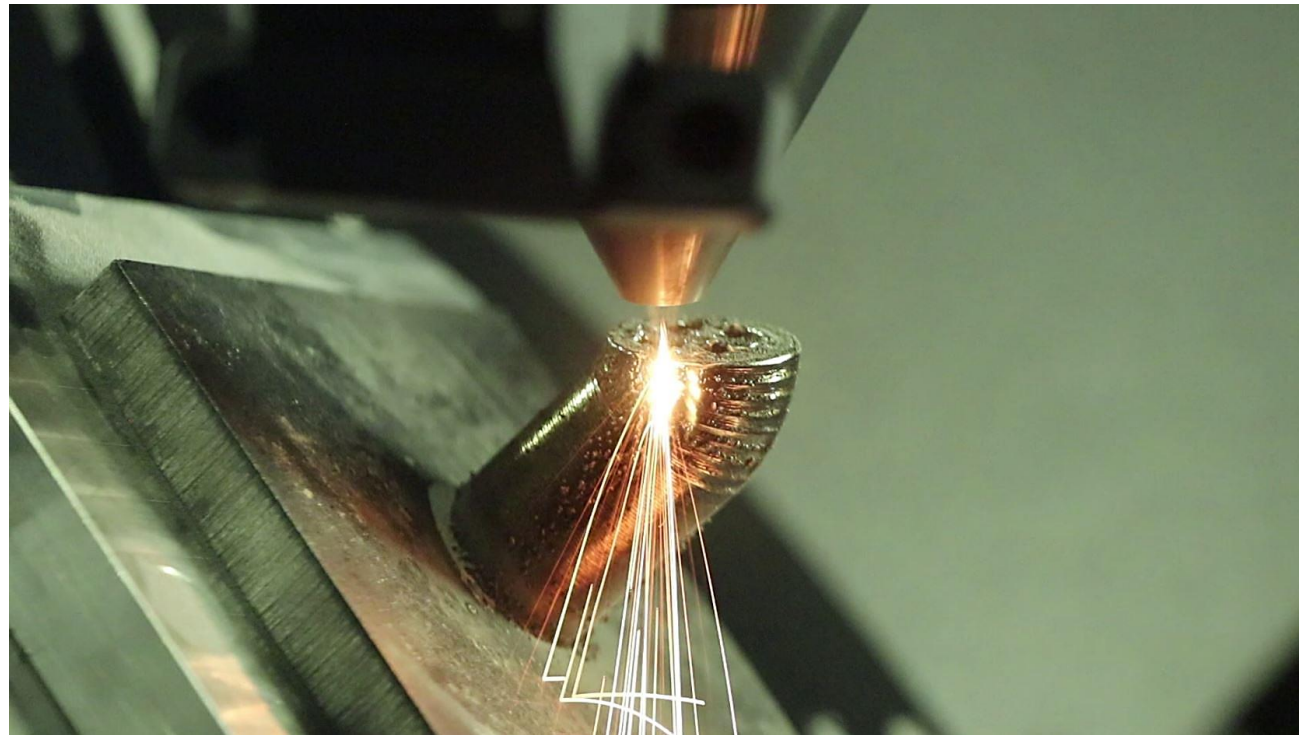
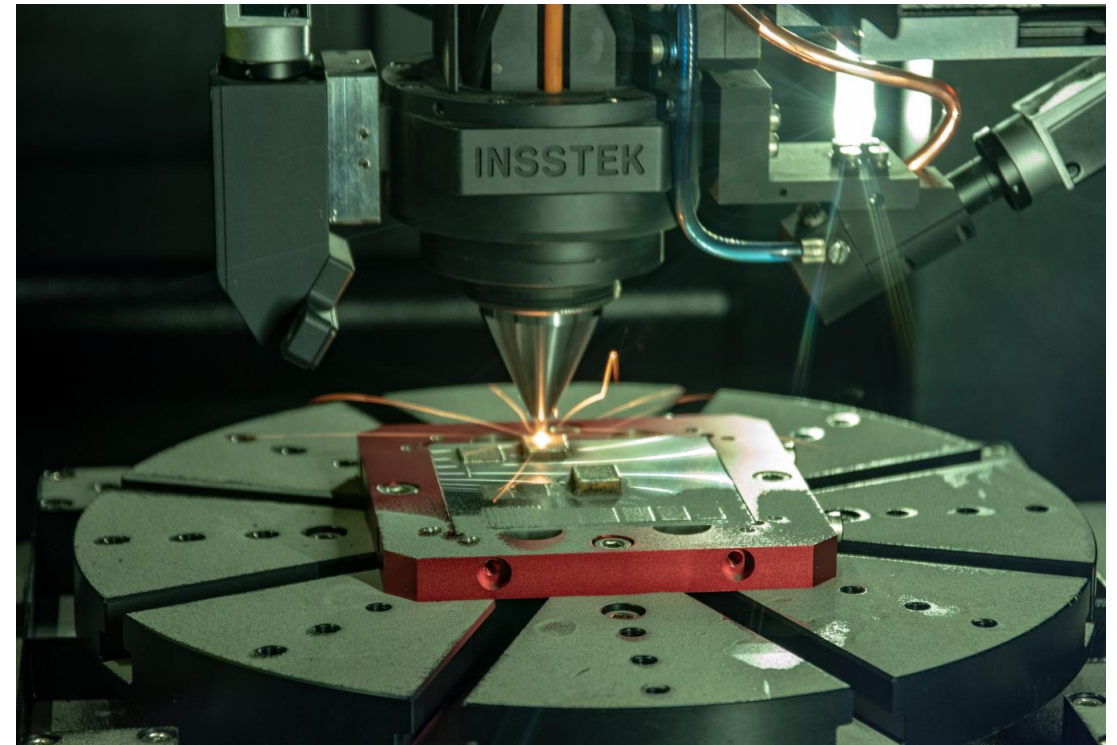


Additive Manufacturing - Directed Energy Deposition Applications



Application fields

- Manufacturing of highly customized components
- Manufacturing of components with very special properties (corrosion resistance, thermal conductivity etc.)
- Optimization of tools and molds by printing of special active parts
- Renovation of worn tools, cutting edges etc.



