FIDAMC

AERONAUTICAL STRUCTURES BY AUTOMATIC LAY-UP WITH THERMOPLASTIC COMPOSITES AND MATERIAL BEHAVIOR

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FIDAMC

0. CONTENT

1. INTRODUCTION

1.1 WHY THERMOPLASTIC IS A KEY TECHNOLOGY?

GENERAL

INDEFINITE SHELF LIFE

ROOM TEMPERATURE STORAGE

RECICLABILITY

PROCESSING/ FABRICATION

RAPID FABRICATION

MANUFACTURE COMPLEX PARTS IN A SINGLE STEP

INTEGRATED FABRICATING AND ASSEMBLY

PROPERTIES

DAMAGE TOLERANCE

VERY LOW MOISTURE ABSORTION

EXCELLENT HIGH TEMPERATURE PROPERTIES

OUTSTANDING FIRE RESISTANCE AND VERY LOW SMOKE GENERATION

MAIN DRAWBACKS

HIGH MANUFACTURING TEMPERATURE

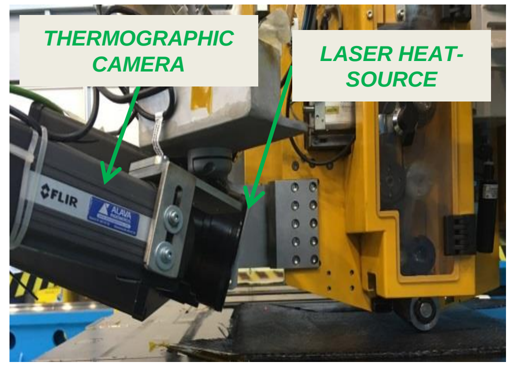
HIGHER MATERIAL COST THAN THERMOSET

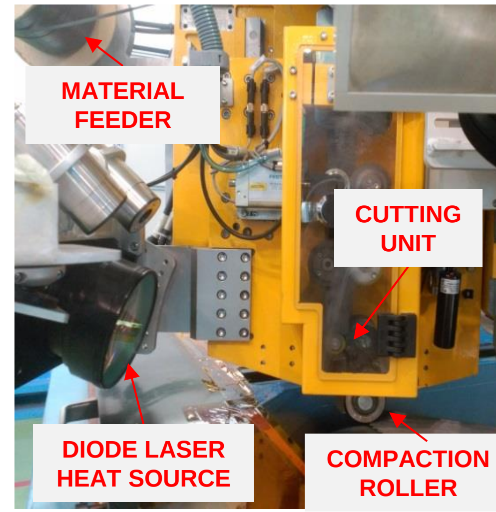
LOW VOLUMEN OF MATERIAL USED IN AERONAUTICAL INDUSTRY

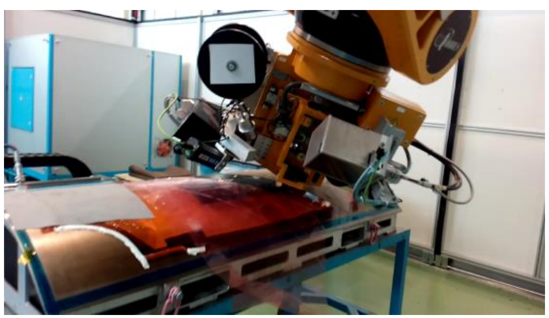
SUPPLIER INTERACTION WITH MANUFACTURER NEEDS

1. INTRODUCTION

1.2 THERMOPLASTIC ROADMAP IN FIDAMC: FROM UNITOW TO MULTITOW HEAD







AFP/ATL PROCCESSING EQUIPMENT

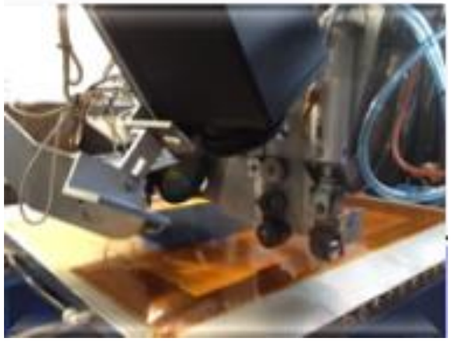
HEAD IS MOUNTED ON GANTRY STYLE TAPE LAYUP MACHINE WHICH MOVES LONGITUDINALLY ON FIXED RAILS WITH:

- LASER HEAT SOURCE
- CONSOLIDATION/COMPACTION ROLLER IN HOT LINE
- TAPE CUTTER
- TENSION CONTROL
- CONTROL SOFTWARE

1. INTRODUCTION

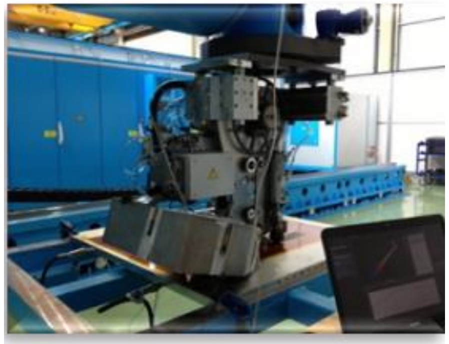
1.2 THERMOPLASTIC ROADMAP IN FIDAMC: FROM UNITOW TO MULTITOW HEAD

1ST Prototype



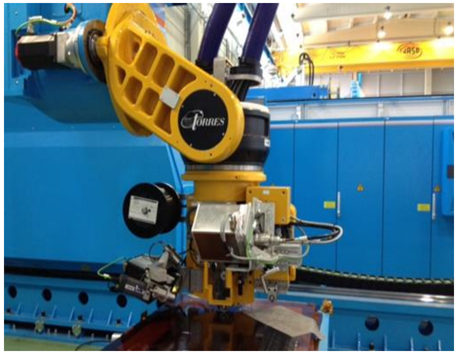
LASER DEVICE
(FIXED OPTIC)

2nd Prototype



LASER DEVICE
(SCANNER)

EXISTING HEAD



EXISTING HEAD INSTALLED IN FIDAMC MACHINE ONE-TOW (1/4” OR 1/2”)

