Volker Wittig

New Developments of hydraulic DTH percussion drilling tools for hard rock type drilling

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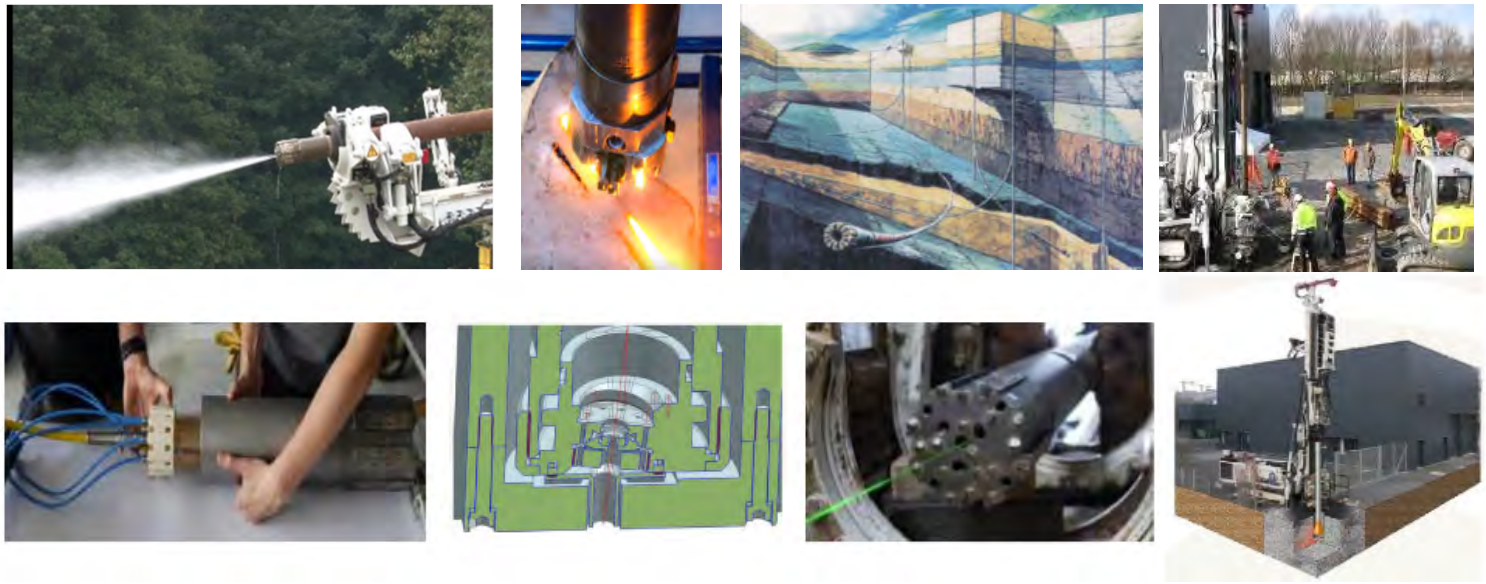
overview of current work and activities

1. Conventional Drilling (jointed pipe)
2. Coiled Tubing Rig + Drilling Technologies
3. DTH-Coring Rig on flex coil (offshore)
4. **Percussion drilling technologies**
5. Thermal drilling systems (**Laser, Plasma pulse, Electro impulse,** Spallation)
6. **Reservoir Stimulation** / High pressure jetting
7. Micro Turbine Milling + Drilling (MTD)
8. **Scaling removal** + pipeline services
9. Acoustic based drilling control + Artifical Intelligence / Nerual Networks
10. 3D rapid prototyping