InssTek MX-600 DED machine

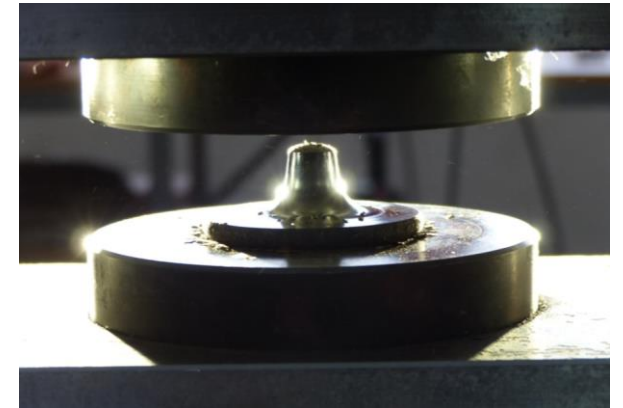
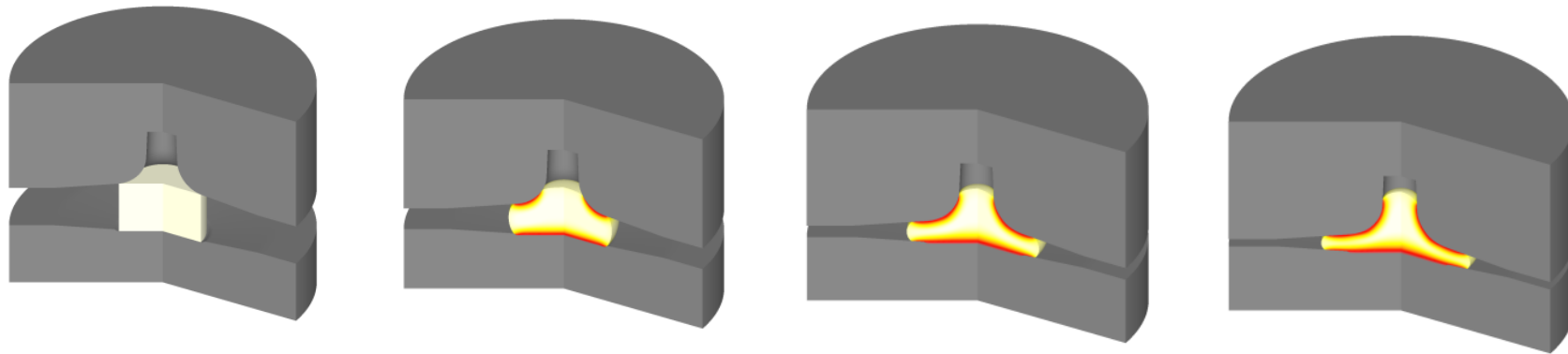
- AM by Direct Energy Deposition method
- 2kW Ytterbium fiber laser
- Working area: 450 x 600 x 350 mm
- Motion: 5 axis
- Multi-material deposition / 4 powder feeding systems

- Three deposition regimes:
 - SDM 800 (beam diameter 800 μm , layer thickness 250 μm),
 - SDM 1600 (beam diameter 1600 μm , layer thickness 600 μm)
 - SDM 2400 (beam diameter 2400 μm , layer thickness 900 μm)

- DMT mode – the printer changes the laser power to maintain a continuous layer
- Particle distribution 50 - 150 μm



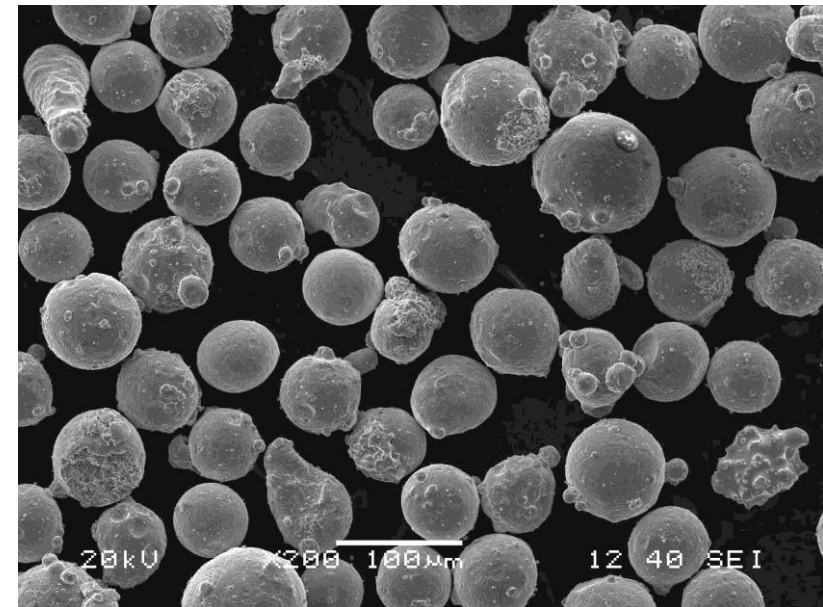
DED application in hot forming processes



Tools optimization using Nimonic 80A

- Material for hot application such as forging, trimming, rolling, ..
- Powder with a particle distribution in the range of 45 - 106 μm
- Chemical composition (weight %):

