ELASTIC PROPERTIES ASSESSMENT OF A SGFR - PA6.6 FROM X-RAY TOMOGRAPHY & FINITE ELEMENT COMPUTATION

A. Ayadi[1*], H. Nouri[1], F. Roger[1] and S. Guessasma[2*]

[1]Mines Douai, TPCIM Department, 941 Rue Charles Bourseul, Douai, France.

[2]INRA, Research Unit BIA UR1268, Rue Geraudiere, F-44316 Nantes, France.

Contacts:

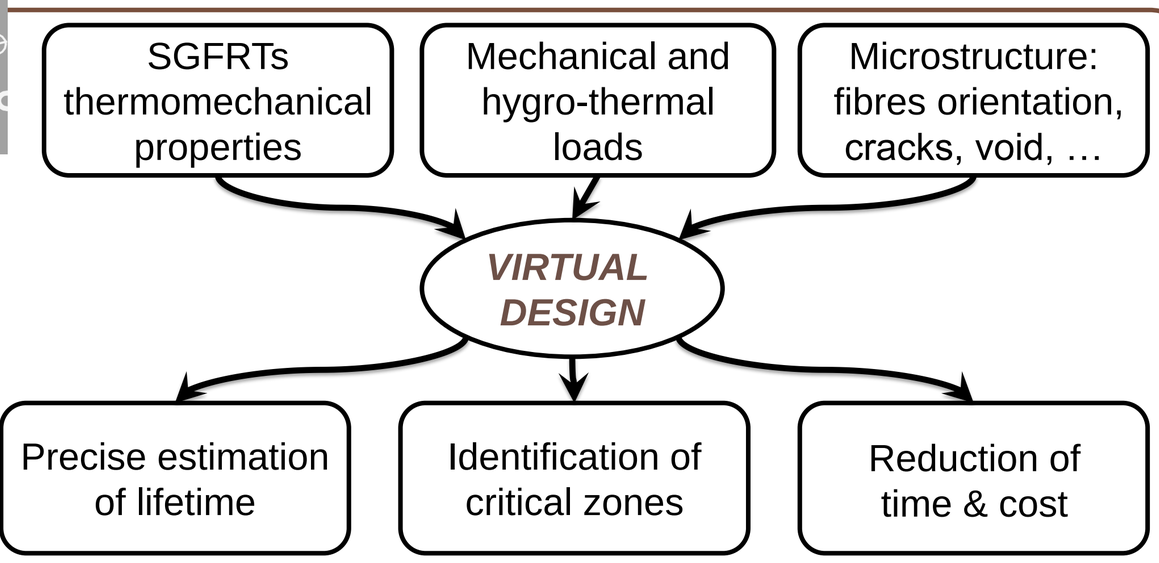
sofiane.guessasma@nantes.inra.fr

abderrahmane.ayadi@mines-douai.fr

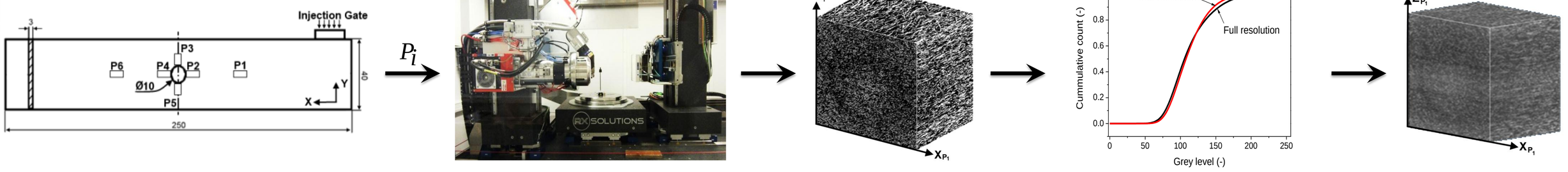
INDUSTRIAL CONTEXT

- New over demanding environmental standards in the transport market (CO_2 emission levels & fossil fuels consumption).
- Need for reducing the weight of brand-new vehicles.
- Increasing use of SGFRTs for under-the-hood applications (Heat, Humidity, Vibrations, Hot oils).
- Material of interest : PA66-GF35
  - Nominal fibre diameter: 10 µm;
  - Average fibre length: 250 µm.

OBJECTIVE



DATA ACQUISITION



Geometry of an open-hole sample. Regions of interest $P_i \| i \in \{1,2,..,6\}$

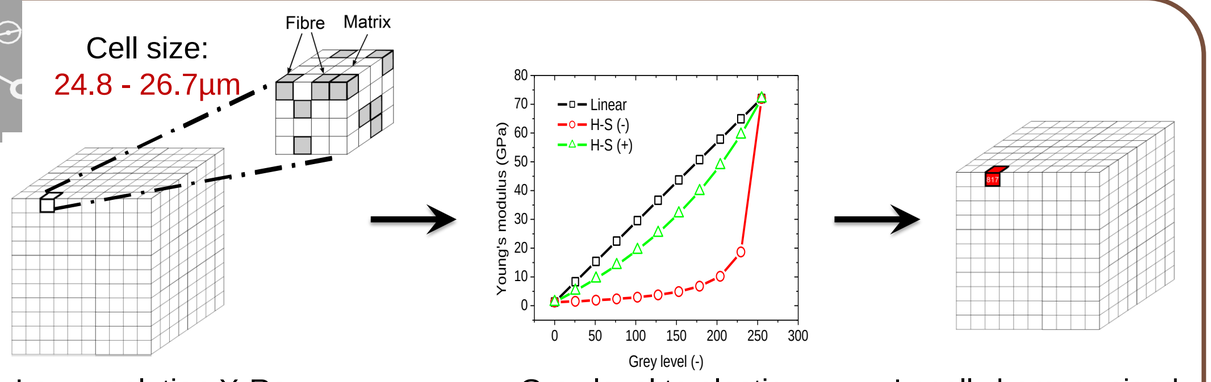
X-Ray tomography equipment (LML- ISIS4D project)