Drilling technology : overview + history

> 100 year old drilling process

1900

- Cable Drilling

1909

- Roller Cones

1935

- Tricone Roller cones

1980

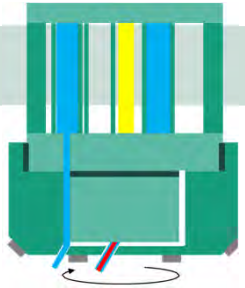
Fixed Cutter Bits / PDC

2000

Hydraulic DTH hammers

Possible Future

Thermal type drilling



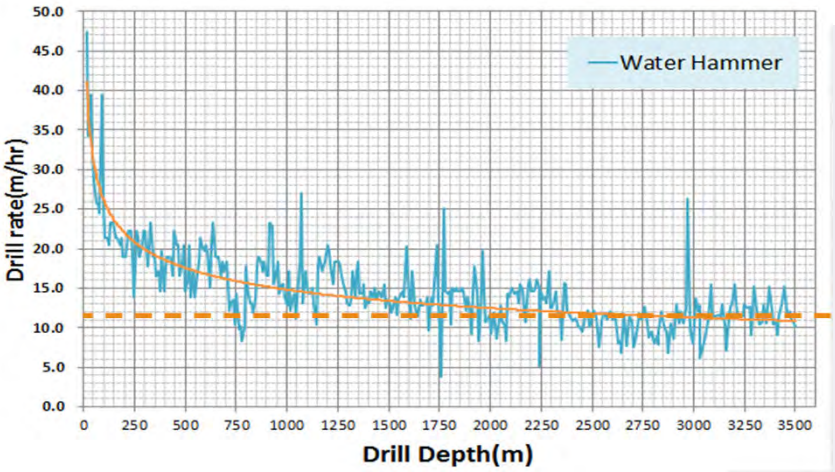
DTH hammer power solutions

compressed air or hydraulic / liquid

- **Mud rotary, static** **PDC bit**
  Roller Cone
- **DTH Hammer:** **Air**
- **DTH Hammer: Water / Fluid**

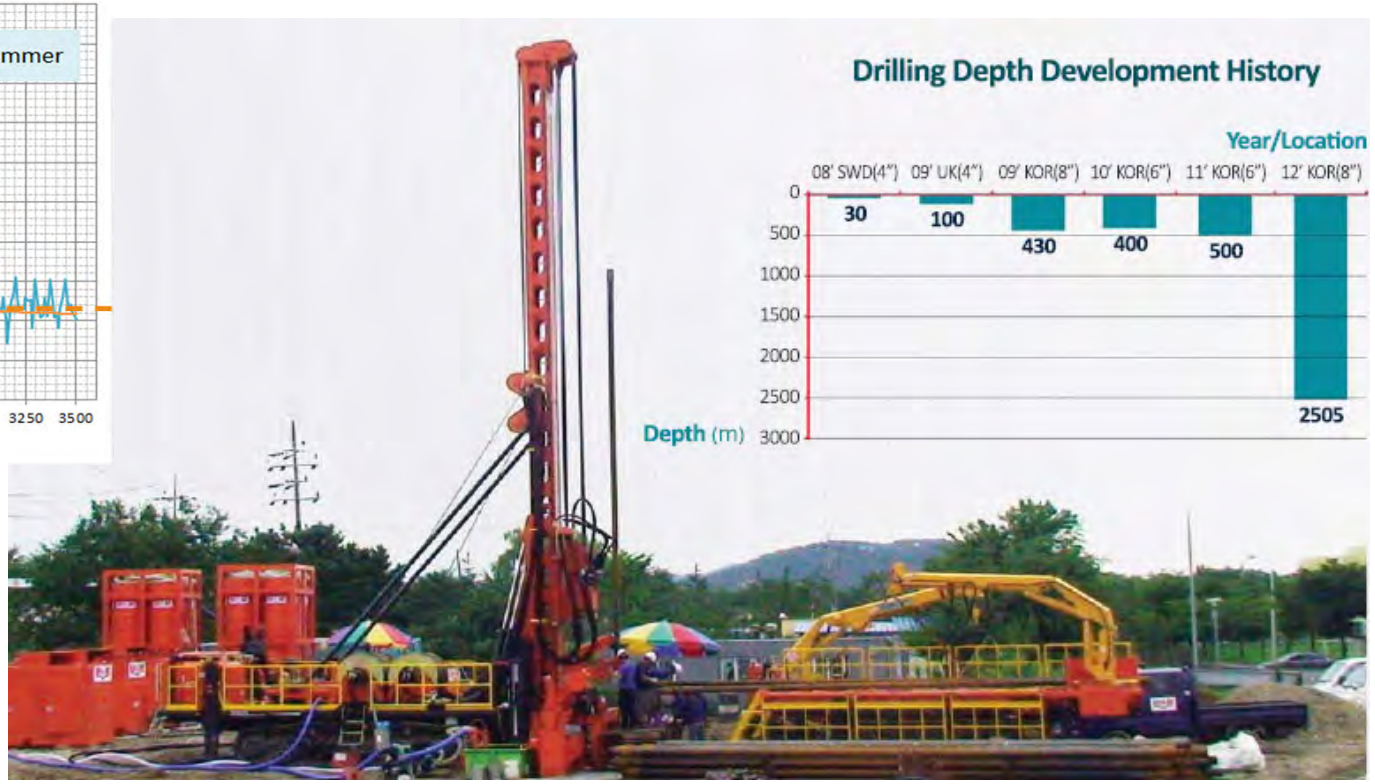
2015: deep drilling with DTH Water hammer Recirculation with air lifting support tested

