The Influence of Silicon Carbide Abrasive on Machining of Ti-6Al-4V by AWJ

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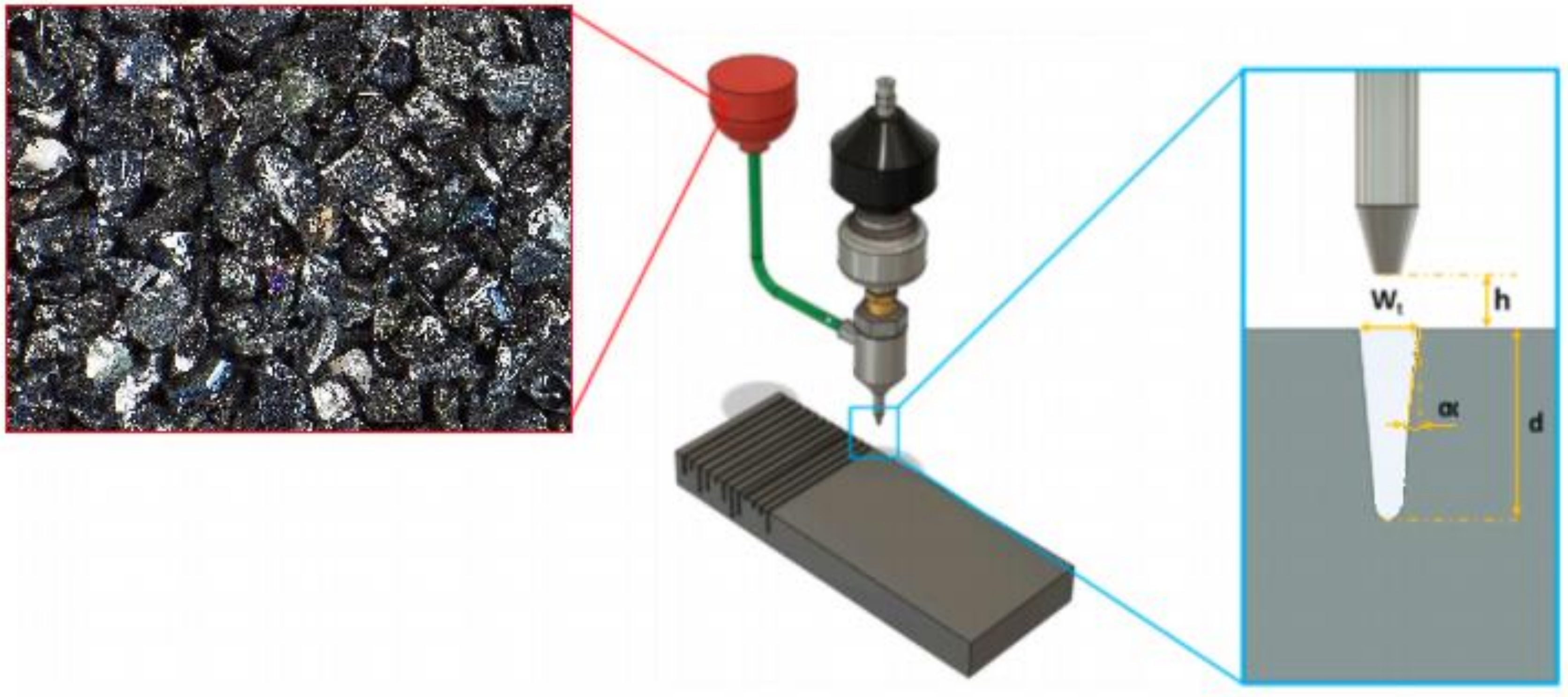
1st International Electronic Conference on Machines and Applications

Abrasive waterjet - Introduction

- AWJ technology was developed to improve cutting abilities of the pure waterjet (PWJ)
- This method allows cutting both brittle and ductile materials including hard-to-machine objects
- No thermal impact on workpiece materials
- High versatility, small machining force and high flexibility

Experimental procedure



Experimental procedure

- Machine: H. G. RIDDER Automatisierungs-GmbH model HWE-P 1520
- Workpiece material: Ti6Al4V
- Abrasive material: SiC (mesh size 60)
- Process parameters:
  - Jet pressure: 150 [MPa]
  - Traverse feed rate: 500-900 [mm/min]
  - Abrasive mass flow rate: 2-8 [g/s]
  - Stand-off distance: 1-5 [mm]
  - Diameter nozzle: 1[mm]

