NUMERICAL SIMULATION OF LASER SHOCK PAINT STRIPPING ON AIRCRAFT ALUMINUM SUBSTRATES

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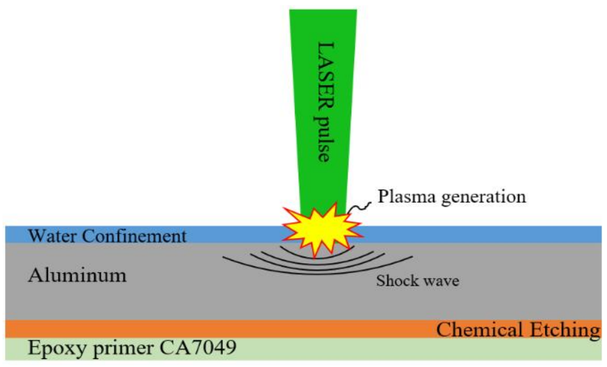
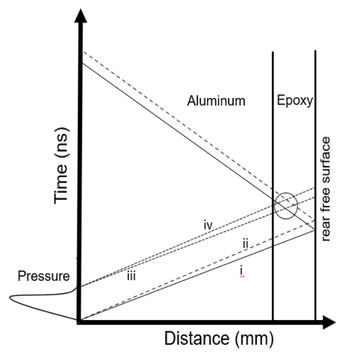
Paint stripping on aircrafts

The paint stripping process uses a hazardous chemical with an important environmental impact followed by a plastic media blasting, which damages the substrate's material surface. It is, therefore, important to develop more environmentally friendly methods for laser stripping which do not damage the substrate.

Laser shock-based paint stripping*



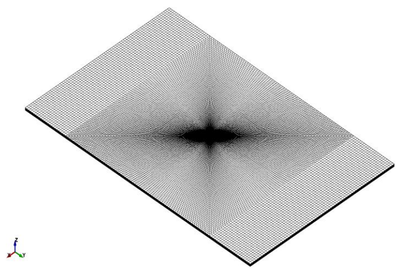
Experimental Setup



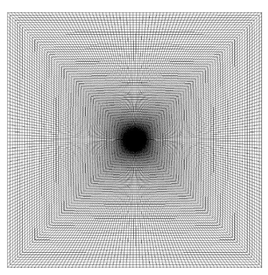
Shock wave propagation

Finite element model

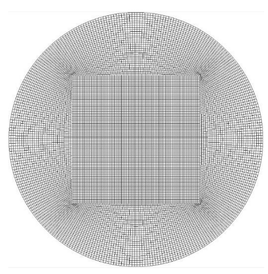
An explicit 3D FE model has been developed in the **LS-Dyna** software to simulate the laser shock paint stripping on aircraft aluminum substrates.



3D Model



3D Model (zoom)



Loading Area

Material	LS - DYNA Material Model
Aluminum	MAT15_JOHNSON_COOK
Epoxy	MAT_10_ELASTIC_PLASTIC_HYDRO
Interface	MAT_138_COHESIVE_MIXED_MODE

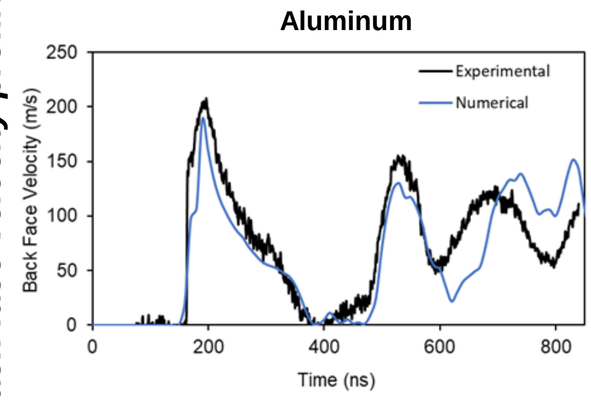
Table 1. Material modeling.