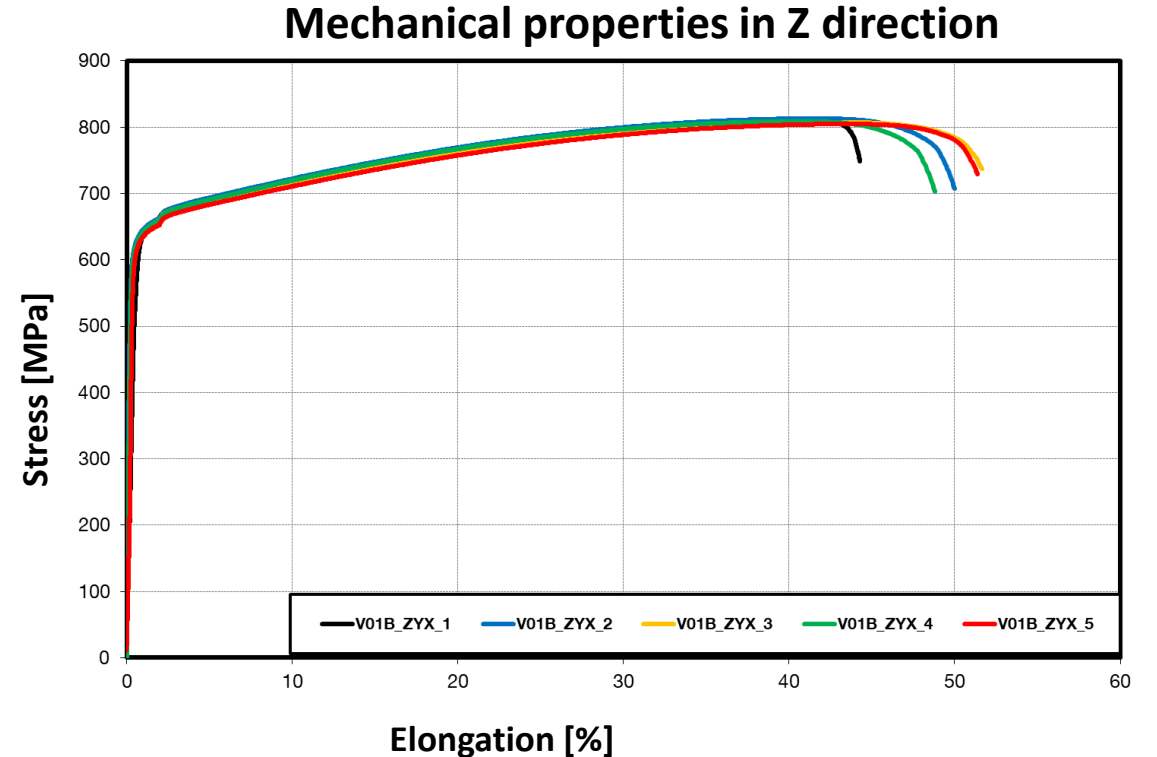
Ni	C	Mn	Cr	Co	Fe
Bal.	0.1	1.0	19.5	2.0	3.0



Mechanical properties of deposited Nimonic 80A

- Material shows anisotropic behavior, therefore the properties were measured in 3 directions
- Hardness ± 260 HV10
- Mechanical properties :

Direction	$R_{p0,2}$ [MPa]	R_m [MPa]	A_g [%]
X	714 ± 4	945 ± 6	21 ± 1.2
Y	692 ± 12	939 ± 4	23.9 ± 0.4
Z	613 ± 5	809 ± 2	41.4 ± 0.7
Interface	-	793 ± 8	-

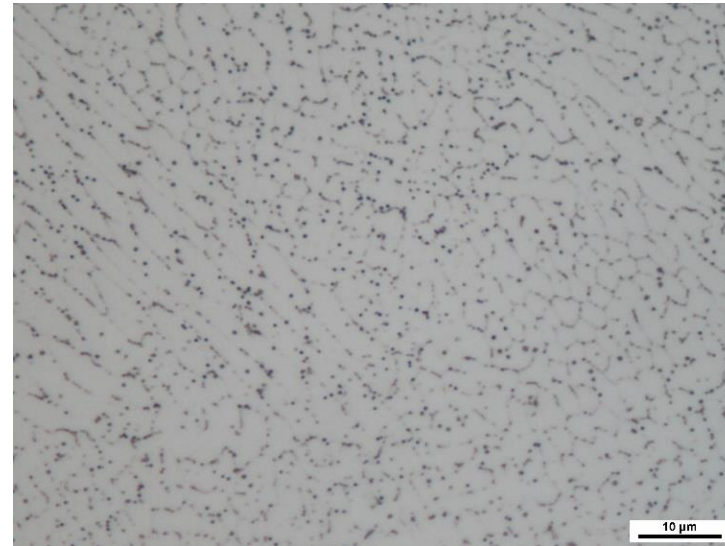


Metallographic analysis of deposited Nimonic 80A

- Porosity less than 0.1%
- No cracks observed
- Heat affected area less than 0.3 mm
- The microstructure is formed by an austenitic matrix with the presence of carbide particles



Scale 50x



Scale 1000x

Trimming punch

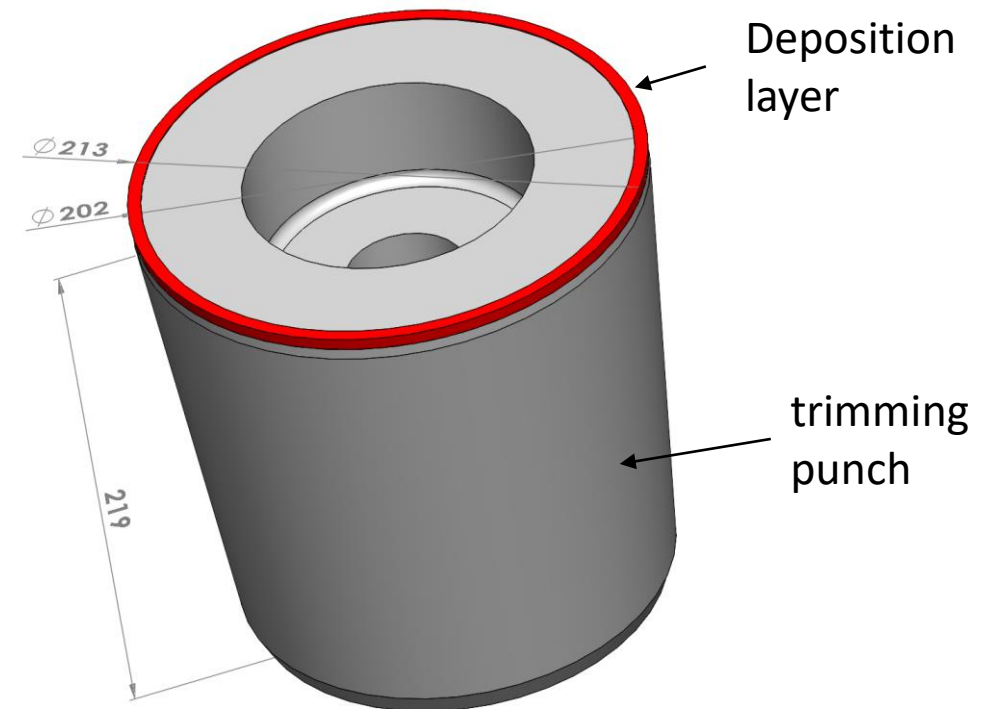
- Goal: increasing of the tool life in trimming proces at the hot forging temperature
- Trimming punch was made of C45 steel
- Deposition of the cutting edge in the shape of annular area

