Fluid Powered percussion engine for deep, hard rock (geothermal) drilling applications

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Drilling technology : overview + history

- **> 100 year old drilling tools and process**





1900

- Cable Drilling

1935

- Tricone Roller Bits

1909

- Roller Cones

1980

Fixed Cutter Bits / PDC



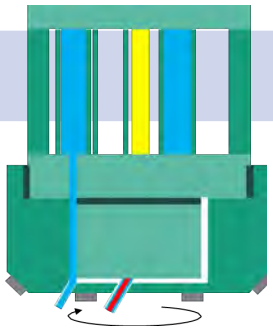


2000

Hydraulic DTH hammers

Possible Future

Thermal type drilling

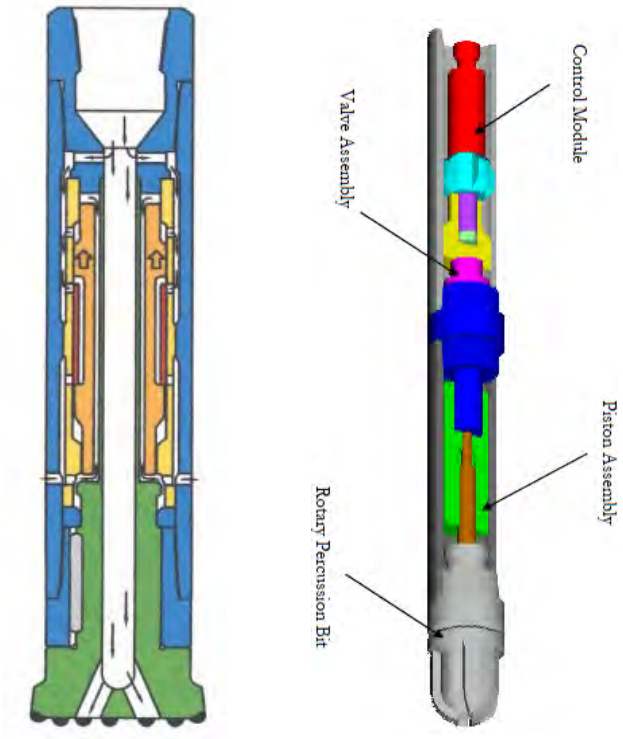


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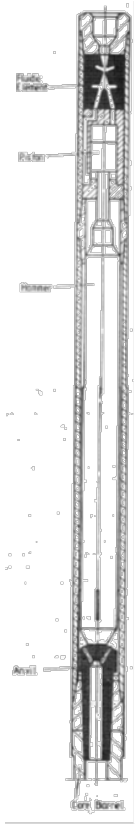
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DTH hammer concepts worldwide of past 50+ years

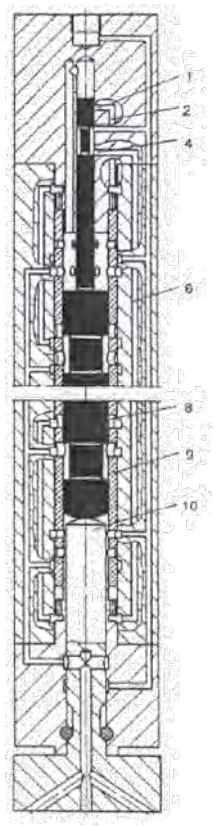
- **lots of mechanical parts, even incl. springs**