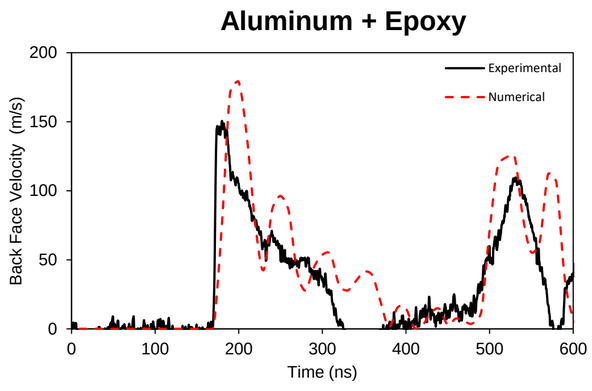
Material	Range	Reference
Aluminum thickness	0.7 – 1.2 mm	0.97 mm
Epoxy thickness	25 – 150 μm	25 μm
Laser spot diameter	2.5 – 5.0 mm	4 mm
G_{IC} and G_{IIC}	Division factor: 1.25, 1.50, 1.75, 2.0	1018.52 J/m^2 and 783.41 J/m^2
P_{max} for 1.75 GW/cm^2	2300 MPa – 2650MPa	2639 MPa

Table 2. Parameter's range of the parametric study and reference parameters.