MULTITOW HEAD

MULTI-TOW HEAD CONCEPT DEVELOPED WITH MTORRES

1. INTRODUCTION

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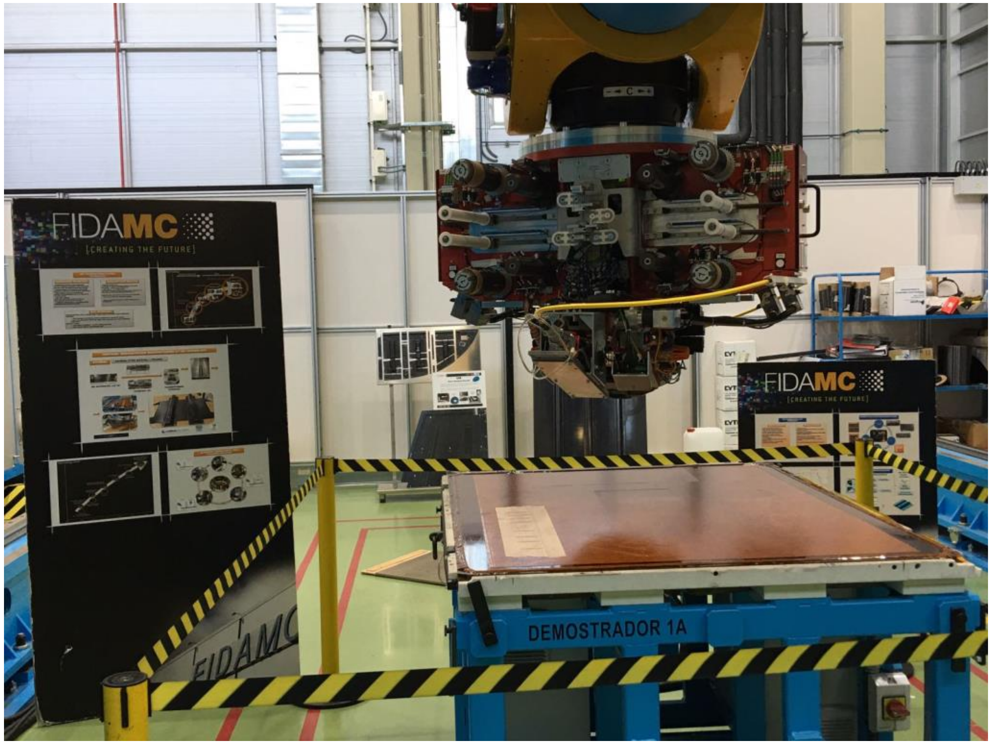


EIGHT TOWS HEAD

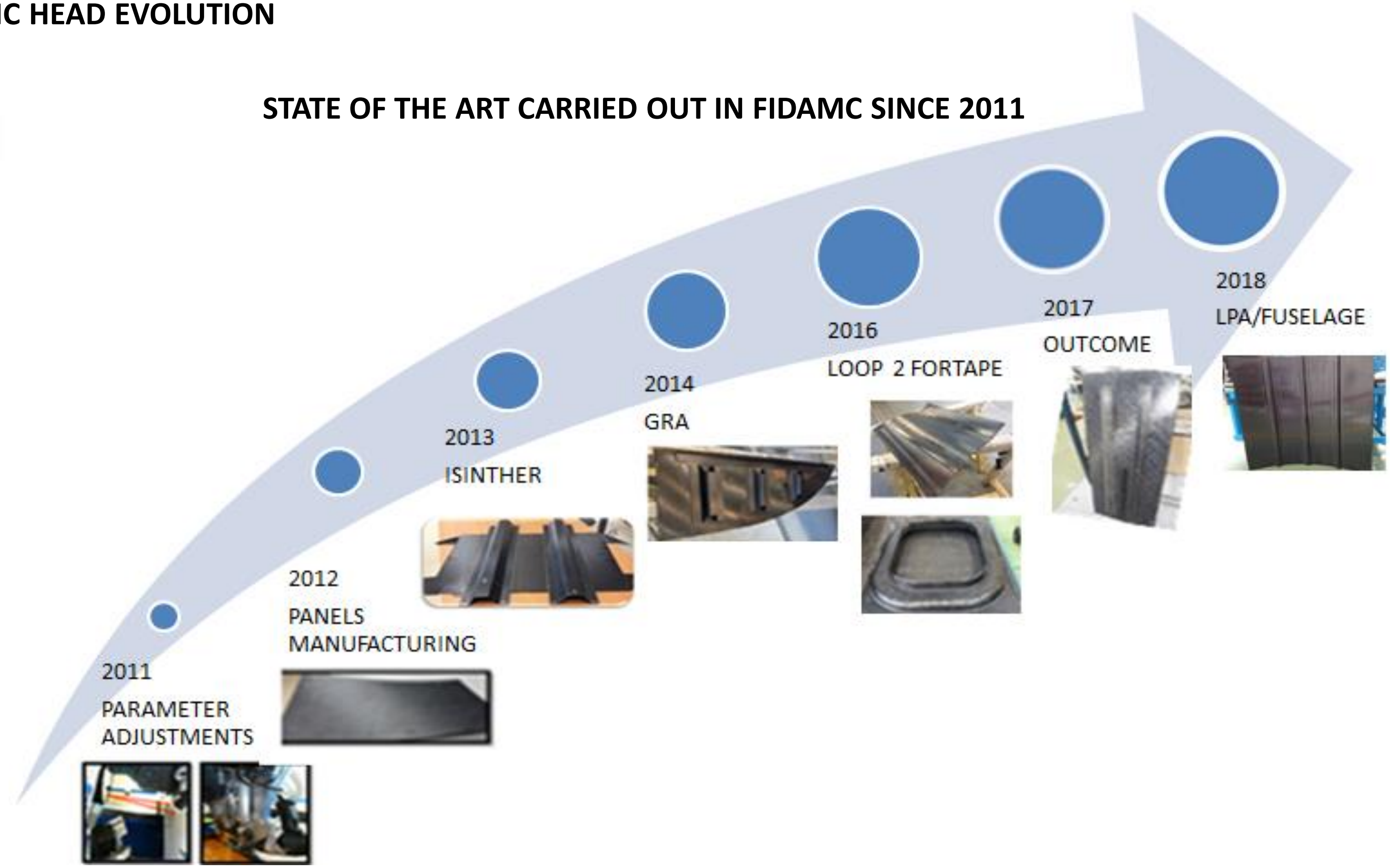
NEW CONCEPT OF HEAD: MULTI-TOW (8)