✓ Old technology:

- Additive welding (electrode made of 1.2567)
- Tool life 300 pcs.,
re-sharpening after each 50 pcs.

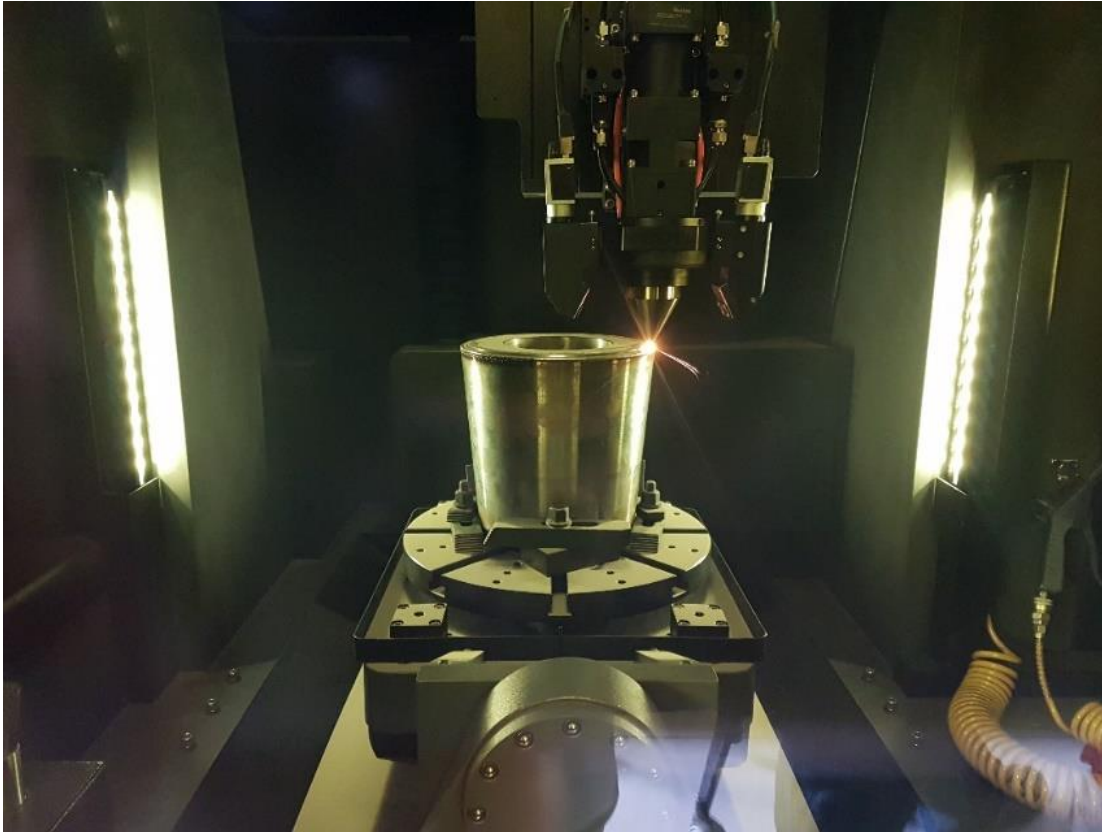
✓ DED deposition:

- Nimonic 80A powder
- Tool life test is still running,
currently **810 pcs. without resharpening**



Trimming punch

- Process costs of DED deposition: lower than 3 times re-sharpening



Trimming die for connecting rod

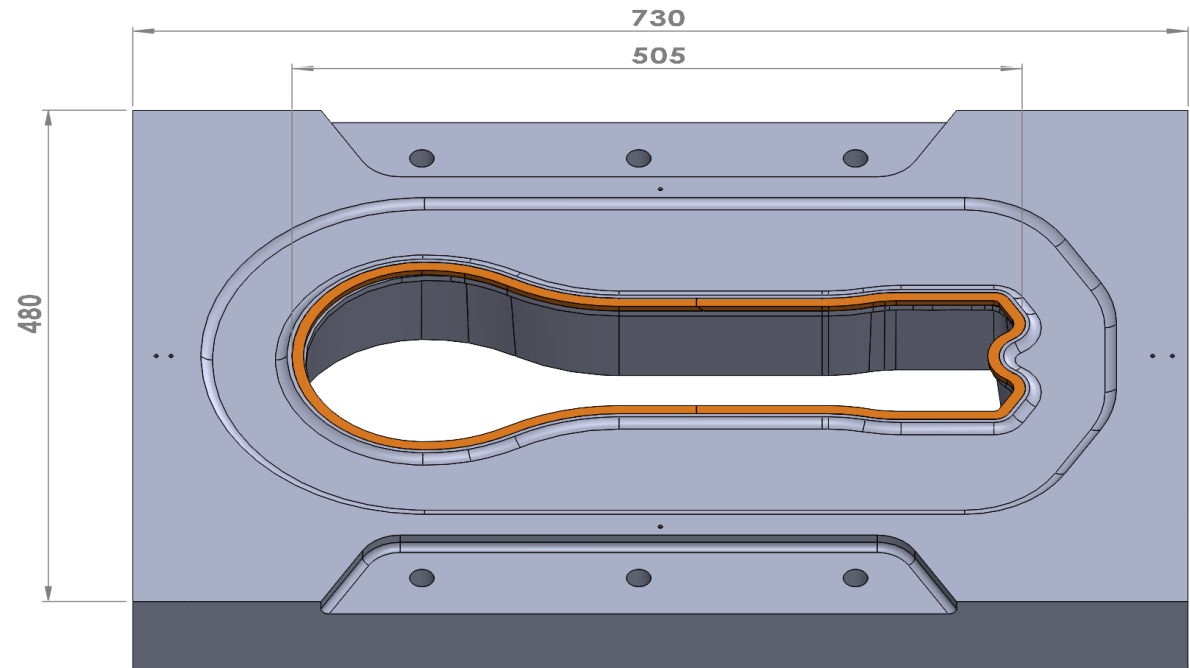
- Goal: increasing of the tool life in trimming proces at the hot forging temperature
- Trimming die was made of S355 steel
- Deposition of cutting edge