South Korea



depth over 3.500m

ROP > 10m/hr
in Granite, 8 ½ in open hole



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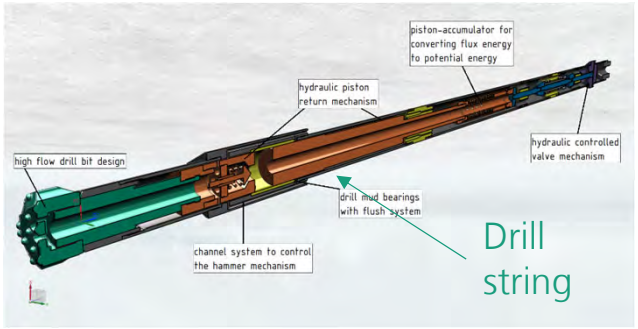
Hydraulic DTH percussion systems: 2 basic designs

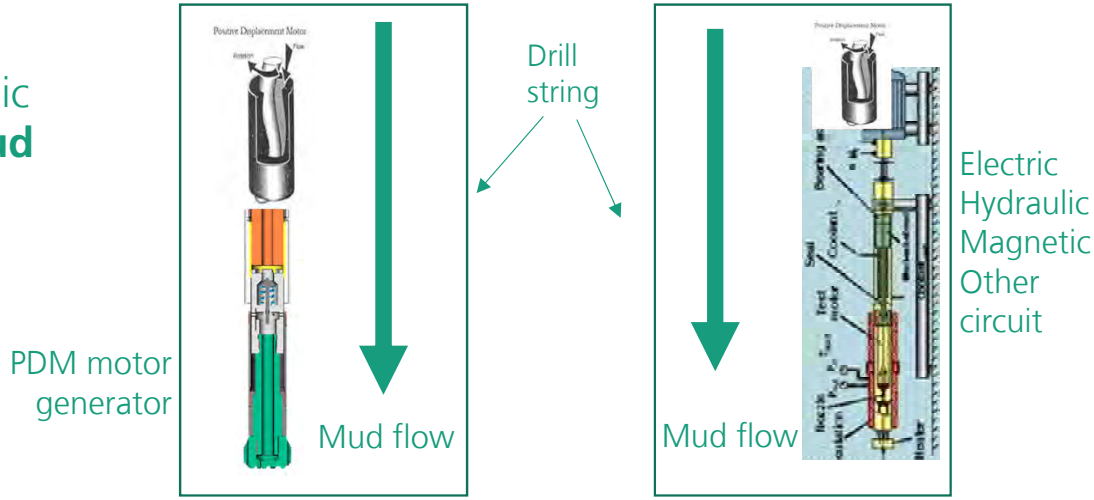
- **Flow through, internal system → e.g. Wassara in Sweden, Hanjin South Korea, DrillKing, all other developments in the past 30 + years**

- **External Closed loop system ("plug & play")** → percussion section is being powered with hydraulic or electric energy being generated downhole via **mud generator** → tool may be added to any BHA with enough flow

Flow through, internal

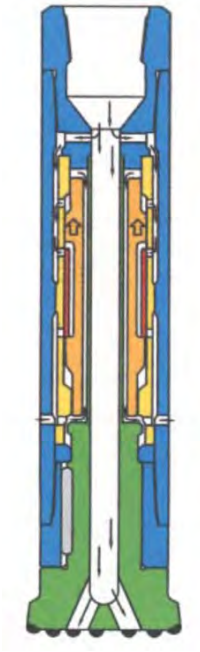


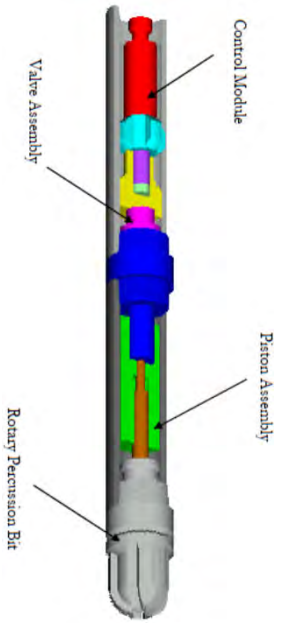
External Closed loop



Some DTH fluid hammer concepts worldwide of past 40+ years

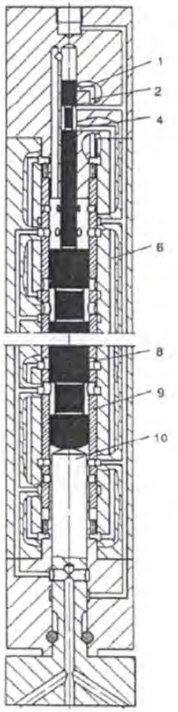
lots of mechanical parts, even incl. springs





