Titanium Ti-6Al-4V alloy milling by applying industrial robots

Robots as an alternative to machine tools

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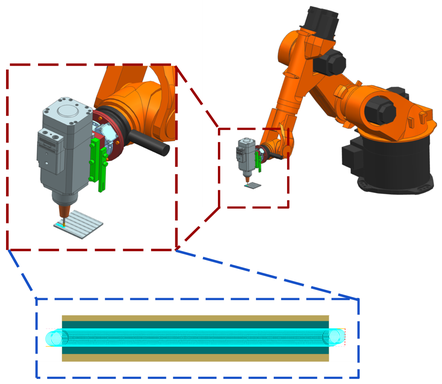
Introduction

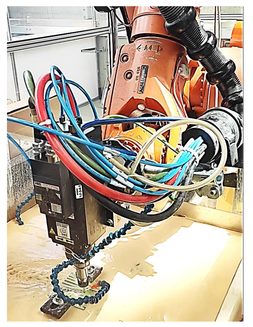
- Titanium alloys are increasingly used in aeronautical projects
  - High strength to weight ratio
- Low thermal conductivity and high chemical reactivity
  - → Impact on the cutting tool wear and the cutting force F
  - → Impact on surface quality
- Milling process with robots are an alternative for manufacturing large-scale components of titanium alloys
  - → Performance machine
  - → Flexibility process
  - → Cost-effective alternative
  - → Low stiffness
  - → High cutting forces F



Trochoidal tool path

Materials and Methods

- Material for milling test **Ti-6Al-4V alloy**
- Machines
  - → KUKA **KR 60 HA** from KUKA ROBOTER GMBH,Germany
  - → **DMU 50** from DMG MORI, Bielefeld, Germany
- Cutting Tool
  - → Cutter with chip separators, a coating of TiAlN, a cutter diameter of Φ = 6 mm, a number of teeth z = 5, a helix angle of 45 °



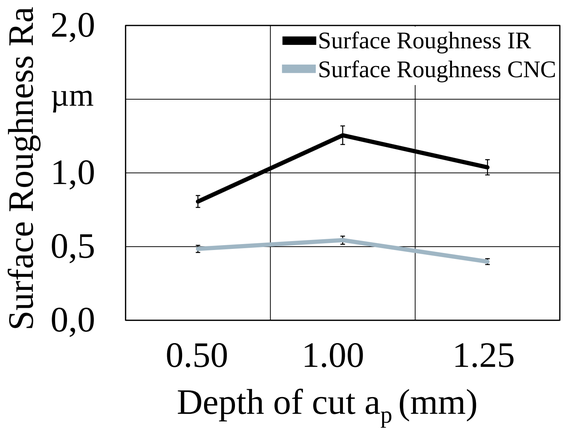
Robot System – KUKA KR 60 HA

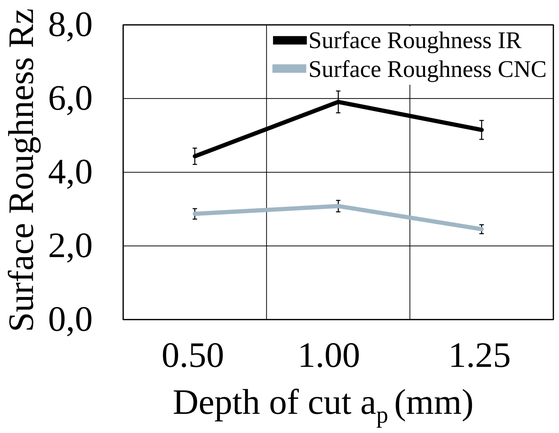
Machine tool – DMU 50

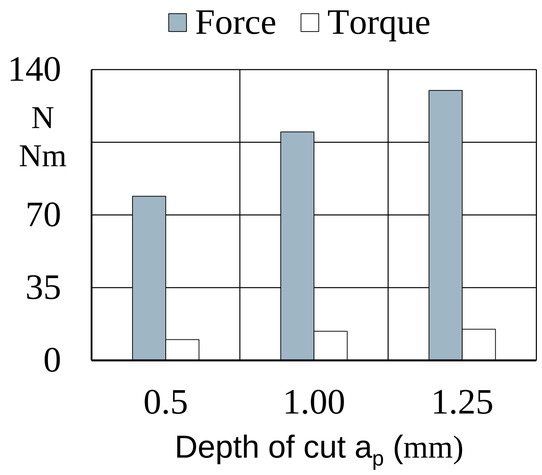
Feed per tooth f_z [mm]	Depth of cut a_p [mm]
0.090	0.5
0.045	1.0
0.036	1.25

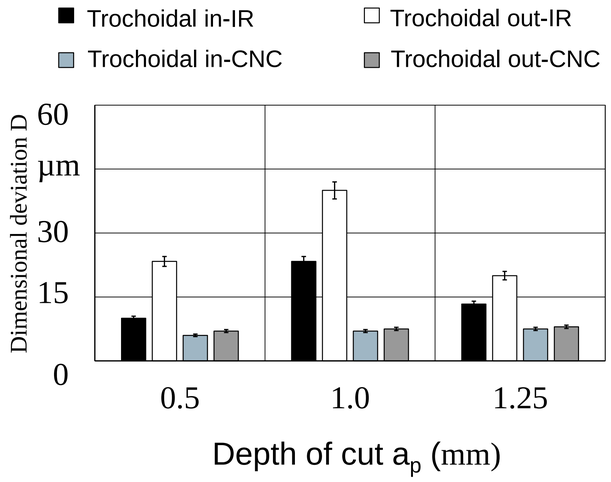
Cutting parameters

Results









Conclusion

- The results for the surface roughness for the IR is more than twice as high as the values for the machine tool. Nevertheless, this results are satisfactory.
- The low stiffness results for the cutting depth condition ap = 1.00 mm in high dimensional deviations D, cutting forces F and surface roughness.
- However, by increasing the depth of cut to a_p = 1.25 mm the quality of the machined surfaces increases too.
- Compared to the machine tool, the values for the deviation D are up to 9 times higher, depending on the depth of cut a_p.
- The lowest deviation of D = 10 µm for a robot is reached with a_p = 0.50 m during the input of the cutting tool.
- The cost of a robot and a machine tool, machining with an IR with adapted parameters can be useful in certain situations.
- The use of industrial robots in new processes is a tendency of companies to achieve the development of Industry 4.0. However, further research is necessary to understand the behavior of industrial robots in each type of application.

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