PROTOTYPE HEAD WITH NEW OPTIC LASER

1. INTRODUCTION

1.3 THERMOPLASTIC ROADMAP IN FIDAMC: EVOLUTION OF THERMOPLASTIC MACHINE AND STRUCTURES

THERMOPLASTIC HEAD EVOLUTION



2. FULL SCALE DEMONSTRATORS: WING PANEL AND FUSELAGE SHELLS.

THERMOPLASTIC ROADMAP IN FIDAMC: FULL INTEGRATEDSTRUCTURES-TECHNOLOGICAL DEMONSTRATORS

STRINGER MANUFACTURING


ISC Lay-up flat panels


Stamping process

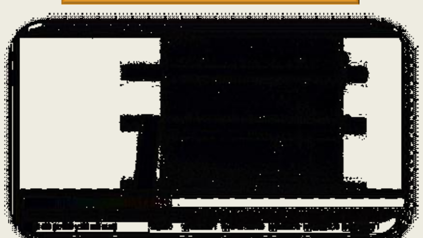

Stamping stiffener

INTEGRATION AND SKIN LAY-UP WITH ISC


Modular tool for Stiffener positioning


Skin lay-up

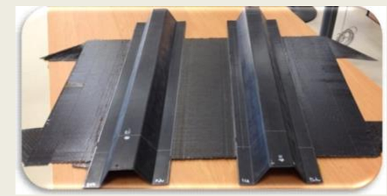
US INSPECTION



ASSEMBLY

FIDAMC PROJECTS

ISHINTER



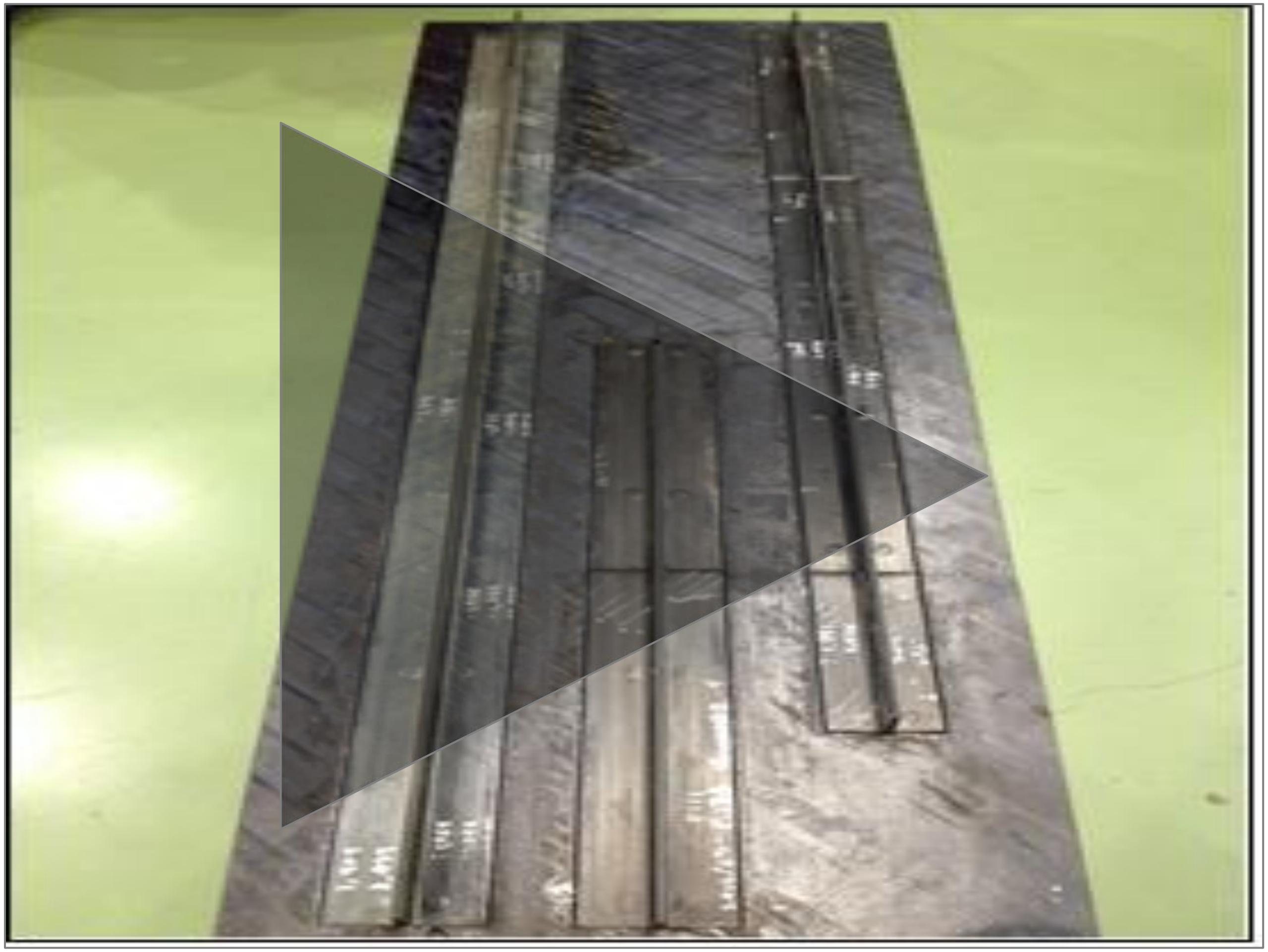
GRA

OUTCOME

LPA FUSELAGE

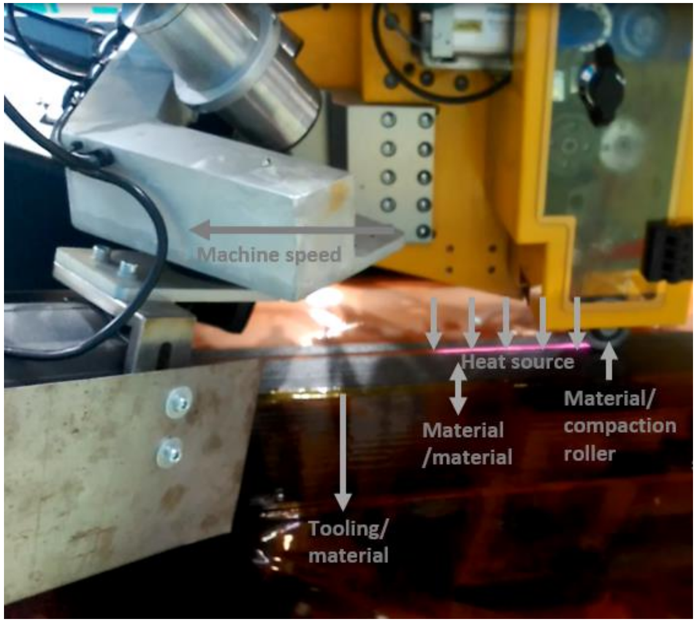
2. FULL SCALE DEMONSTRATORS: WING PANEL AND FUSELAGE SHELLS.