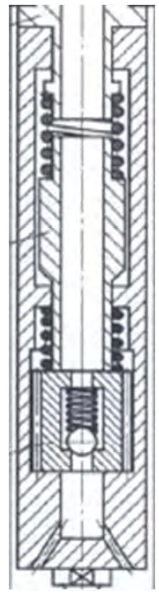
NovaTek, Utah / DOE
Flow through Mud
Hammer 2005 USA

Fluidic Hammer
China

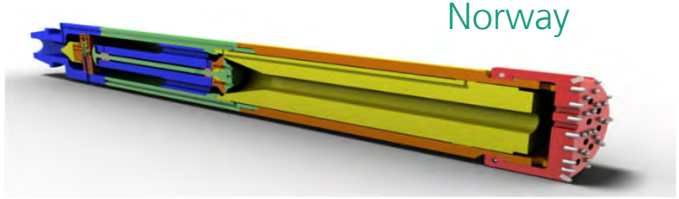


ITE / TU Clausthal
Hammer

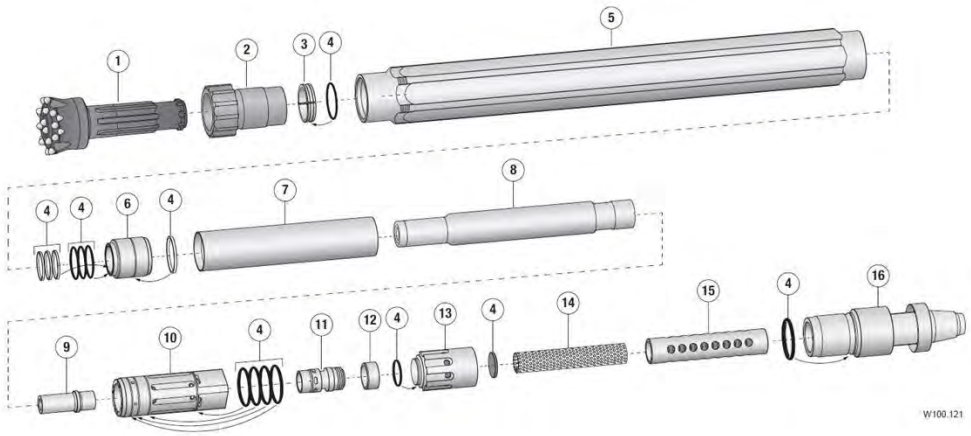
DSK Seilkern
water hammer
mid 1980s
Germany