Full resolution range [2.48 - 2.67]µm

Controlled resolution decrease (factor 1:10)

Sub-resolution range [24.8 - 26.7]µm

VOXEL TO ELEMENT CONVERSION



Low resolution X-Ray tomography data

Grey level to elastic properties conversion

Locally homogenised elastic properties

Grey levels to elastic properties conversion schemes

- Linear approximation

$$E_i = E_M + n_i\,(E_F - E_M)/255 \qquad \nu_i = E\,\nu_M + n_i(\nu_F - \nu_M)/255$$

- Hashin-Shtrikman lower bound

$$K_i^- = K_M + \frac{(n_i/255)(K_F - K_M)}{1 + \frac{3(1 - n_i/255)(K_F - K_M)}{3K_M + 4\mu_M}} \qquad \mu_i^- = \mu_M + \frac{(n_i/255)(\mu_F - \mu_M)}{1 + \frac{3(K_M + 2\mu_M)(1 - n_i/255)(\mu_F - \mu_M)}{5\mu_M(3K_M + 4\mu_M)}}$$

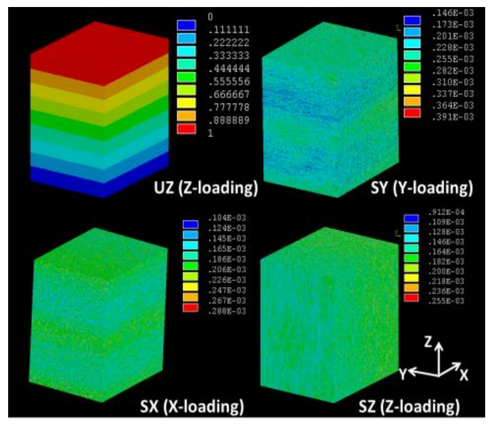
- Hashin-Shtrikman upper bound

$$K_i^+ = K_F + \frac{(1 - n_i/255)(K_M - K_F)}{1 + \frac{3}{3K_F + 4\mu_F}(n_i/255)(K_M - K_F)} \qquad \mu_i^+ = \mu_F + \frac{(1 - n_i/255)(\mu_M - \mu_F)}{1 + \frac{3(K_F + 2\mu_F)}{5\mu_F(3K_F + 4\mu_F)}(n_i/255)(\mu_M - \mu_F)}$$

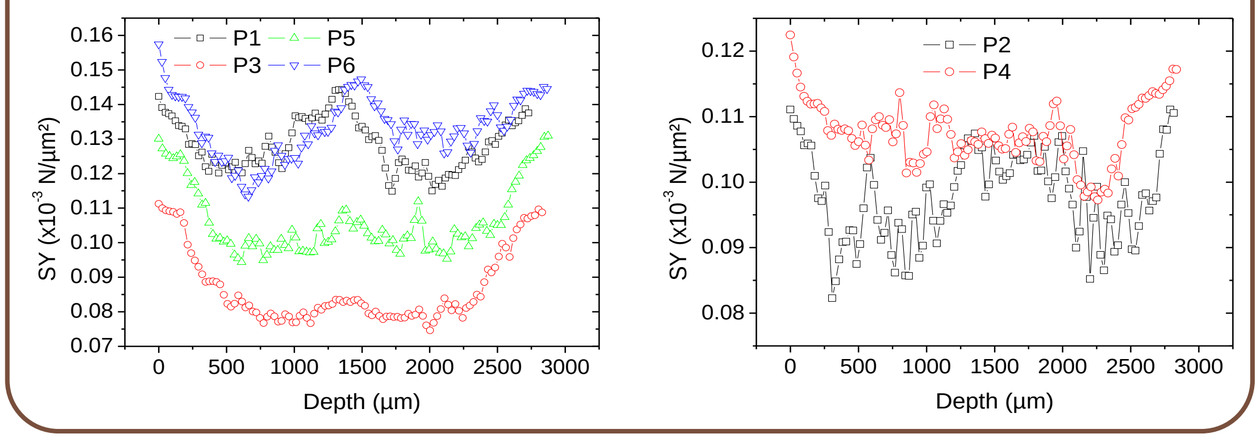
FINITE ELEMENT COMPUTATIONS

Based on grey levels to elastic properties conversions: 256 FE models

- Periodic boundary conditions were used to assess the elastic moduli in the main directions (X, Y and Z).
- Computational ressources: 12-core Xeon CPU X565, 2.67GHz, 48GB-RAM.



Average stress profiles (SY) in XY plane



CONCLUSIONS

- Voxel to finite element conversion was successfully used to estimate local elastic properties from µ-CT data.
- Stress profiles reveal a five-layer quasi symmetric structure evolving to three-layer near the circular opening.

REFERENCES

[1] Ayadi A, Nouri H, Guessasma S, Roger F. Compos Struct (2015),125, 277–86.

[2] Guessasma S, Della Valle G. J Cell Plast (2009), 45, 119–36.

[3] Vincent M, Giroud T, Clarke A, Eberhardt C. Polymer (2005), 46, 6719–25.

[4] Lauke B, Fu S. Compos Sci Technol (1999), 59, 699–708.

Acknowledgements

The authors gratefully acknowledge the International Campus on Safety and Intermodality in Transportation (CISIT), the Nord-Pas-de-Calais Region and the European Community (FEDER funds) for partly funding the X-ray tomography equipment. And they wish also, to thank Dr. Ida RAOULT from PSA Peugeot-Citroën for kindly providing the non-damaged notched specimens.