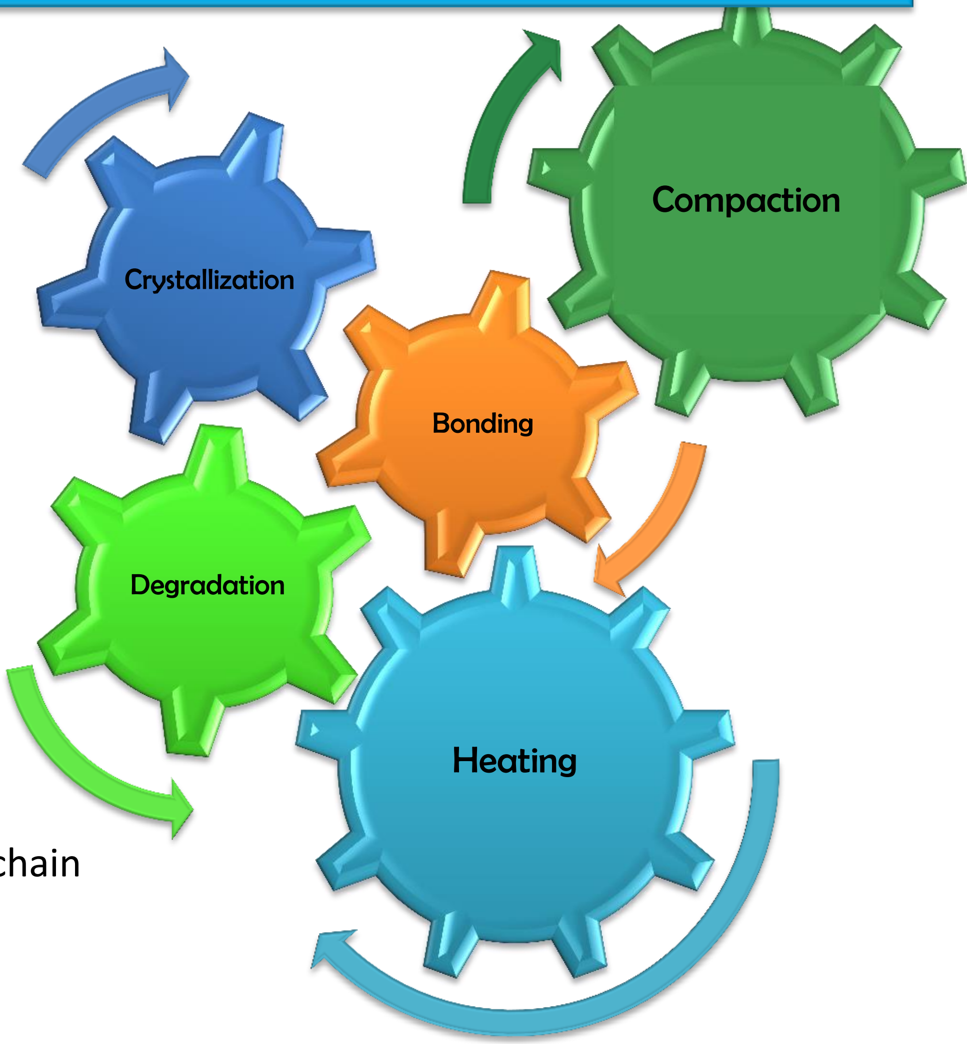
FEASIBILITY DEMONSTRATOR PANEL: PANEL WITH CO-CONSOLIDATED "T" SHAPED STRINGERS



3. MECHANISMS AND MODELS

3.1 INTERACTION





- Heating – diode laser → polymer melting
- Short time → ↑temp. → thermal degradation
- Adhesion → roughness/pressure/temperature/chain movements
- Cooling → crystallization

3. MECHANISMS AND MODELS

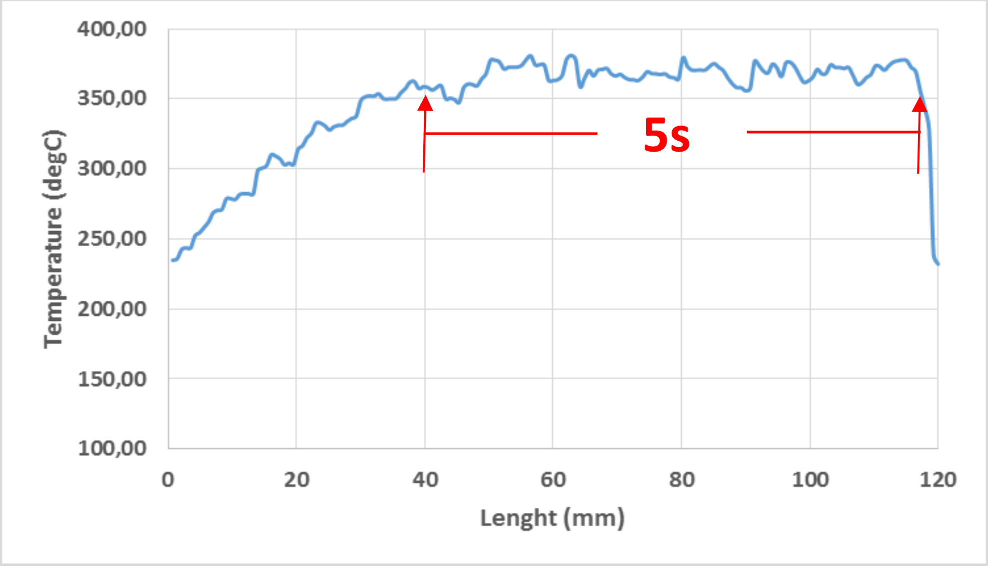
3.2 HEATING

1 single tow machine → Multiple tow machine

Scanning laser → Fix optical laser

Temp. distribution in the lenght depending on the requirements
Complex behavior

Greater heating area
Difficulties to focus the temperature on the required area
Easier behavior



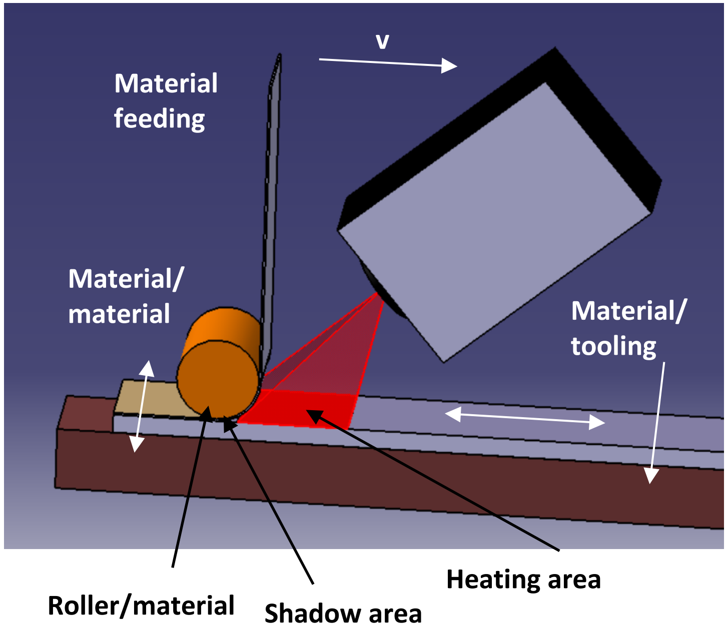
THERMAL CONTROL - THERMOGRAPHY

ONE FIXED SPEED
(COULD BE MODIFIED/VARIABLE DURING LAMINATION)
ONE FIXED COMPACTION PRESSURE (COULD BE MODIFIED)
LASER FIXED POSITION (COULD BE MODIFIED)
TOOLING TEMPERATURE (COULD BE MODIFIED)

VARIABLE POWER / VARIABLE LASER PROFILE

3. MECHANISMS AND MODELS

3.2 HEATING



Heat source – power density

Heat transferences:
- Material-material
- Material-roller
- Material-tooling
- Material-air

Variable thermal properties in the material (conductivity, heat capacity…)

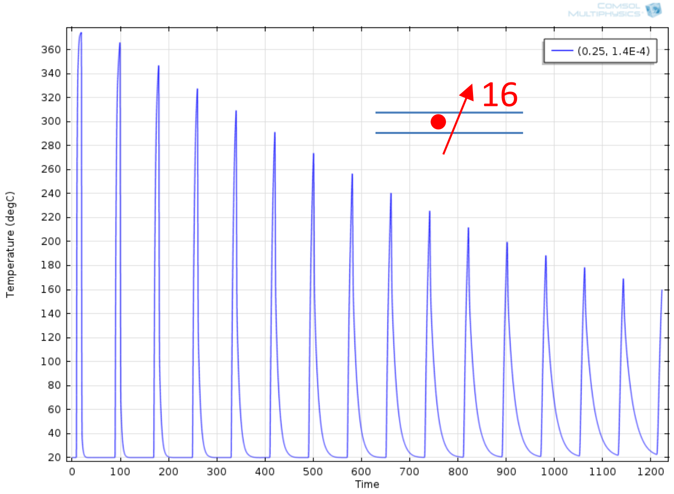
The performances of the laminate / part are not only related to the surface heating but with the whole state of the set.