Experimental procedure - Measurements

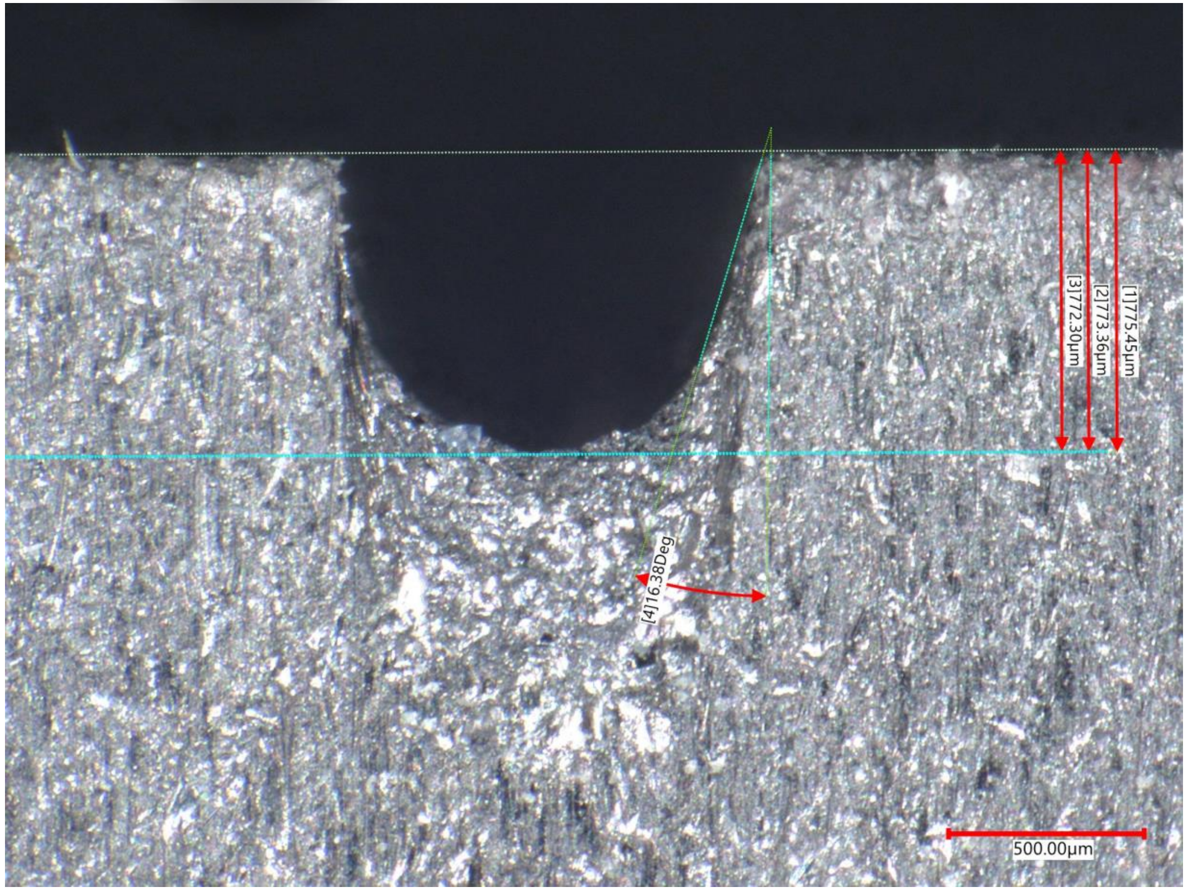


Fig. 1. Measurements of depth and angle of one of the grooves

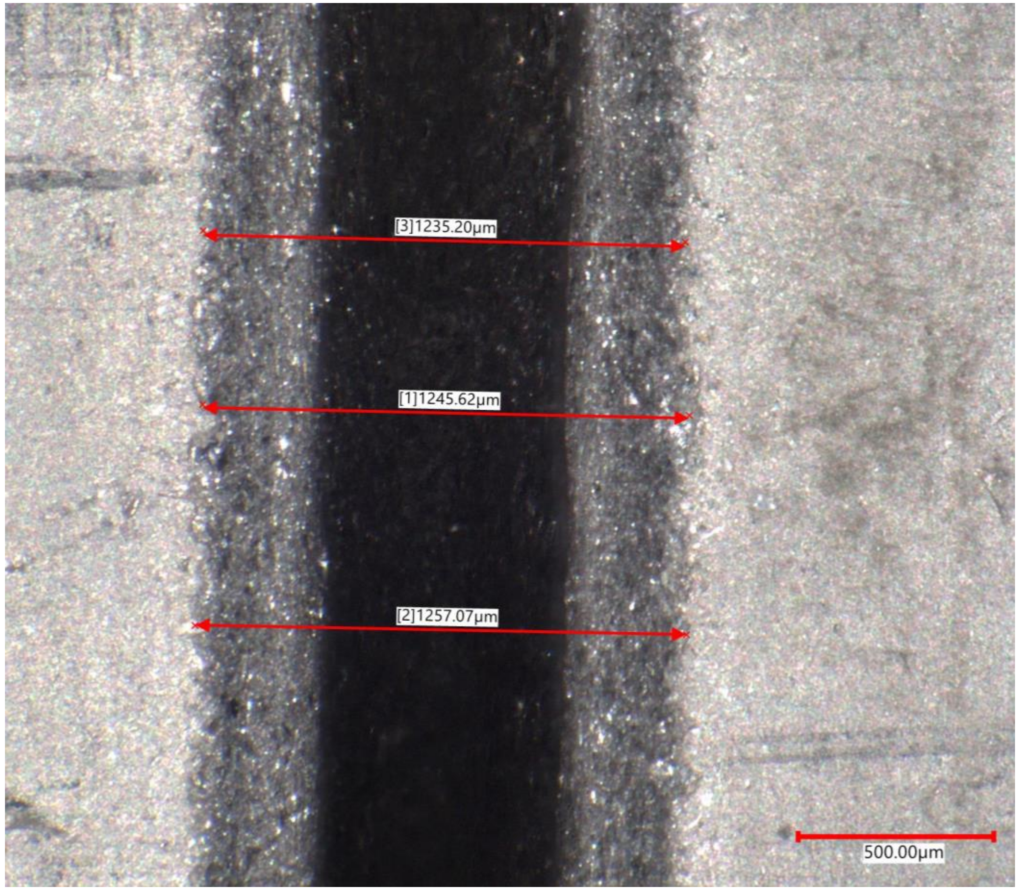


Fig. 1. Measurements of width of one of the grooves

Workpiece material properties – Ti6Al4V

PROPERTIES

- High strength
- Low weight ratio
- Outstanding corrosion resistance

APPLICATIONS

- Biomedical implants
- Aerospace components
- Cryogenic applications
- Offshore equipment

TYPICAL CHEMICAL SPECIFICATIONS

Al	6%
V	4%
C	0.03%
Fe	0.1%
O	0.1%
N	0.01%
H	<0.003%
Ti	Balance

BASIC MECHANICAL PROPERTIES

Modulus of Elasticity	120 GPa
Yield Strength	930 MPa
Ultimate tensile Strength	970 MPa

Abrasive material properties - SiC

PROPERTIES

- Low density
- High strength
- High hardness, rigidity and wear resistance
- High sublimation temperature
- Highly inert chemically

BASIC MECHANICAL PROPERTIES

Elastic Modulus	410 GPa
Fracture toughness	4.6 MPa $m^{1/2}$
Vickers hardness	2800 Kg/mm^2