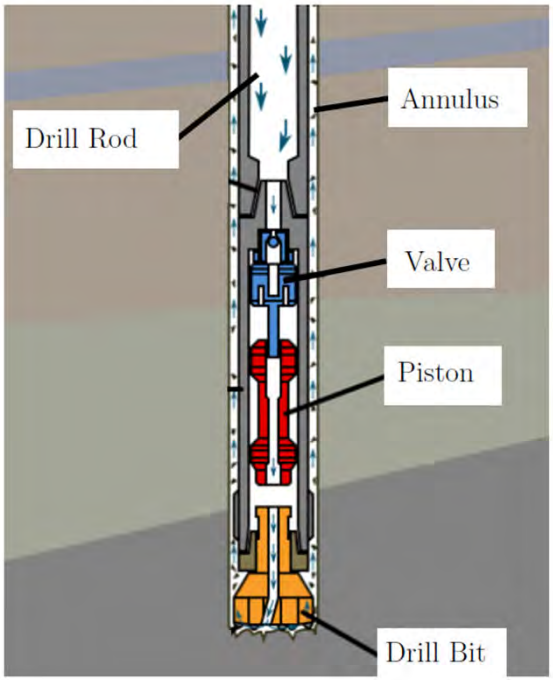


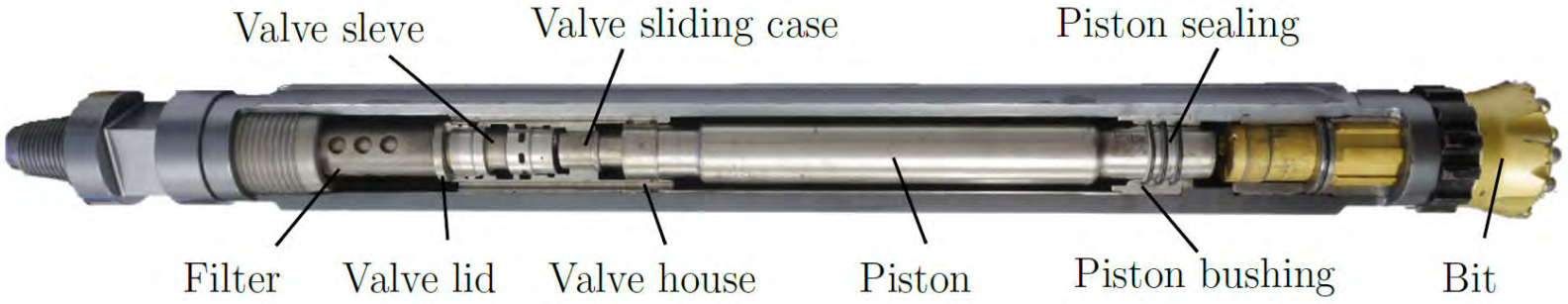
Penrock Hammer
concept 2006
Norway



Todays DTH water / fluid hammer drilling technology







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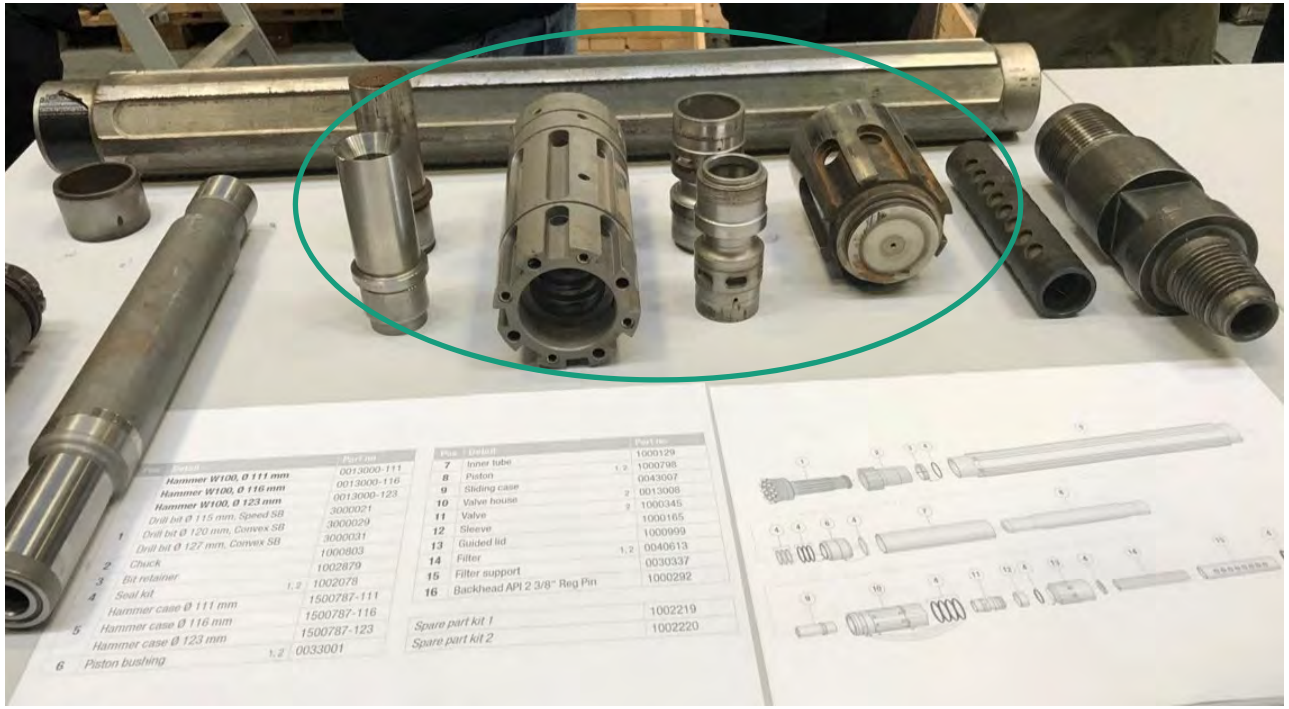
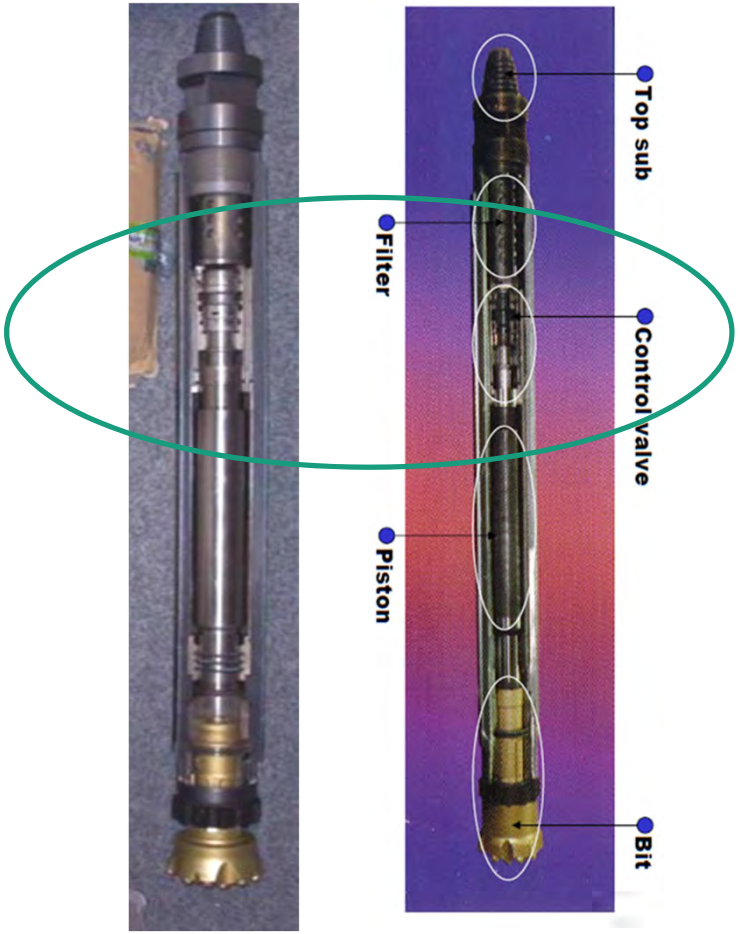
DTH water hammer : assembly + wear parts