Layers are subsequently heated by conduction from the upper one.

Controlling variable: temperature at the surface of the substrate/NIP point

Internal measurements by using thermocouples / simulation with the information from the upper layer

SIMULATIONS DEVOTED TO KNOW THE INTERNAL STATE ON THE SET, GIVING INFORMATION ABOUT RE-HEATING IN THE DOWNER LAYERS AFFECTING



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ONE FIXED COMPACTION PRESSURE (COULD BE MODIFIED)

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THERMAL DEGRADATION

HEATING TIME

DEGREE OF INTIMATE CONTACT
DEGREE OF HEALING
DEGREE OF BONDING

HEATING TIME/HEATING TEMPERATURE

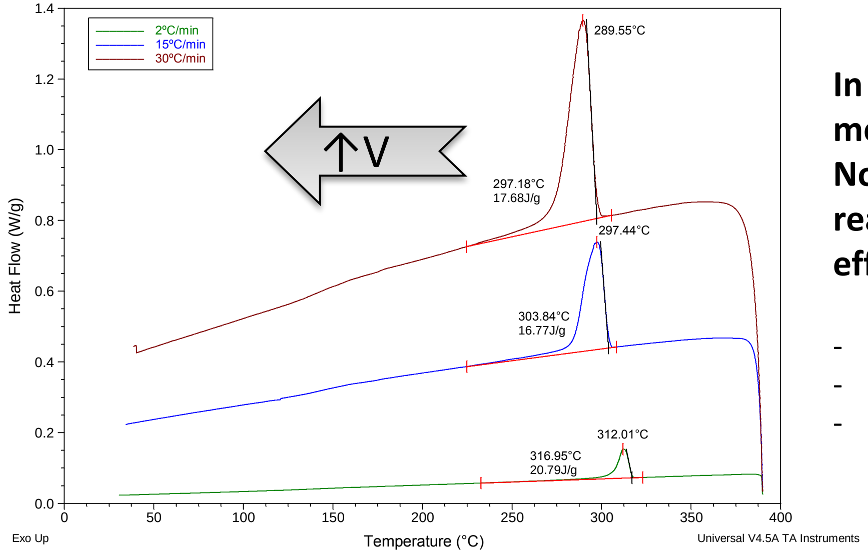
MELTING

CRYSTALLIZATION

COMPLEX INTERRELATION AMONG MANY PARAMETERS //
ALMOST IMPOSIBLE TO BECOME INDEPENDENT

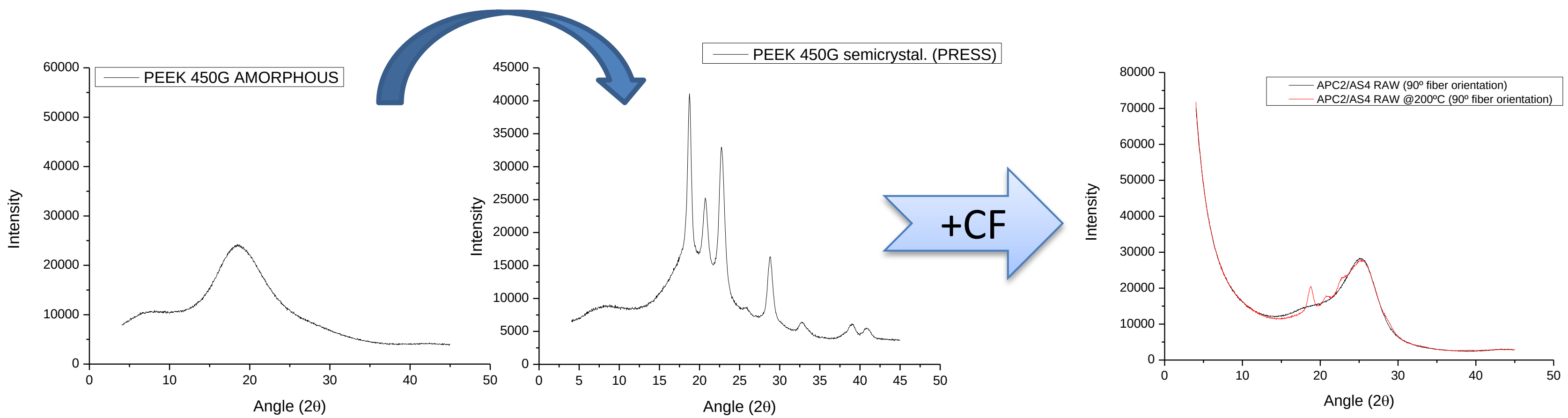
3. MECHANISMS AND MODELS

3.3 CRYSTALLIZATION AND DEGRADATION INTERACTION



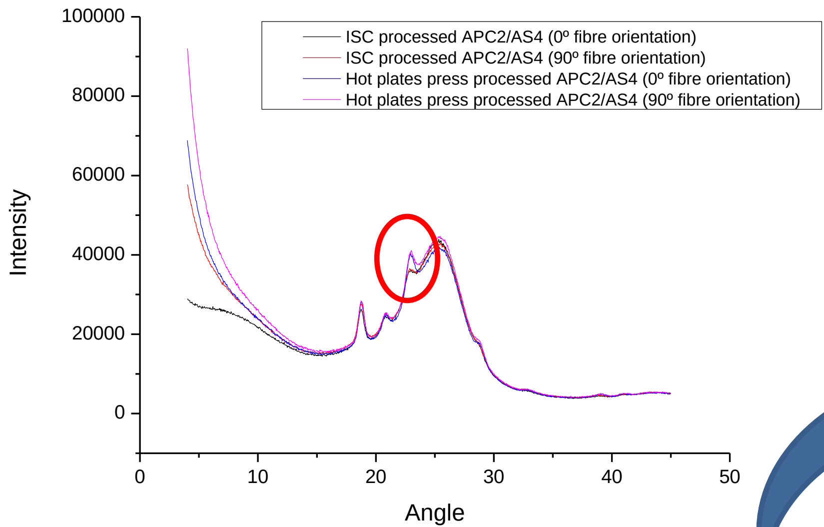
In this manufacturing process – cooling speed is so high. It means that an ~ amorphous structure is obtained. Normally, it is accepted that it is OK when a specific % is reached (defined as a huge range) In the ISC process, many effects take place:

- ABRUPT COOLING
- MULTIPLE RE-HEATING STEPS OVER Tg (HIGH SPEED HEATING)
- MAINTENANCE ON A TOOLING WHICH IS NORMALLY OVER Tg



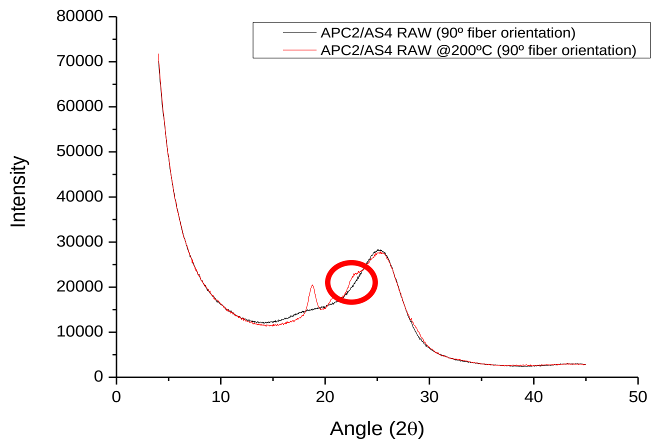
3. MECHANISMS AND MODELS

3.3 CRYSTALLIZATION AND DEGRADATION INTERACTION

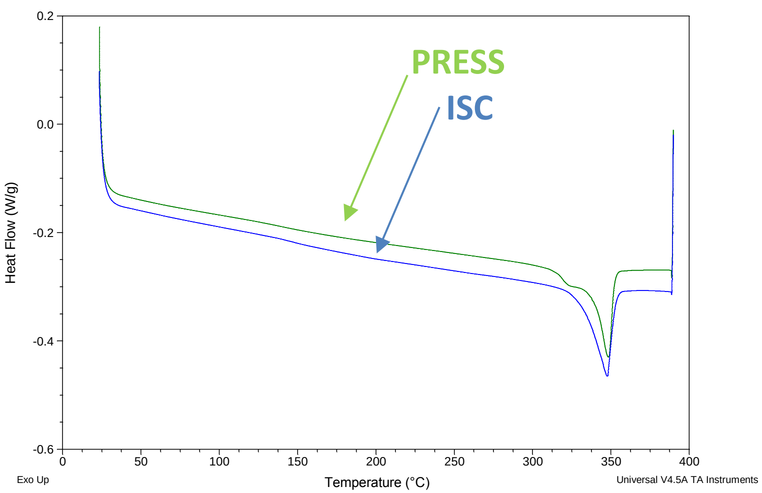


THERE IS A SMALL BUT IMPORTANT DIFFERENCE BETWEEN PRESS/ISC RESULTS BY XRD

THE RESULT IN THE ISC IS SIMILAR TO THE RESULT PREVIOUSLY SHOWN IN THE INDIVIDUAL LAMINA PLACED OVER HEATING TOOLING



DSC



3. MECHANISMS AND MODELS

3.3 CRYSTALLIZATION AND DEGRADATION INTERACTION

THERMAL DEGRADATION IN THE MATERIAL CAN BE PRODUCED BY OVERHEATING

MAINTENANCE TIMES AT HIGH TEMPERATURE ARE REALLY SHORT

TGA ANALYSIS

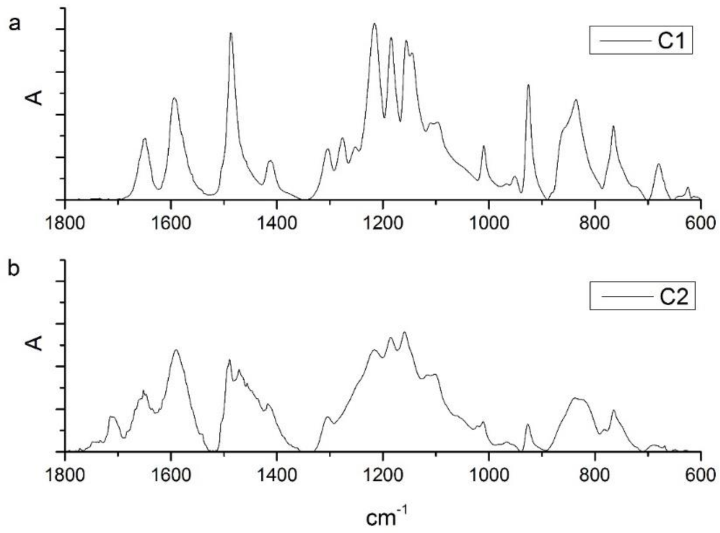
Weight loss

RHEOLOGICAL ANAYLISIS

Viscosity variations

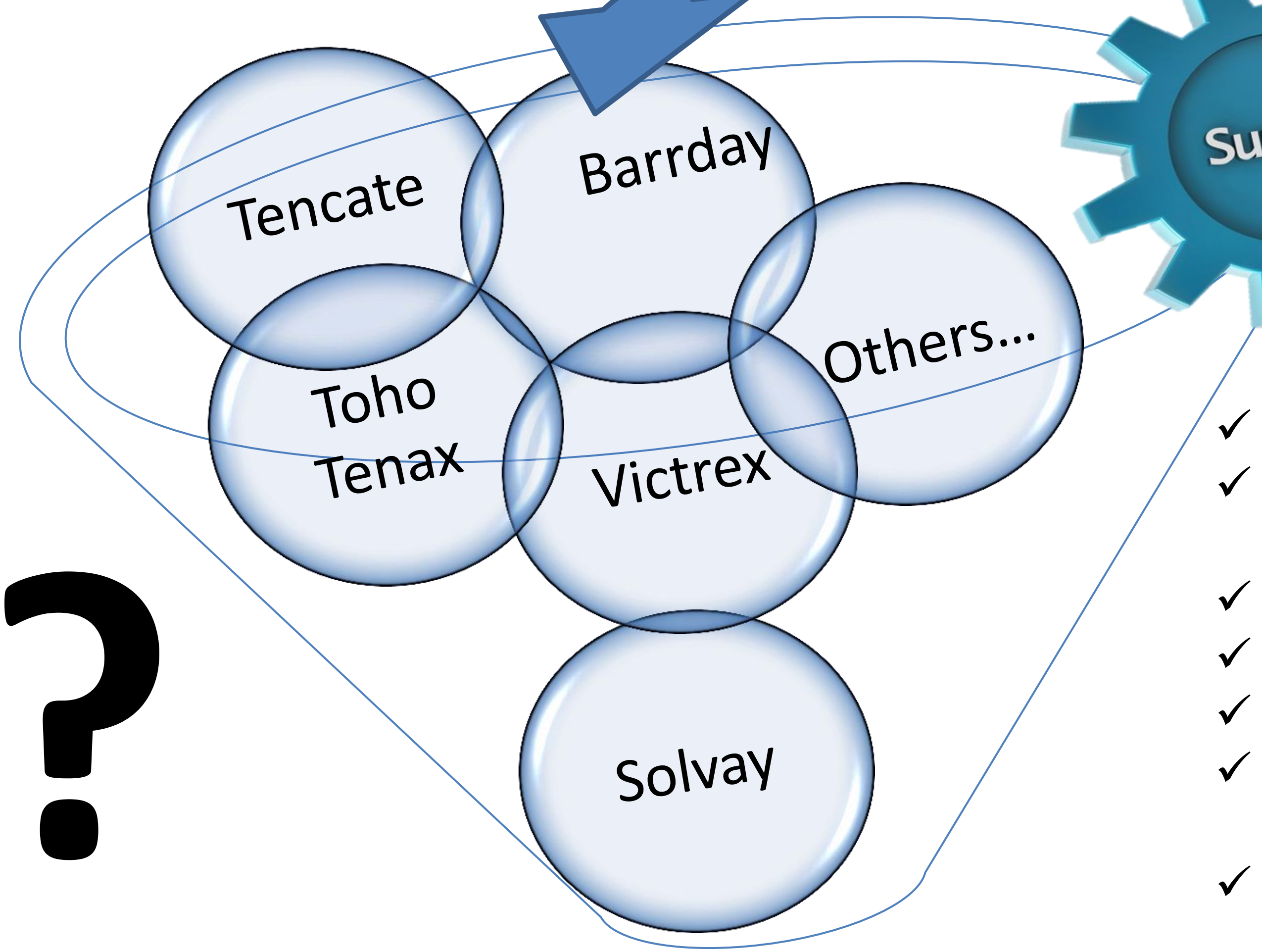
FIXED LAMINATION PARAMETERS PERMIT TO OBTAIN GOOD QUALITY LAMINATES WITH NO DEGRADATION EFFECTS