✓ Old technology:

- Additive welding (special steel electrode)
- Tool life 300 pcs
- Re-sharpening needed after each 60 pcs

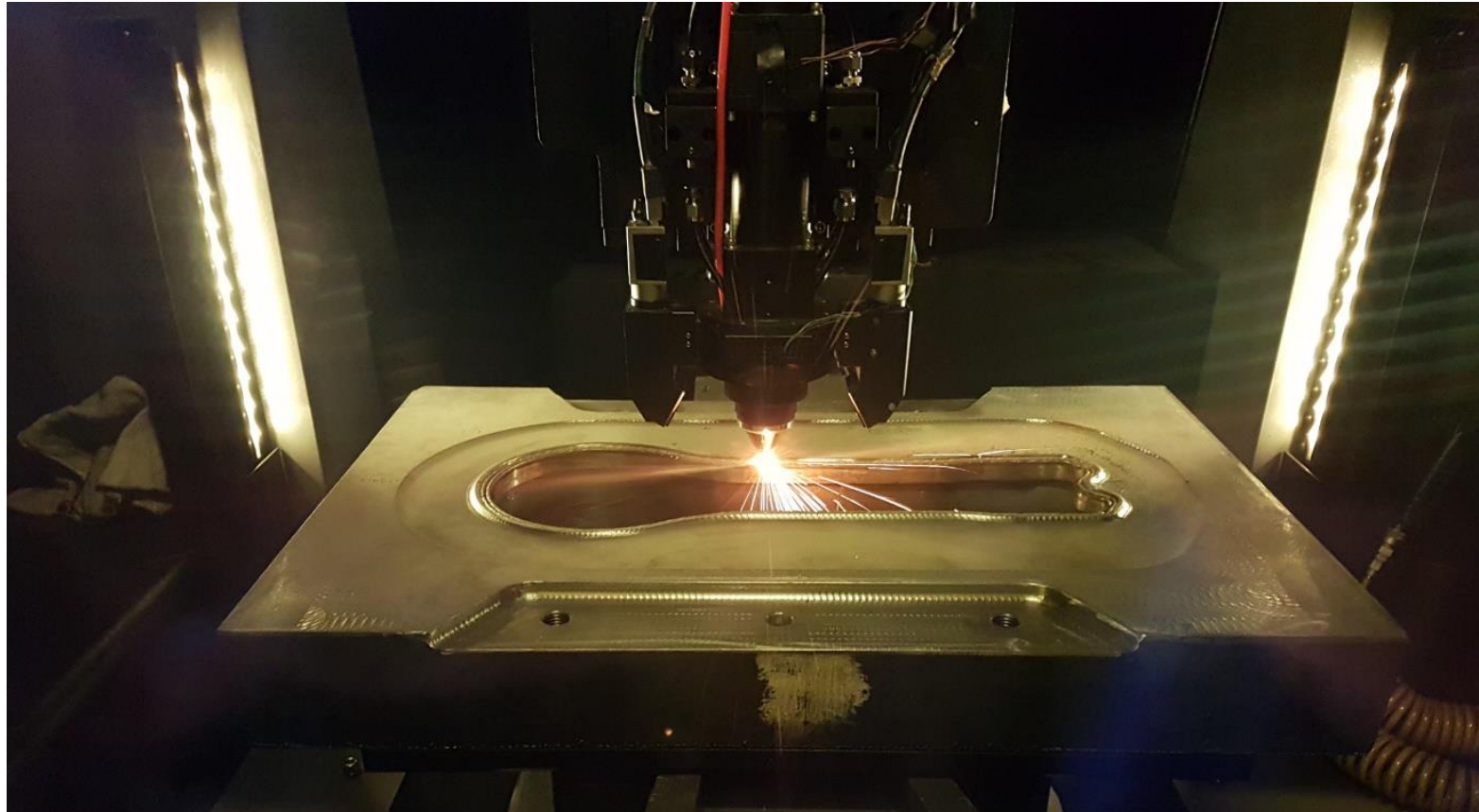
✓ DED deposition:

- Nimonic 80A powder
- Tool life test is still running, currently **1448 pcs. without re-sharpening**