Wear within hydraulic DTH water hammers



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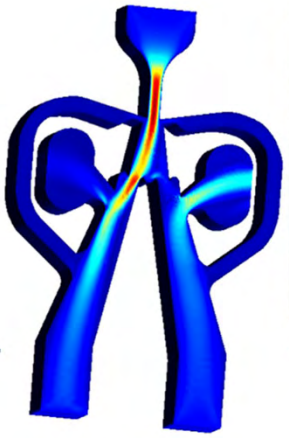
New percussion control based on fluidic switch

- No metal, moving hardware component
- **Single part for entire valve / hammer**
- **No need for** accurate, high **tolerances**
- **High flow rate + low diff. pressure possible**
- Reliable oscillation at HT + HP
- switch function with **low quality fluids**, small particles / solids (e.g. dill mud)
- Design and assembly **as wear part** possible
- **Variable percussion frequency** possible
- Cost efficient / additive / 3D type manufacturing possible

feasable **solution for deep drilling**, also at HT + HP



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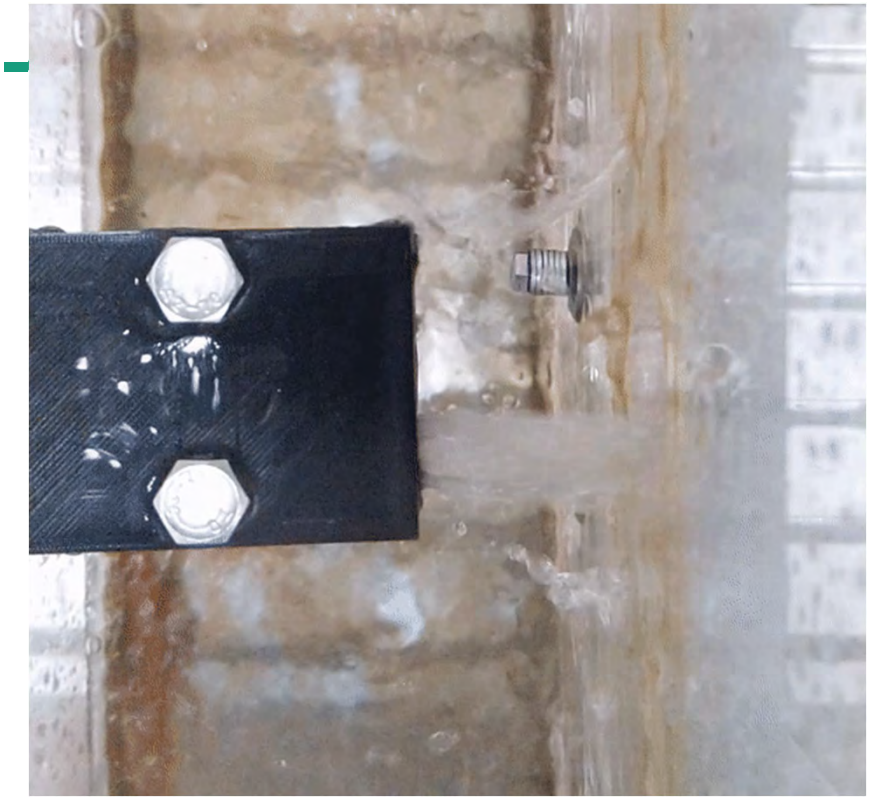
Experimental validation of switch assembly