FTIR-ATR (PEEK 450G DEGRADATED)



4. PEEK/PEKK MATERIAL COMPARISON. RAW MATERIAL SUPPLIERS

PEEK/PEKK/PAEK…

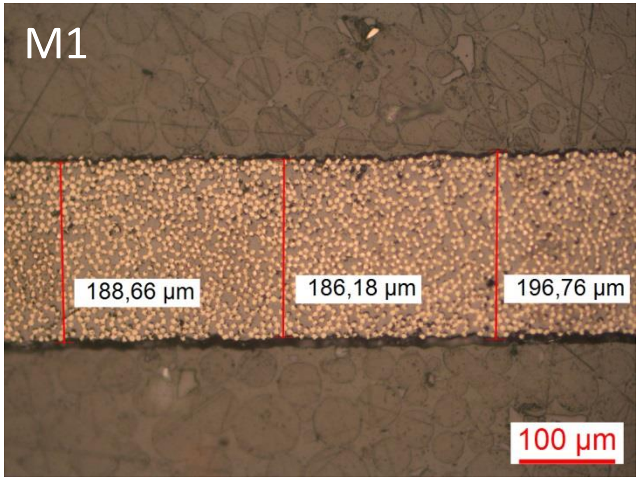


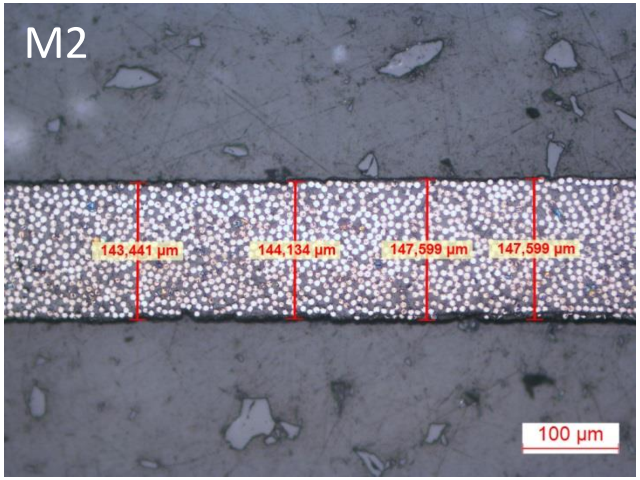
- ✓ **Flat material**
- ✓ **Homogeneous distribution resin-fiber**
- ✓ **Resin at the surfaces?**
- ✓ **Accurate tolerances**
- ✓ **Best performances**
- ✓ **Low melting points**

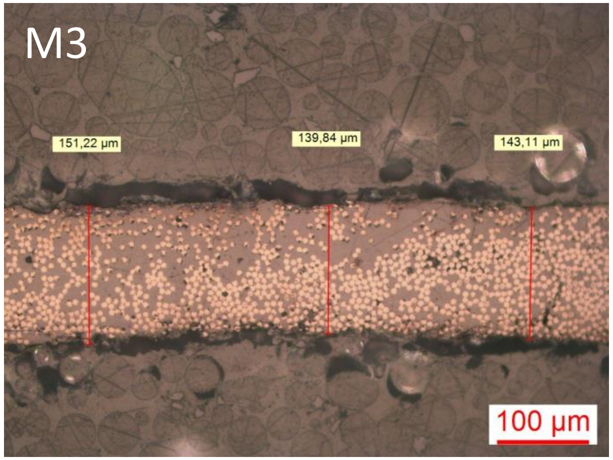
- ✓ **Supplier capabilities**

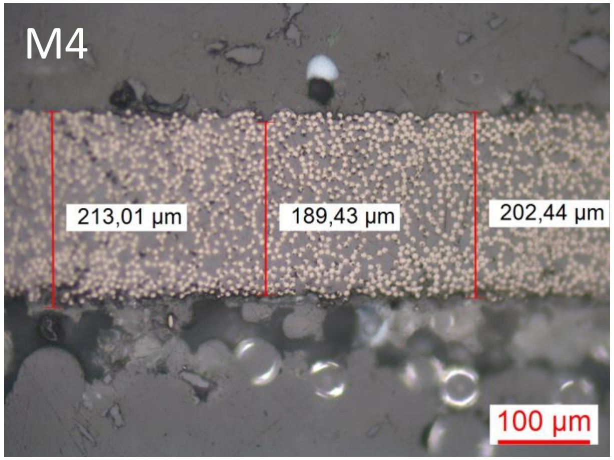
4. PEEK/PEKK MATERIAL COMPARISON. RAW MATERIAL SUPPLIERS

