Design and optimization of a robot for Al/CFRP/Ti orbital stacking drilling

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Introduction

- My thesis topic is part of the project *European and Chinese Platform for Stacked Aero-Structure Drilling Process and Equipment* (or ECSASDPE) whose final objective is the creation of a robot dedicated to high quality Al/CFRP/Ti stacking drilling on complete aeronautical structural elements such as a wing or a fuselage section.
- The machine thus designed will improve the quality of the holes, the speed at which these holes are drilled and reduce inconvenience for technicians.

Context

- Machined materials:
  A stack of glued Aluminium,Carbon Fiber Resin Polymer and Titanium:
  - Aluminium: easily machinable material;
  - Carbon Fiber Resin Polymer: easily machinable but also easily damaged;
  - Titanium: hard material and bad temperature dissipator. [1]
  - ↪ Best way to machin is Orbital Drilling

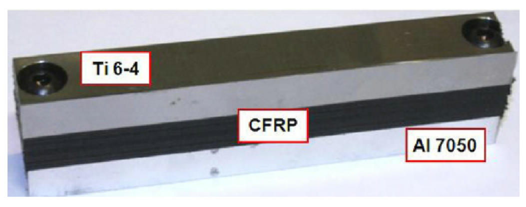

Figure 1:Al/CFRP/Ti Stack

- Tool cinematic:
  2 main process design:
  - Conventional Orbital Drilling (COD): Rotation & revolution of the tool.
  - Tilted Orbital Drilling (TOD): Rotation, revolution & tilting of the tool. [2]
  - ↪ Specific cinematic for Orbital Drilling

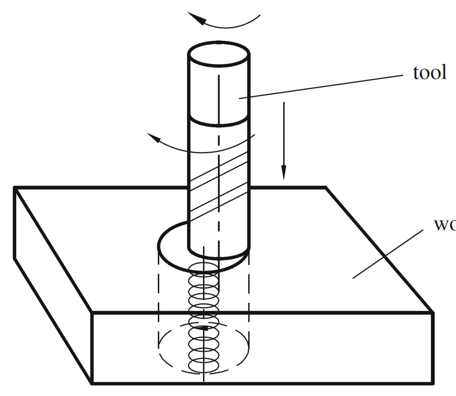

Figure 2:Orbital drilling concept

- Cutting forces modelisation: [3]
  - $dF_i = K_{ic} \cdot h \cdot \partial a_p + K_{ie} \cdot \partial S$
    $i = \{t, r, a\}$
  - ↪ Low effort for Orbital Drilling

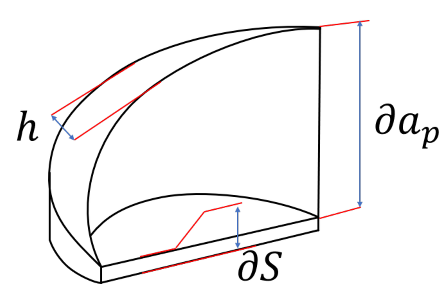

Figure 3:Chip definition

- Drilled holes quality:
  - Geometry of the hole.[4]
  - Roughness of the hole.[4]
  - Burr at interfaces.[4]
  - No ruins of the CFRP.[5]
  - ↪ Several quality items to check

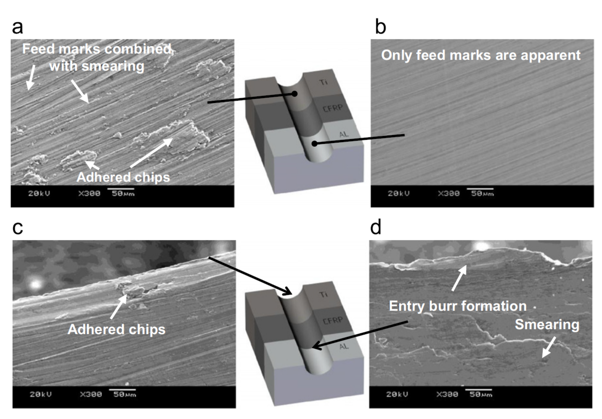

Figure 4:Hole micrography

Methodology

1. Modelise the Tripteor X7 in explicit formulation & identificate structure parameters.
2. Apply the model to other Exechon type machines.
3. Determine an optimised architecture for Parallel Kinematic Machine to do orbital drilling.

Parallel Kinematics Machine (PKM)

- Presentations of PKM [6] :
  - Advantages of PKM: stiffness & high deplacement rate.
  - Difficulties of PKM: complex command & low deplacement range.
- Tripteor X7 specifications (overconstrained PKM):
  - 3 controled linear parameters
  - 2 controled angular parameters
  - 6 end-effector position parameters
  - 13 intermediary angular parameters