NovaTek, Utah / DOE
Flow through Mud Hammer
2005 USA

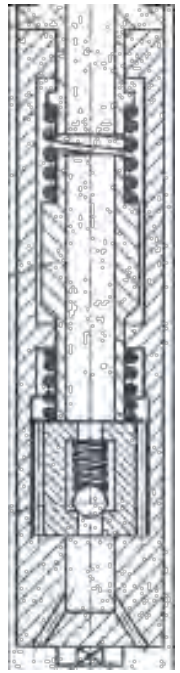


Fluidic Hammer
China

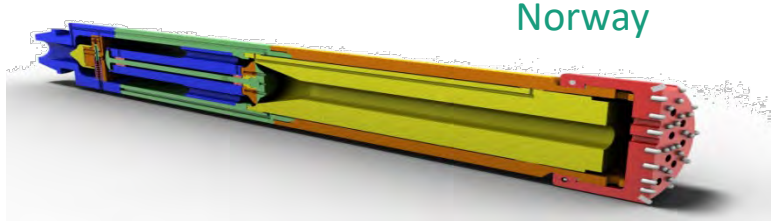


ITE / TU Clausthal
Hammer

DSK Seilkern
water hammer
mid 1980s
Germany



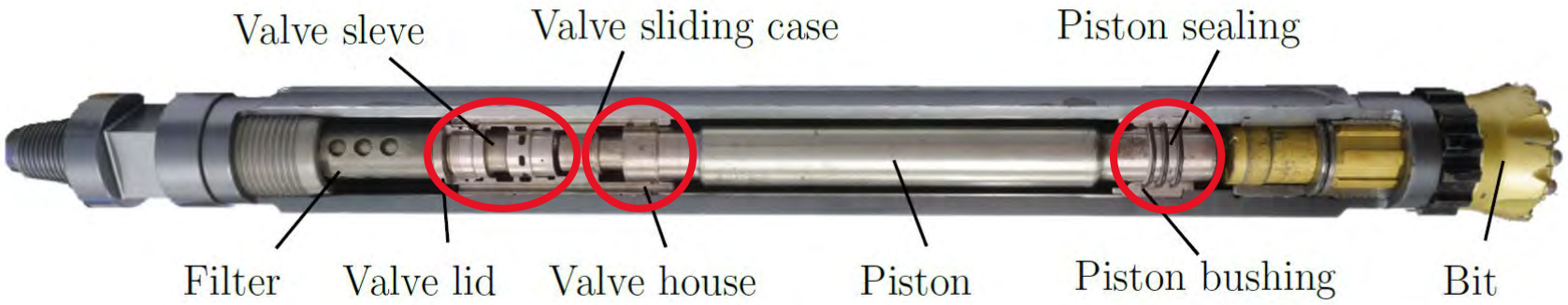
Penrock Hammer
concept 2006
Norway

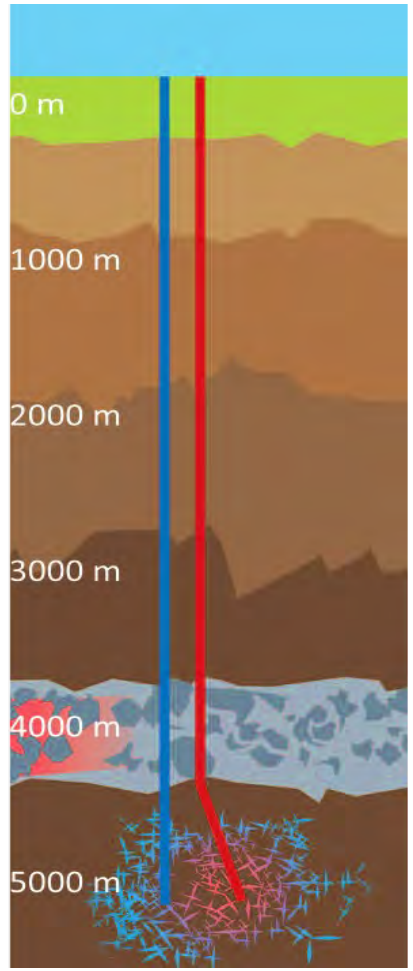


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Situation + Challenge

- Geothermal reservoirs typically in deeper and harder rocks
- DTH hammers are highly efficient in hard rock drilling
- Problems:
  - need good water / fluid quality
  - internal Tool wear (more than pump)

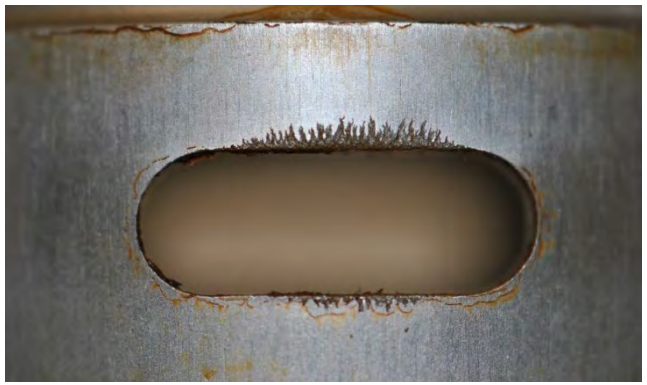




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Known Wear on current industry hammers