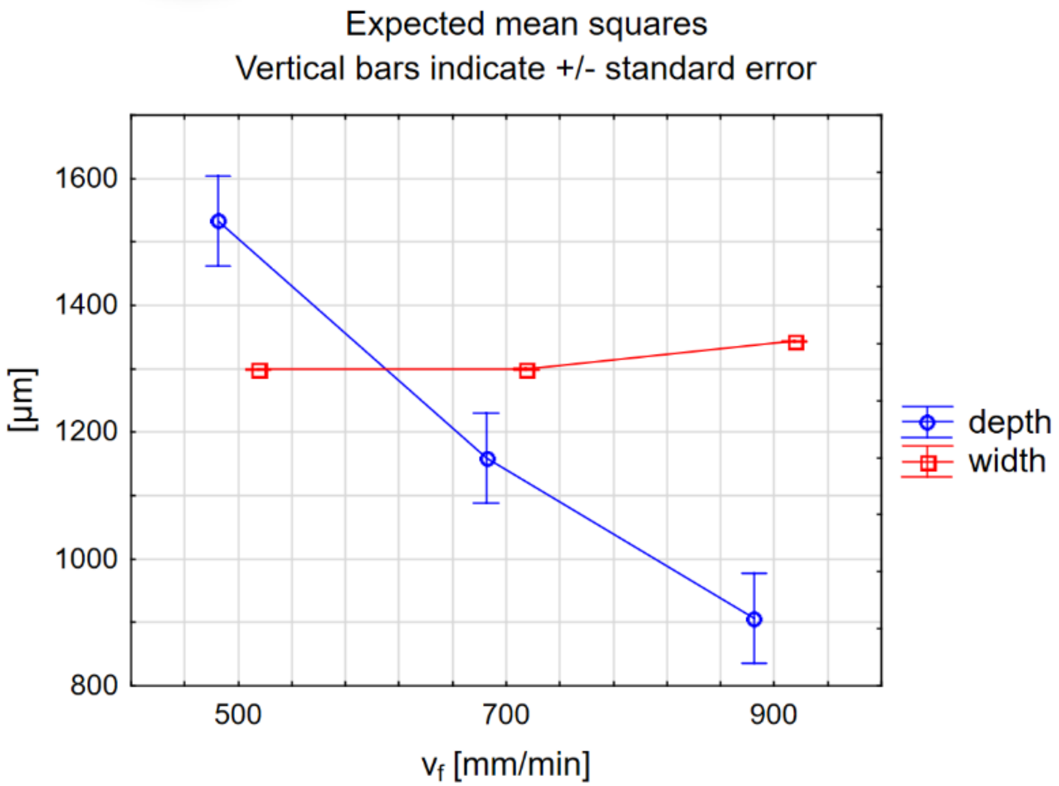
APPLICATIONS

- Abrasive and cutting tools
- Structural material
- Automobile parts
- Electric systems