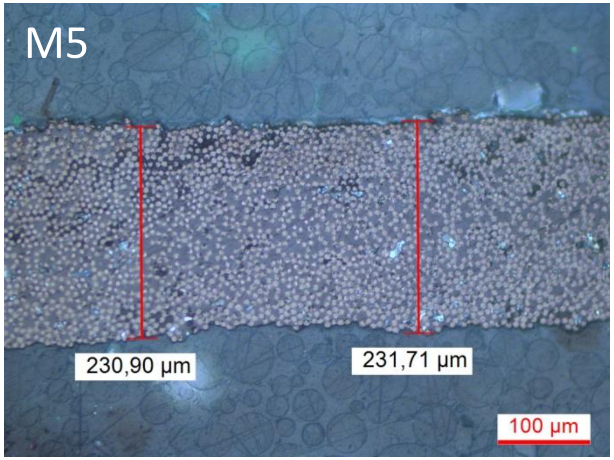
LOOKING FOR
ISC GRADE MATERIAL











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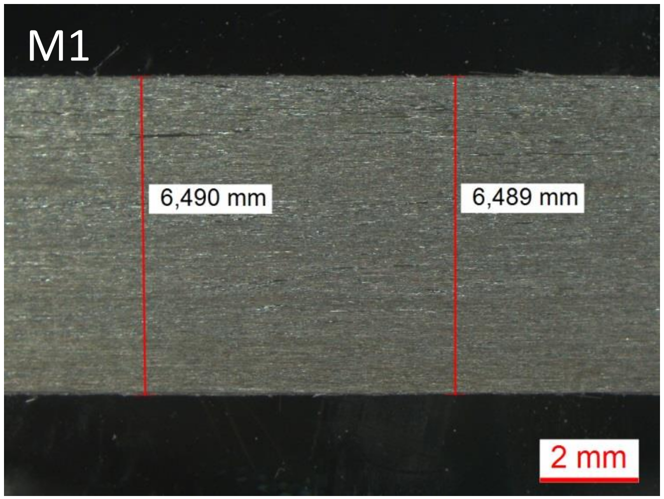

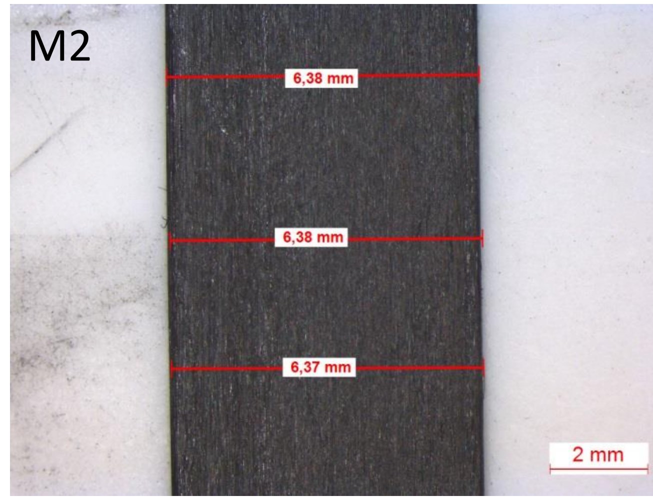

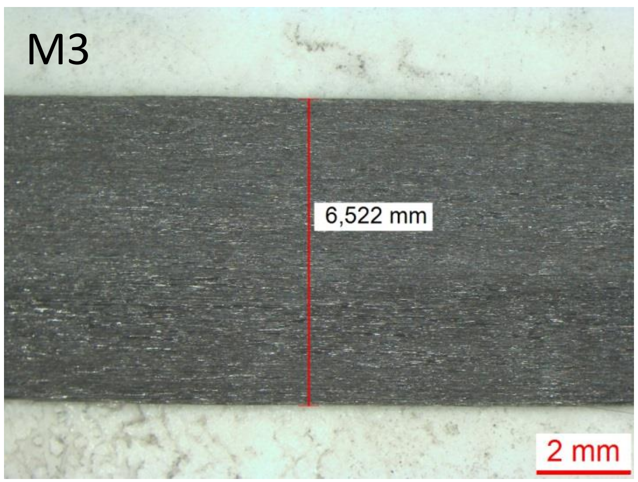

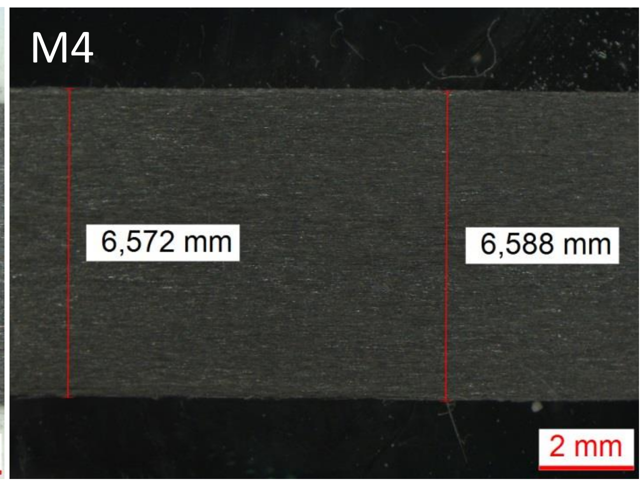

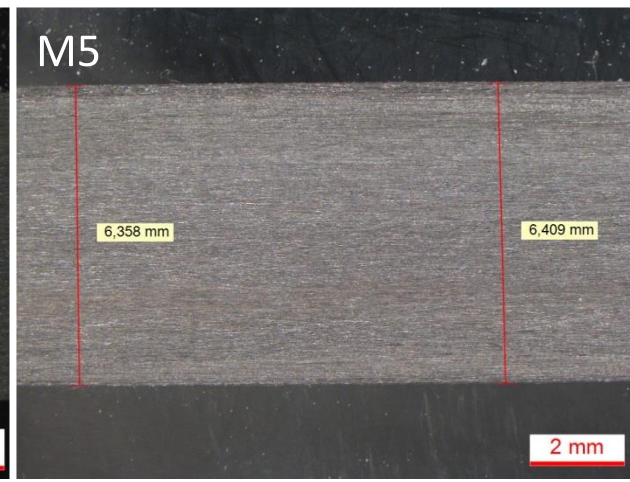

5. CONCLUSIONS AND PERSPECTIVES

- ✓ THERMOPLASTIC COMPOSITE IS A REAL OPPORTUNITY FOR A FASTER PROCESSING, LOWER LIFECYCLE COSTS AND ENVIRONMENTAL SUSTAINABILITY.

- ✓ **JUST NOW, PEEK** IS THE MATERIAL WITH THE DEEPER USE IN LASER ASSISTED AFP MACHINES, HIGHER MATURITY HAS BEEN REACHED WITH IT. DATA BASE → MANUFACTURING/MODELS

- ✓ **PEKK AND PAEK** HAVE PARTICULAR INTEREST AND BOTH ARE A **COMPETITIVE OPTION IN AUTOMATED PROCESS.**

- ✓ **SIMULATION** AND MODELS PERMIT TO UNDERSTAND THE AUTOMATIC LAY-UP PROCESS.

- ✓ **MATERIAL IMPROVEMENTS** WILL CONTRIBUTE TO THE SPEED INCREASE NEEDED TO REACH VALUES OF PRODUCTIVITY CLOSER TO THERMOSETS.

PERSPECTIVES:

- ✓ COOLING NEEDS TO BE CONTROLLED IN ORDER TO ALLOW CRYSTALLIZATION VARIATIONS.

- ✓ ROLLER MATERIAL NEEDS DEEPER RESEARCH WORKS.

THANK YOU FROM THERMOPLASTIC TEAM


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