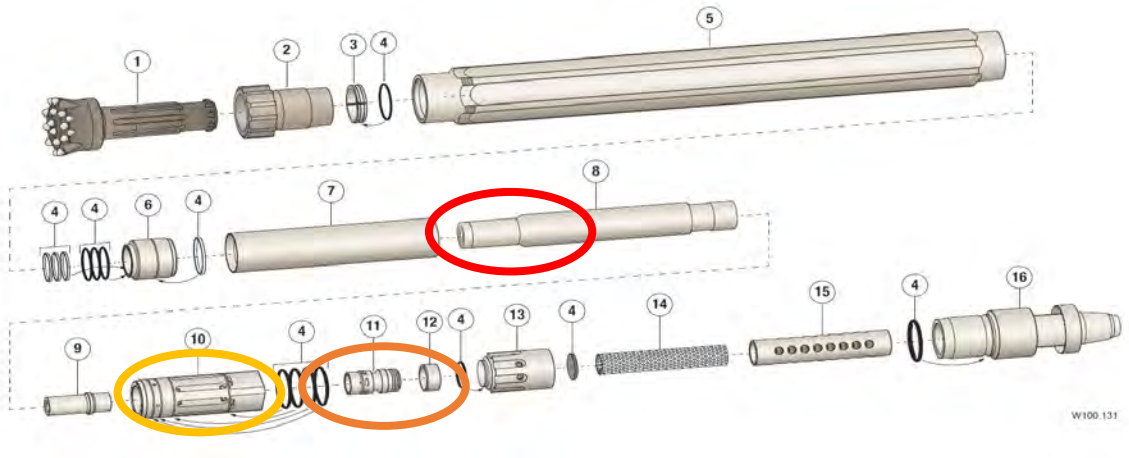










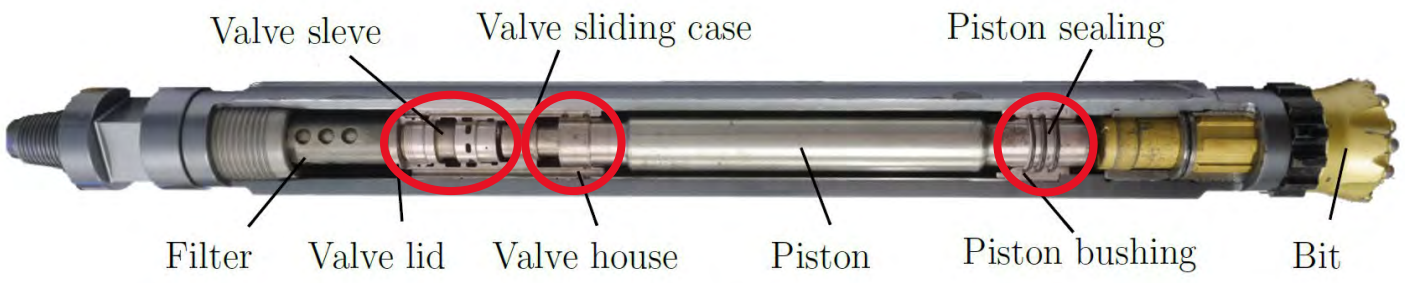


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Objective

- wear resistant fluid powered, hydraulic DTH Hammer
  - Reduce moving parts
  - Eliminate dynamic seals and tight tolerances
  - lower differential pressure
  - increase flow rate
- allow for low quality fluids like Drill Mud and more

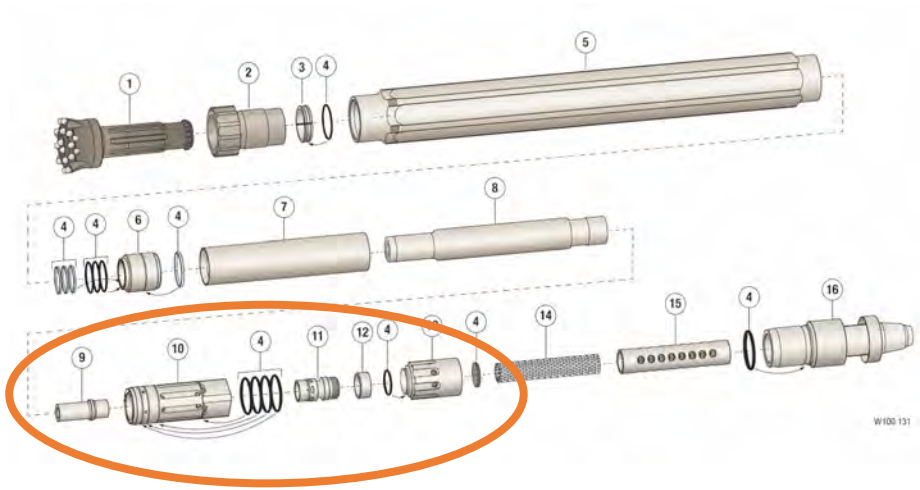


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Innovation : eliminate mechanical valve control