Trimming die for connecting rod

- Process costs of DED deposition: lower than 3 times re-sharpening

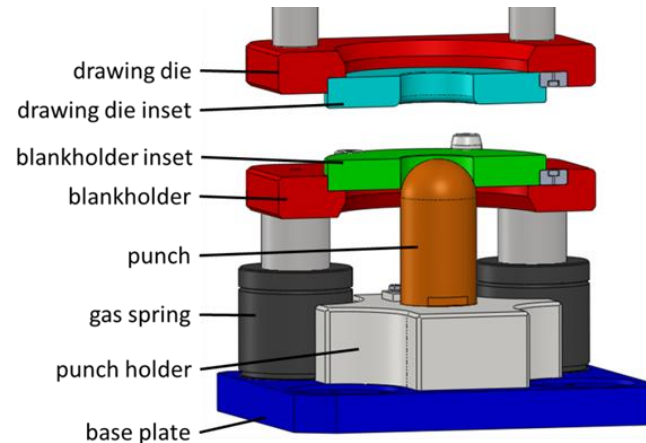
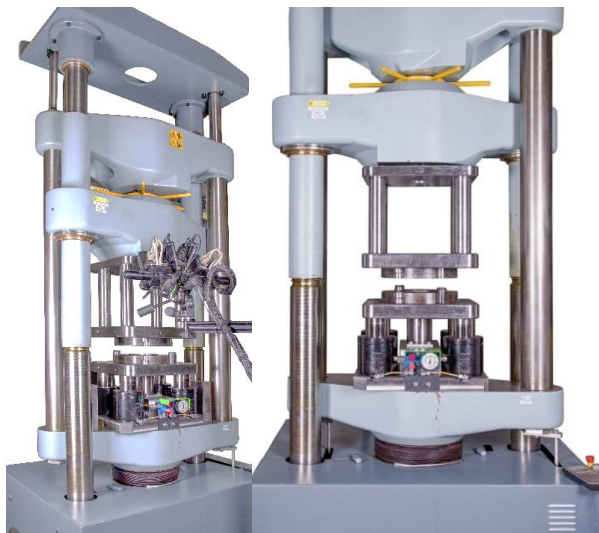
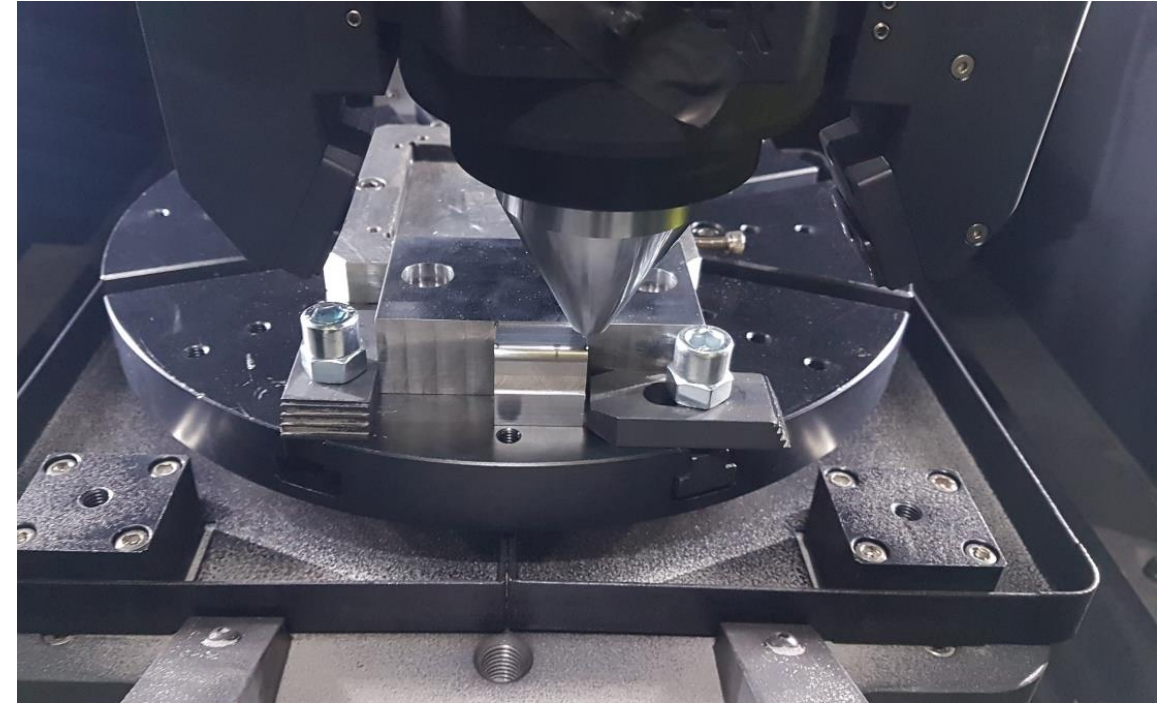


DED application in cold forming processes



Insert for deep drawing test device

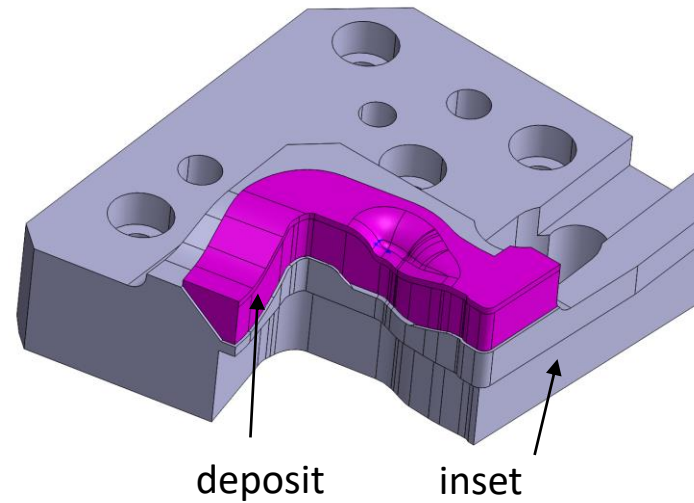
- Functional surface of a deep drawing demonstrator tool
- Basic material DIN 1.2343
- Deposited material DIN 1.2709
- Tool life test is still running



Insert for cutting tool

- Functional surface of the tool for sheet cutting of S500MC
- Basic material DIN 1.2312
- Deposited from M2
- Tool life test is still running, currently 50 000 pcs.