Tripteor X7

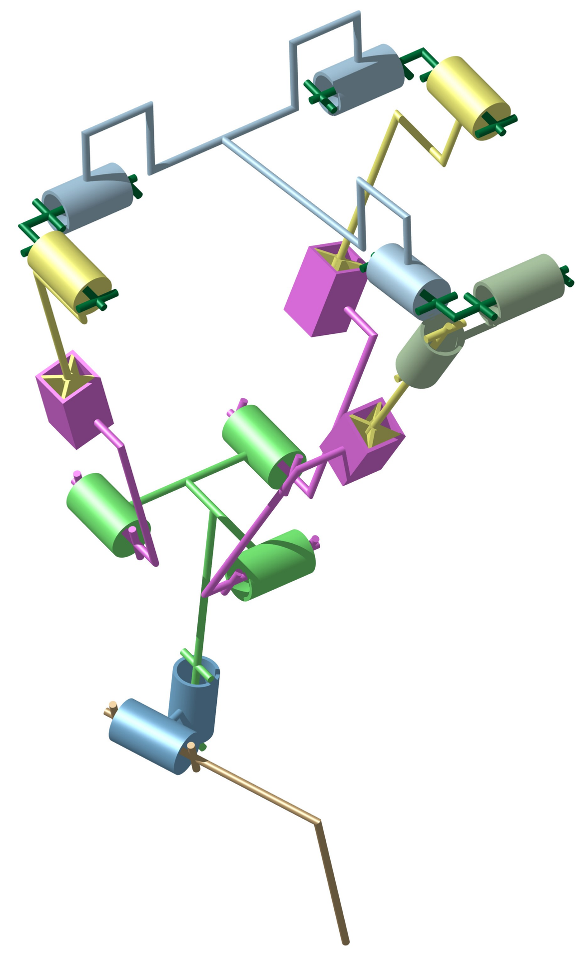

Figure 5:Kinematic schemes of the Tripteor X7

Figure 6:Worplace of the Tripteor X7

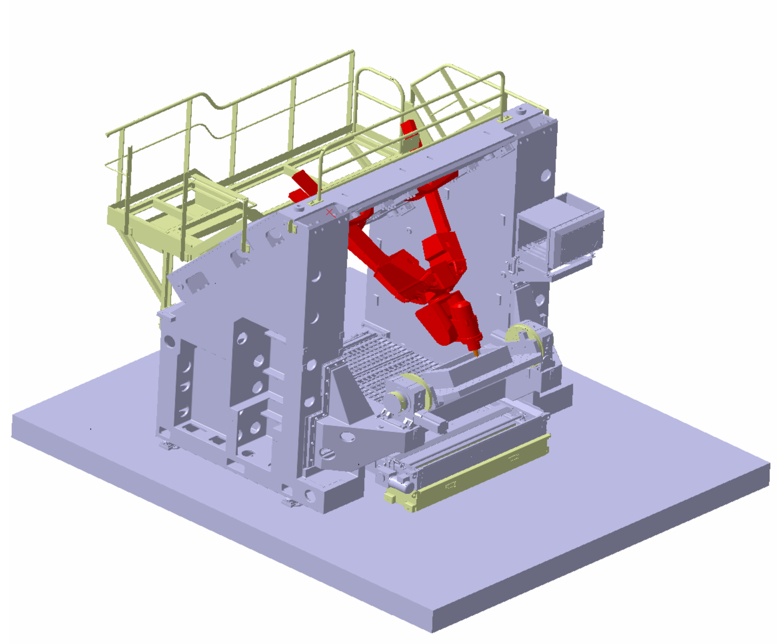

Figure 7:CAD of the Tripteor X7

Parallel Kinematics Machine (suite)

- Vector and angular closure:

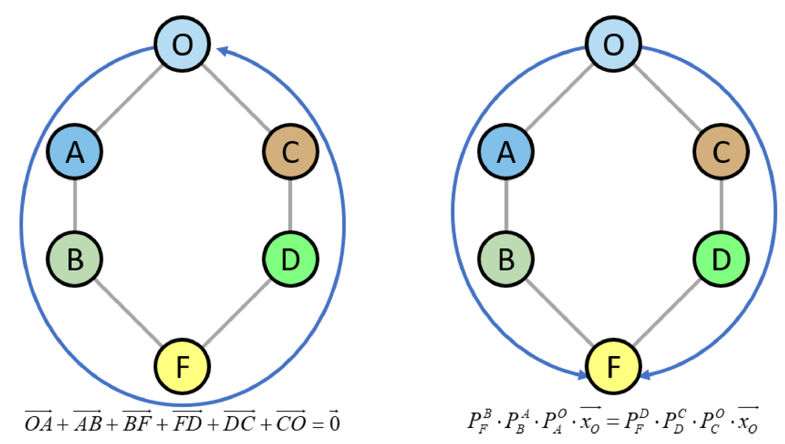

Figure 8:closure method

- 2-time PKM definition:
  1. Parallel structure closure ⇒ Constraint equation:
     $\overrightarrow{X}_{platform} = f(Q_i) \quad i \in \{1, 2, 3\}$
  2. Full structure closure ⇒ Constraint equation:
     $\overrightarrow{X}_{tool} = f(Q_i) \quad i \in \{1, 2, 3, 4, 5\}$
- ↪ Total of 12 3D equations.

Conclusion

- At the moment, the explicit formulation of the explicit geometrical modelisation is about to be completed.

References

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