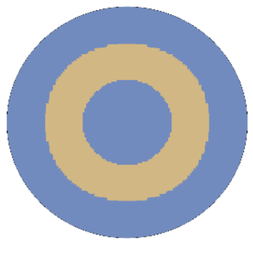
Model validation against tests*

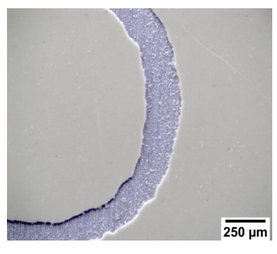
Back-face velocity profiles





stripping pattern

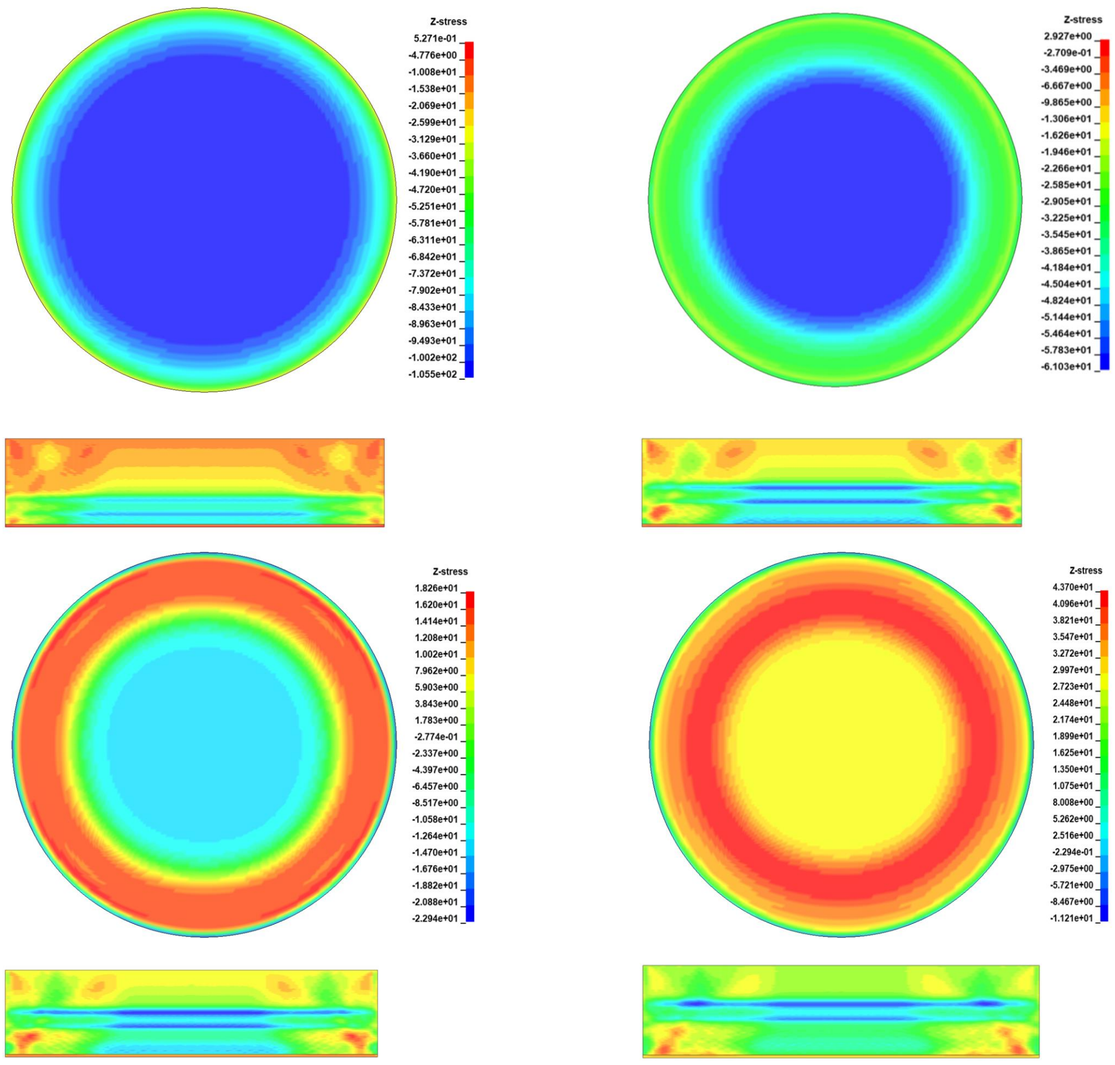




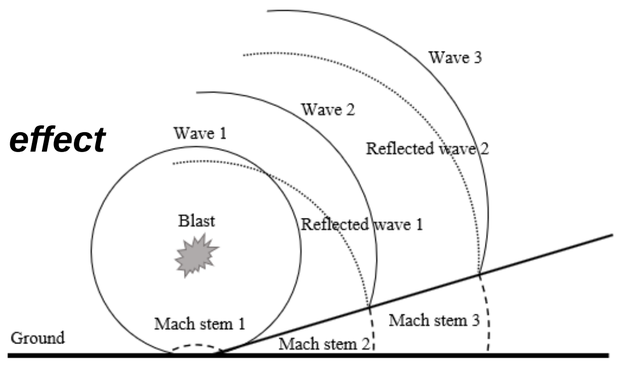
*S. Unaldi et al. (2021). Towards selective laser paint stripping using shock waves produced by laser-plasma interaction for aeronautical applications on AA 2024 based substrates. Optics & Laser Technology 141, 107095. https://doi.org/10.1016/j.optlastec.2021.107095

Results

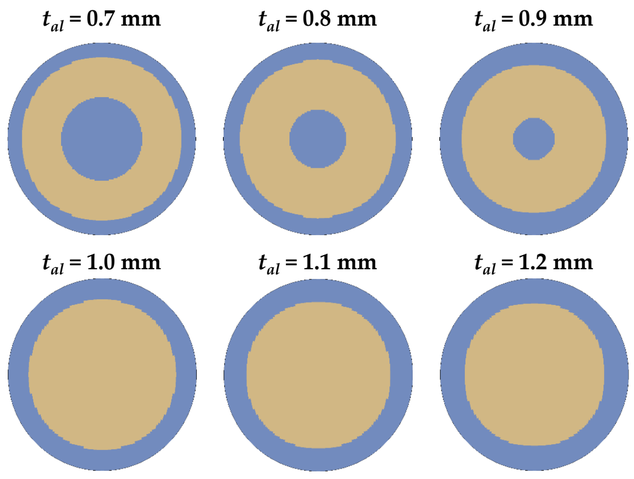
Distribution of normal stress during wave propagation



Corona effect



Effect of substrate thickness on the stripping pattern



Findings of the parametric study:

- With increasing the aluminum thickness, a transition from the annular to the solid stripping pattern takes place. For values of aluminum thickness smaller than 1 mm, an incomplete stripping is predicted.
- With increasing the epoxy thickness, a transition from a solid circular to an annular stripping pattern takes place. For the values of 0.075 mm and 0.1 mm, an incomplete stripping is predicted.
- The laser spot's diameter significantly affects the stripping propagation and the final stripping pattern. For values larger than 4.0 mm, an incomplete strip-ping is predicted.
- G_{IC} affects the first stages of stripping evolution, while G_{IIC} does not affect stripping evolution.
- With increasing the maximum applied pressure, a transition from the annular to the solid stripping pattern takes place. For values smaller than 2500 MPa, an incomplete stripping (annular) is predicted.

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