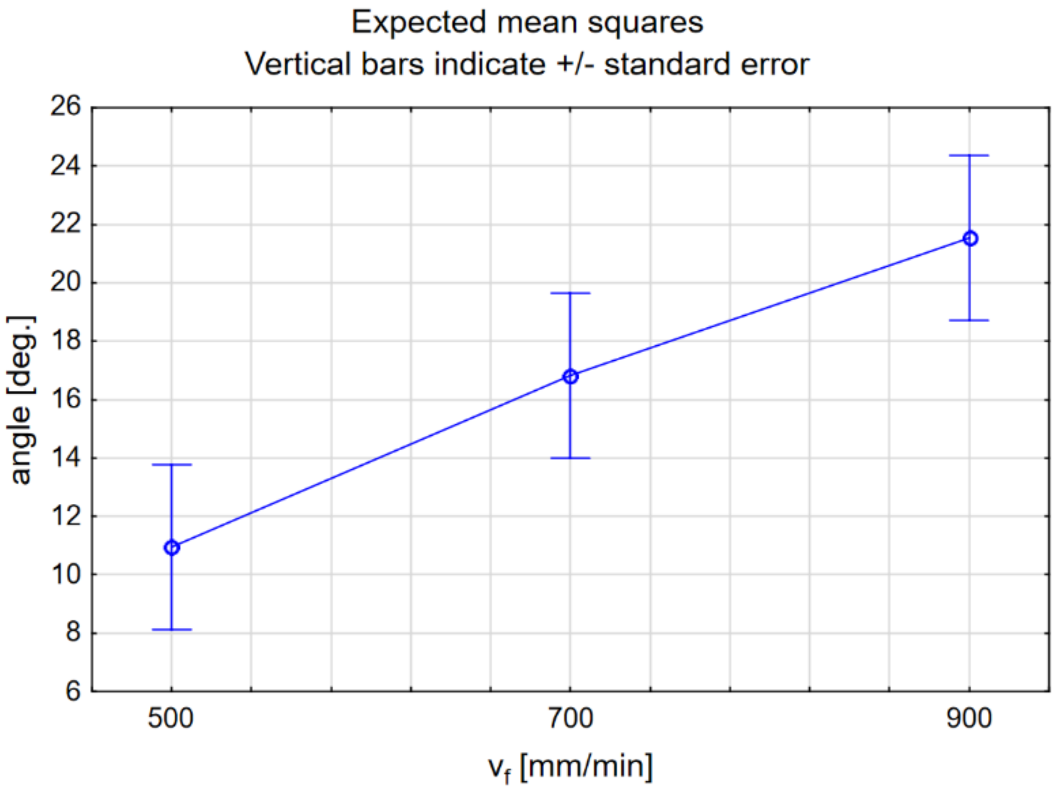
Experimental results

Traverse feed rate [mm/min]	Abrasive mass flow rate [g/s]	Stand-off distance [mm]	Depth [μm]	Top kerf width [μm]	Kerf taper angle [deg.]	MRR [mm^3/min]
500	2	1	877.480	1146.492	10.22	433.603
500	5	3	1726.720	1277.933	11.81	791.605
500	8	5	1994.743	1472.832	10.77	1090.523
700	2	3	558.177	1269.773	27.72	381.532
700	5	5	1278.603	1429.195	14.73	978.298
700	8	1	1639.627	1199.443	8.03	1111.164
900	2	5	478.093	1468.102	38.00	470.978
900	5	1	909.307	1199.140	10.62	841.814
900	8	3	1331.270	1363.540	15.96	1177.547