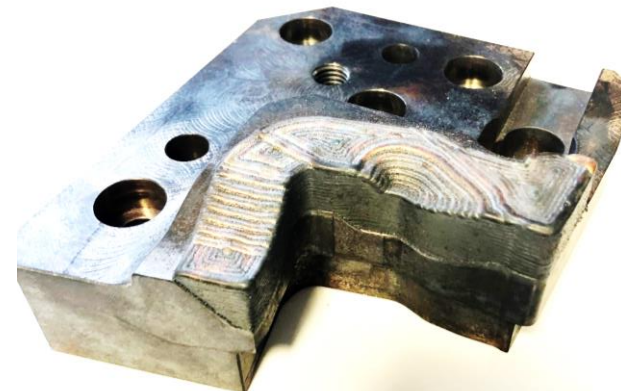
CAD model



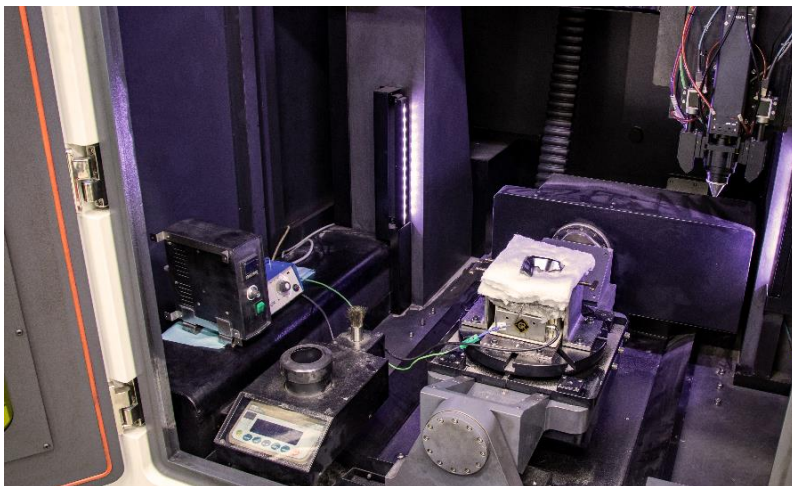
Rough out semiproduct



After deposition



Final shape



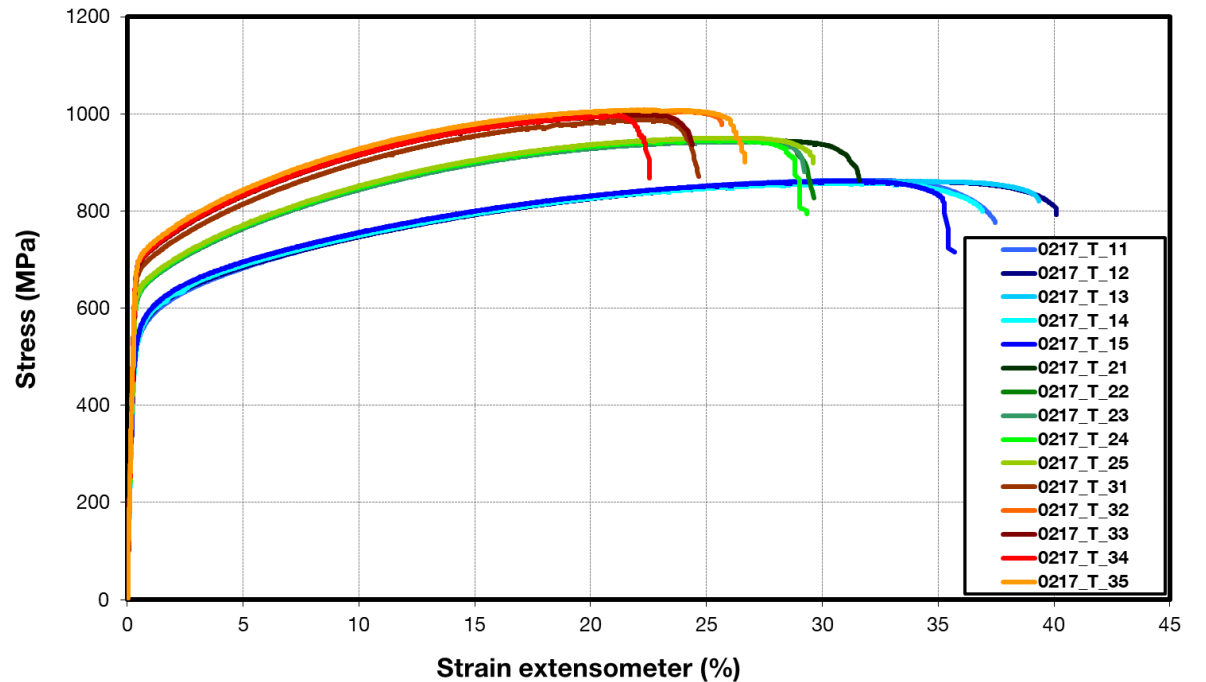
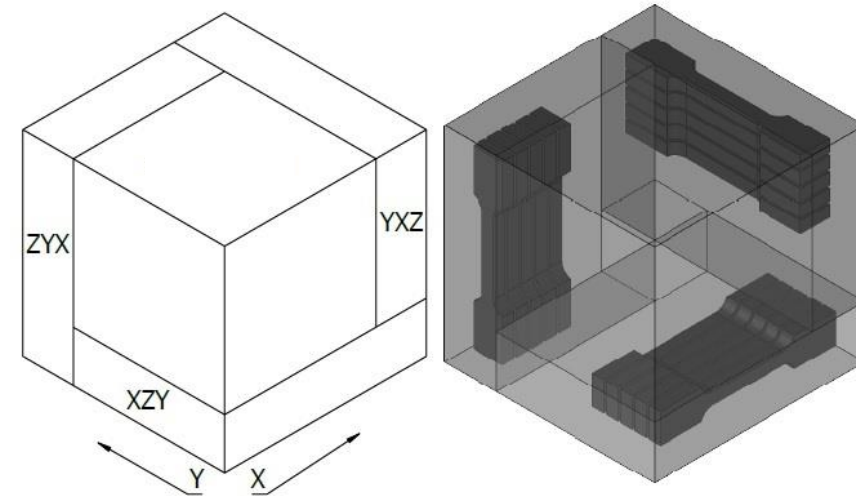
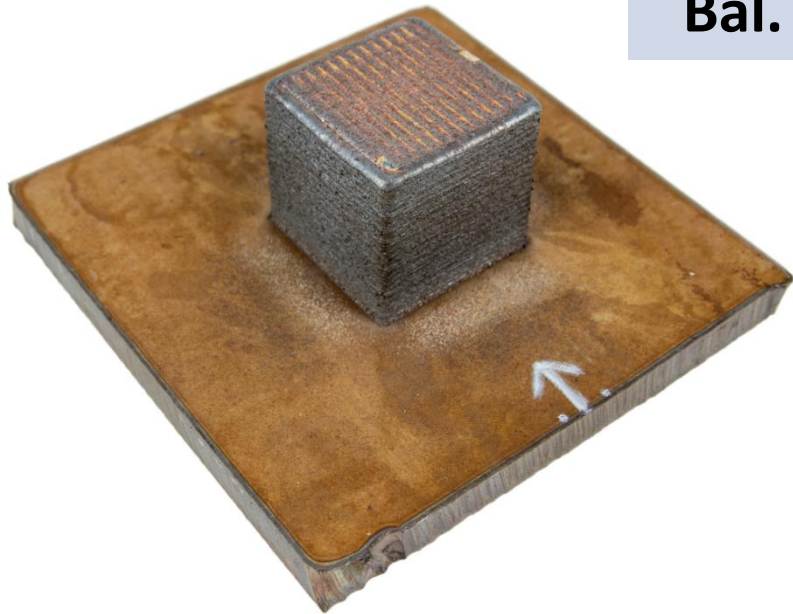
Structural parts