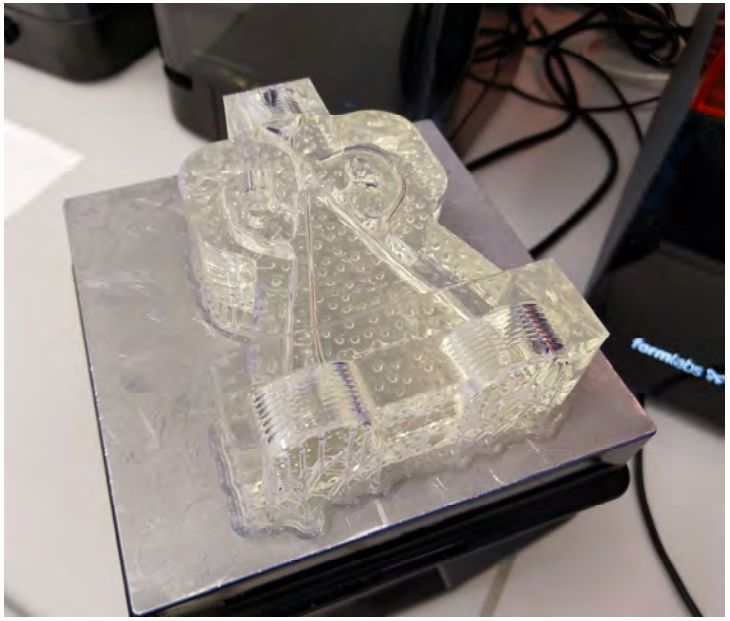
Frequencies Depending onswitch geometry and flow rate:

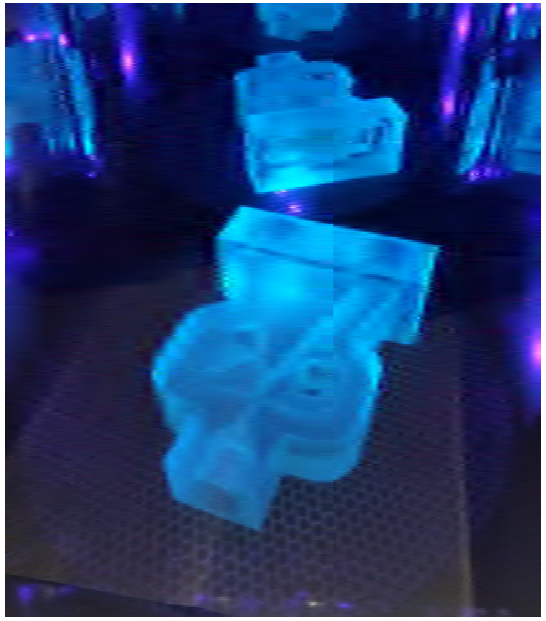
f ≈ 10 - 60 Hz

Laboratory and drill site tests with fluidic switch percussion unit

Optimization of design and functionality

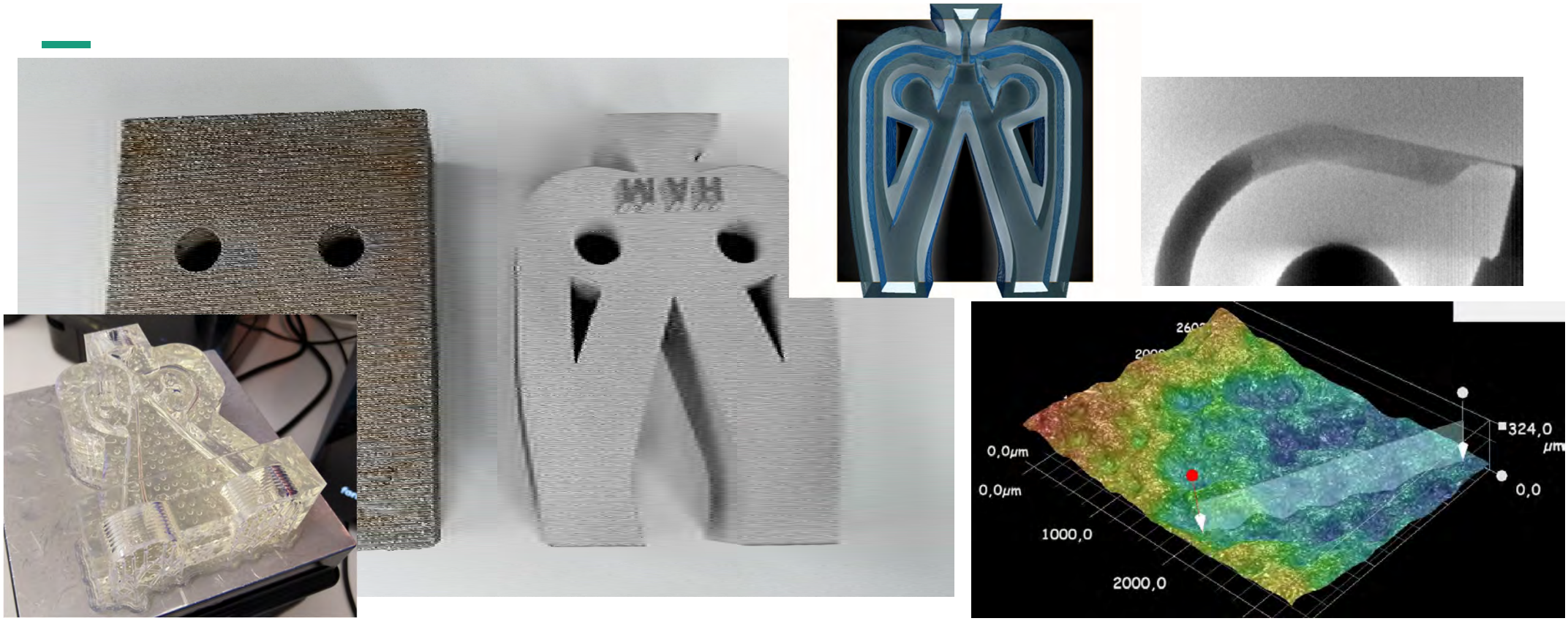
Rapid + numerous prototyping of fluidic switches





