set of defined mechanical loads Minimise stresses resulting from the process 	C: Static Structural Solid Equivalent Stress Cell Type: Equivalent (von-Mise) Stress (Analysis Ply=P1L1_Cellule(ACP (Pre) SR and OSS)) - Top/Bottom Unit: MPa Time: 1 23/04/2021 11:45 223,51 Max 198,78 174,06 149,33 124,61 99,894 75,159 50,434



Process development 🔪

MAINS RESULTS: MULTISTEP SIMULATION OF THE PROCESS (2/2)





Process development Numerical simulation

MAIN RESULTS: QUANTIFICATION OF THE SPRINGBACK



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← Metrological measurement of the module surface at the process output

Correction of the reference plane to ensure coplanarity of the corners

Aim: to have a zero gap at all points to cancel the springback.

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↑ Springback calculation: comparison of the vertical position of the nodes measured by metrology with the theoretical curvature targeted. Positive value ⇔ the front face is less curved than expected.

Numerical simulation Conclu

Towards a correction of

MAINS RESULTS: COMPARISON BETWEEN METROLOGICAL MEASUREMENTS AND MODEL OUTPUT



↑ Extraction of vertical positions of nodes at the output of the numerical simualtion, on a node selection

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Relative error model / measurement ~100 %

↑ Calculation of the simulation error: difference between the vertical position of measured nodes and of corresponding nodes at the output of the simulation.

Aim:

Getting no difference between numerical output and experimental output

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Analyse ageing tests

CONCLUSION AND PERSPECTIVES



Towards process industrialization ...

Finish the validation of the numerical model of the thermocompression process + optimization





NNOVATIONP LASTURGIEC OMPOSITES





THANK YOU FOR YOUR ATTENTION

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