Material IN718 - demonstrator

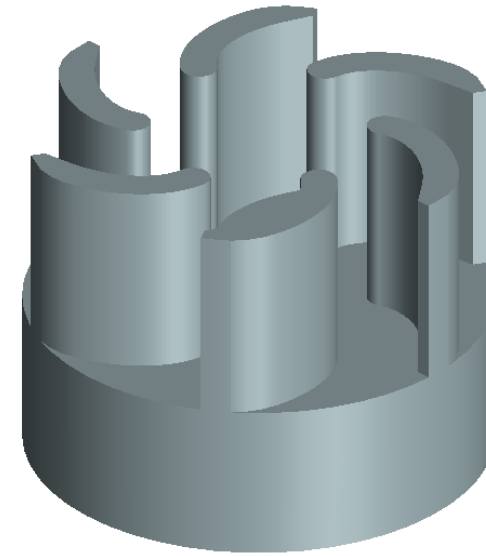
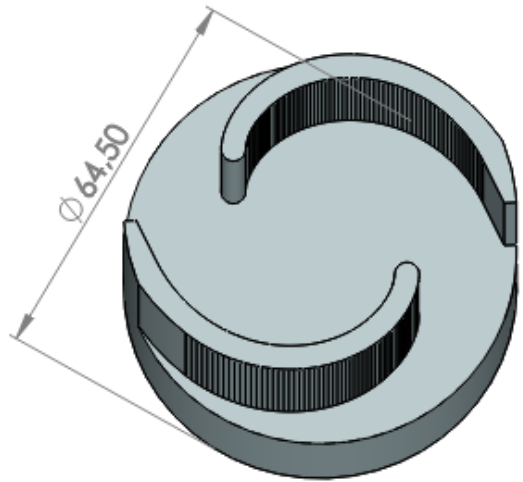
- Chemical composition (weight %):

Ni+Co	Cr	Mo
Bal.	19	3



Molten salt pump impeller

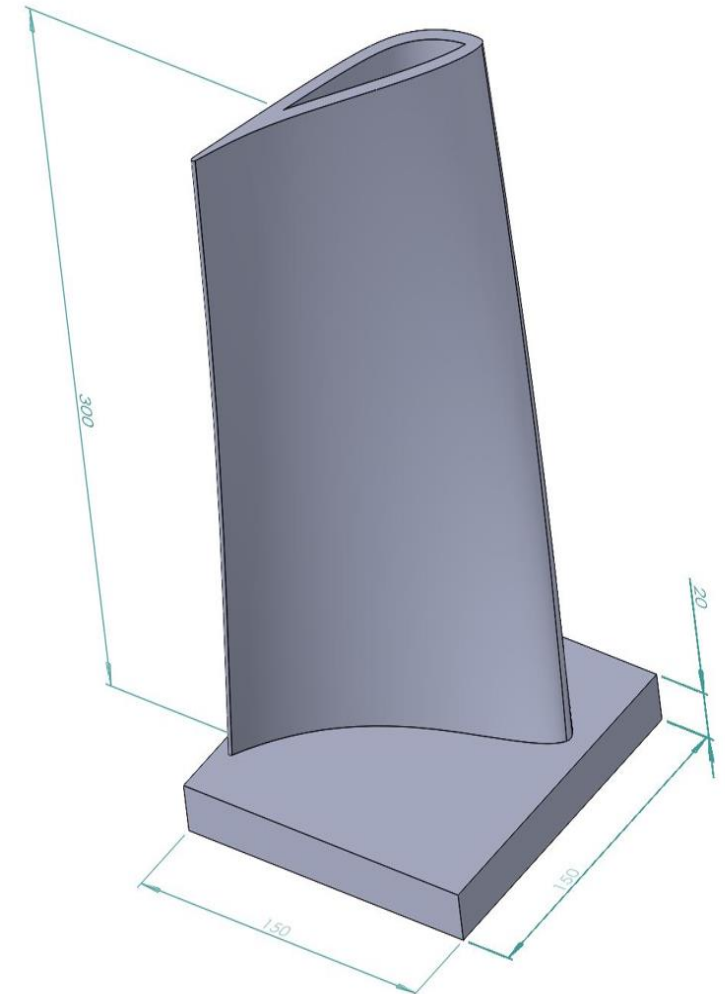
- Material IN718



Turbine blade (length 300 mm)

- Material AISI 316 steel
- Chemical composition (weight %):

Fe	Cr	Ni	Mo
Bal.	17	12	2,5



References