Manufacturing of prototypes using inhouse 3D-printing with engineered plastics

switch design + production for wear resistance



Additive Manufacturing of switches : **3D-printing with metals**
CT scanning for QA + QC required

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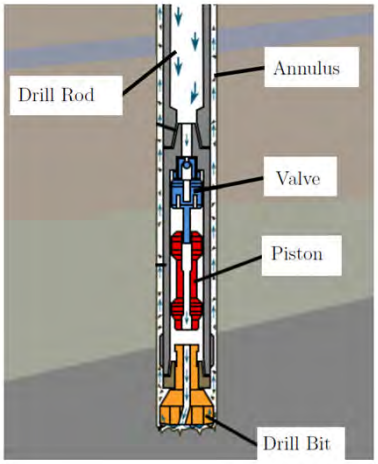
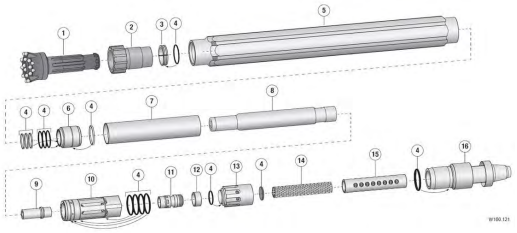
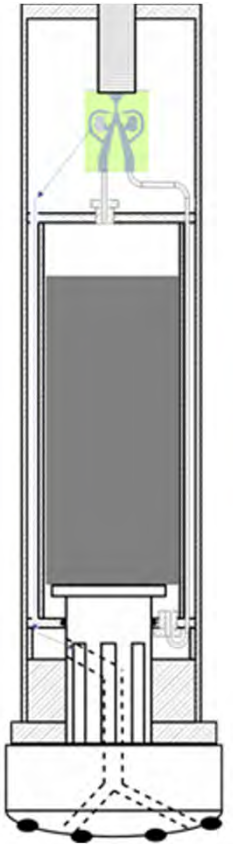
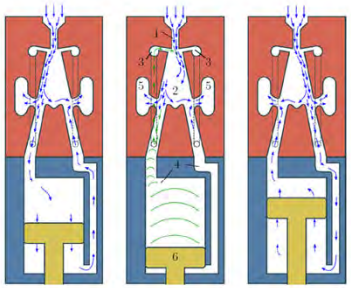
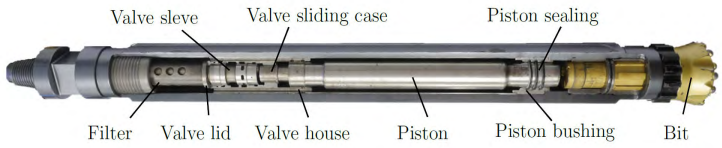
Fraunhofer´s new DTH fluid hammer drilling engine one moving part left inside











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Drilling simulator testing of Fraunhofer´s new DTH fluid hammer drilling engine

Sensor system + data transfer / smart drill pipe in development with EU partners

Recent Field demonstration

DTH hammer and Tool joint for Real time, fast data connection / transfer

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