Experimental results

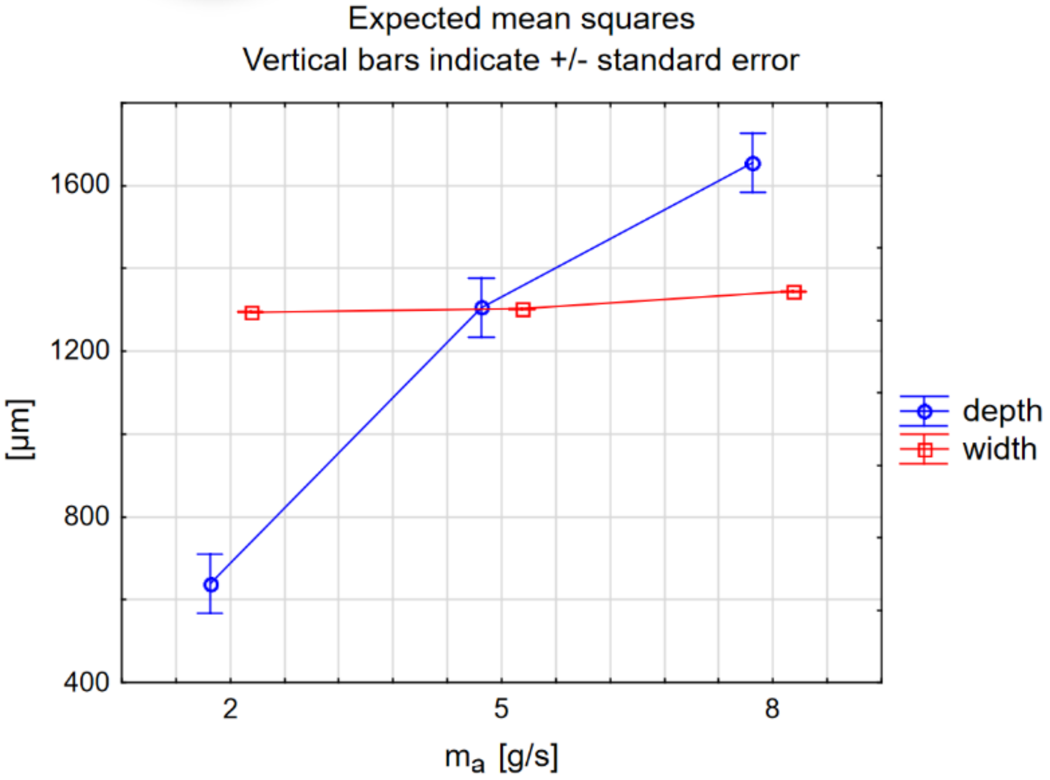


Relation between traverse feed rate and grooves depth and top kerf width

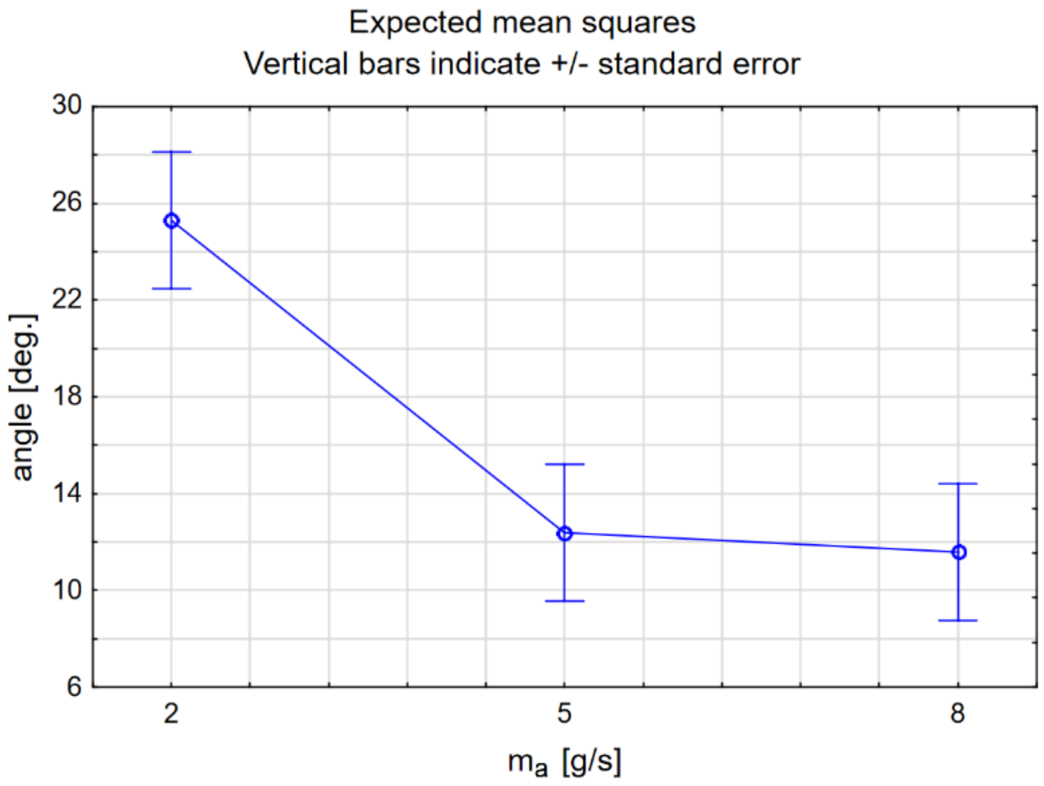


Relation between traverse feed rate and kerf taper angle

Experimental results

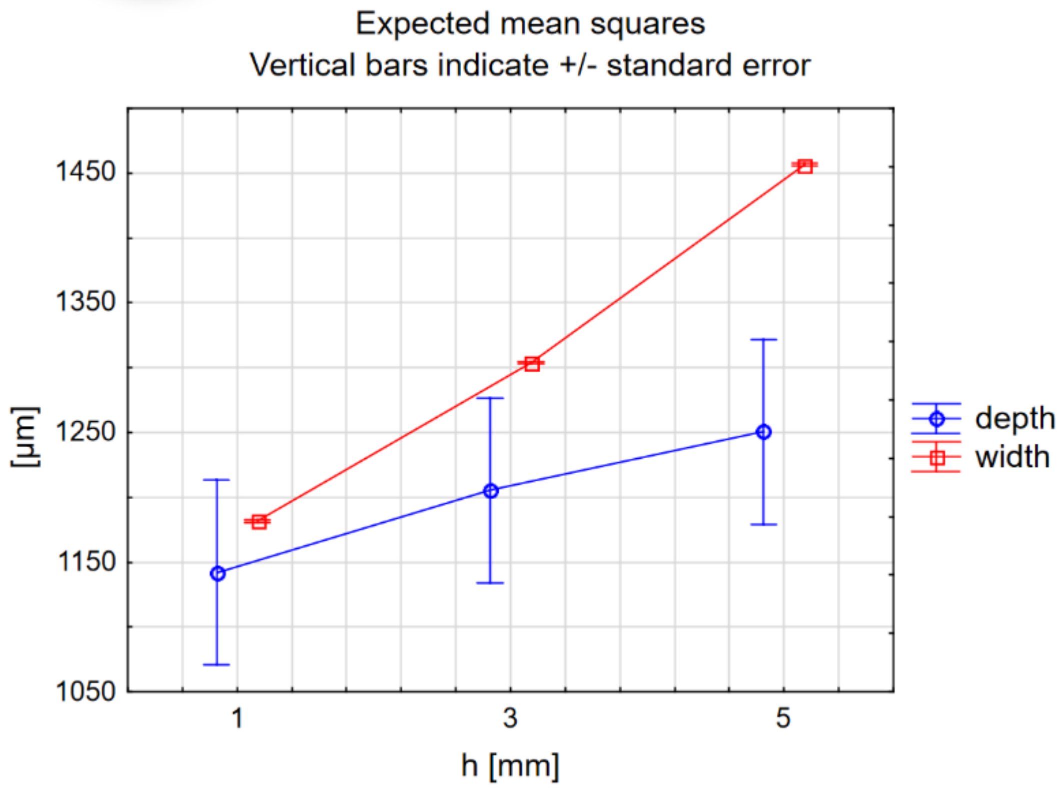


Relation between abrasive mass flow rate and grooves' depth and top kerf width

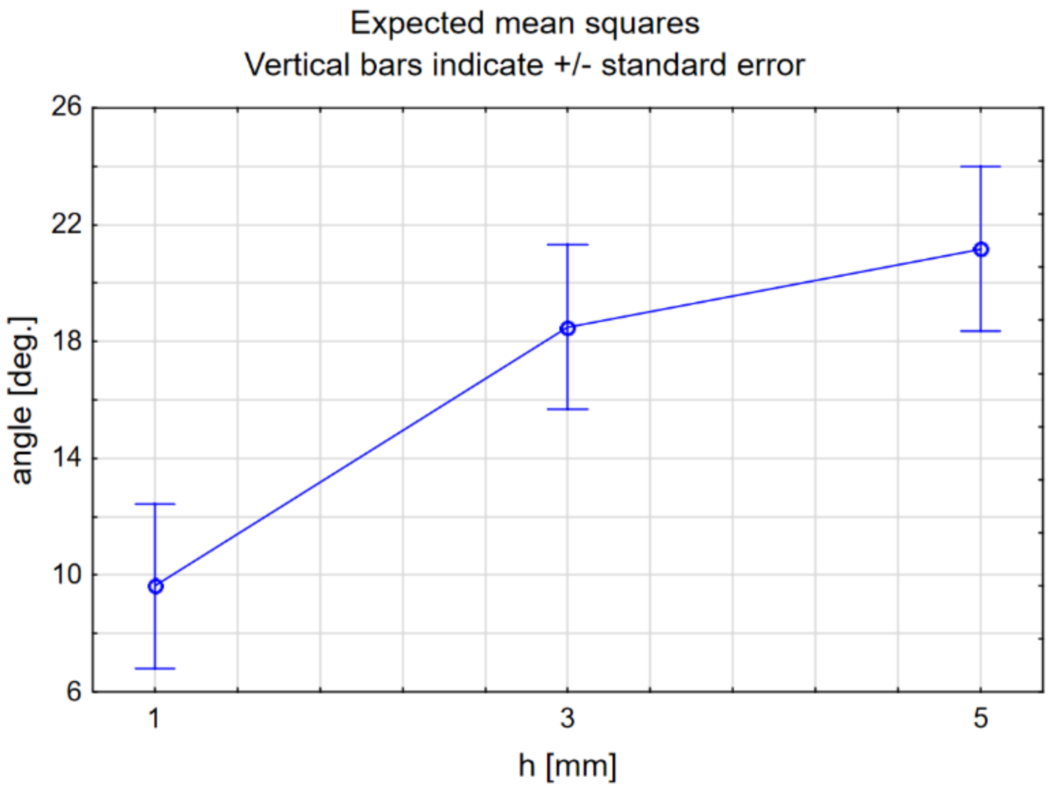


Relation between abrasive mass flow rate and kerf taper angle

Experimental results



Relation between stand-off distance and grooves' depth and top kerf width



Relation between stand-off distance and kerf taper angle

Conclusions

- Silicon carbide as an abrasive can be used in the abrasive waterjet machining process, but its hardness should be taken into account when choosing a nozzle.
- The most significant parameters to control the penetration depth are abrasive mass flow rate, which allows obtaining deeper geometries when it is increased (~70%) and traverse feed rate, which causes intensive deepening of grooves when it is decreased (~45%).
- The accurate input parameter to control the top kerf width of the slots is stand-off distance, which caused grooves to widen by around 20% when increased to the maximum value.
- Parameters which have a significant influence on the depth of the grooves also cause changes in the kerf taper angle. The deeper the grooves are, the sharper the angle becomes. Moreover, with an increase in the stand-off distance, the kerf taper angle increases by 53%.
- Productivity of the machining process, expressed by MRR, is shown to be most affected by abrasive mass flow rate, whereas traverse flow rate and stand-off distance were found to be less significant within the selected parameter range.