→ Use Coandă effect

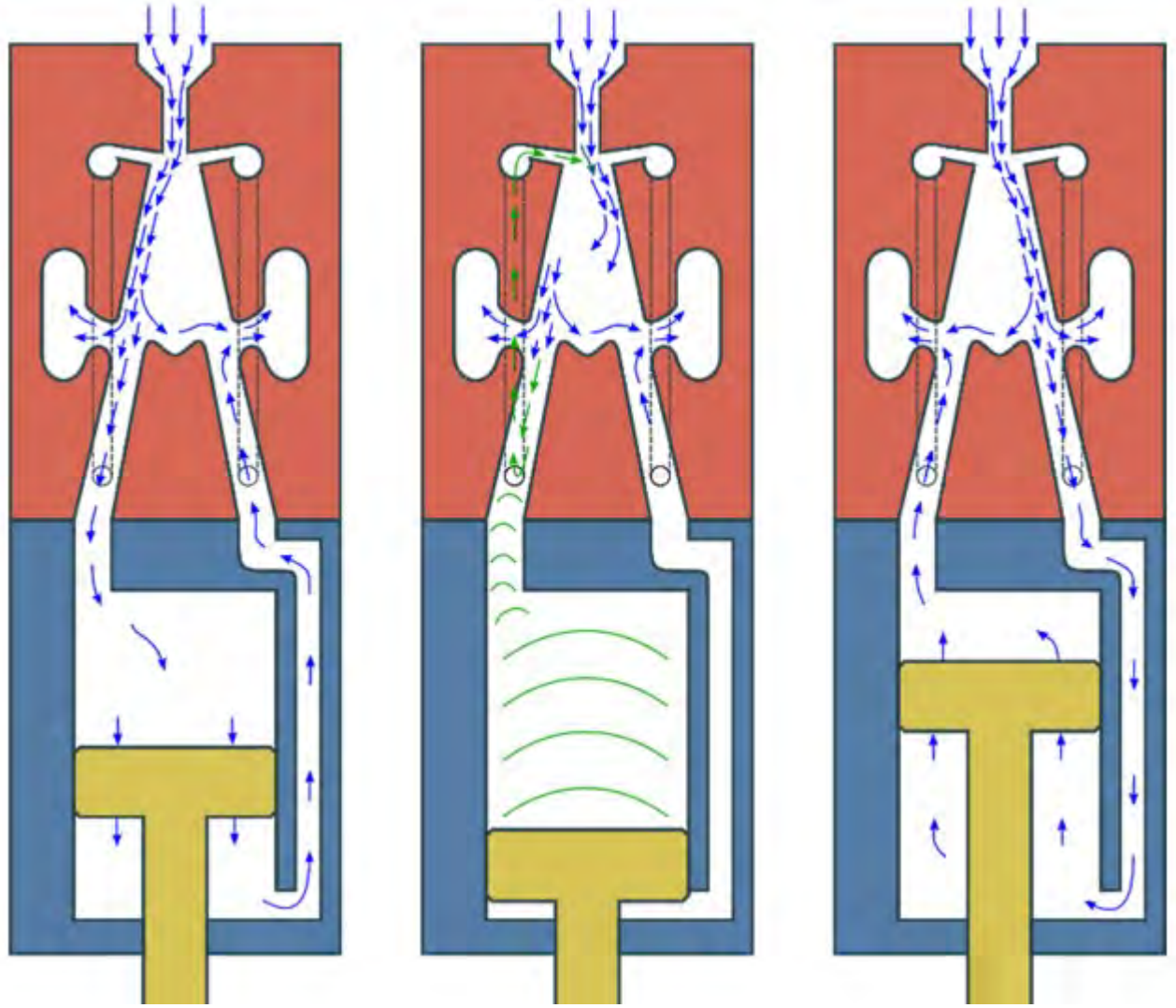




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Fluidic Switch control principle

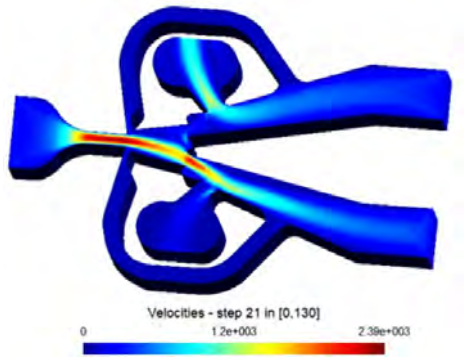
- Uses Coandă effect
- Flow “sticks” to wall
- Piston “pushes” stream to opposite wall
- Piston is reset
- Cycle restarts
- only 1 moving part → piston

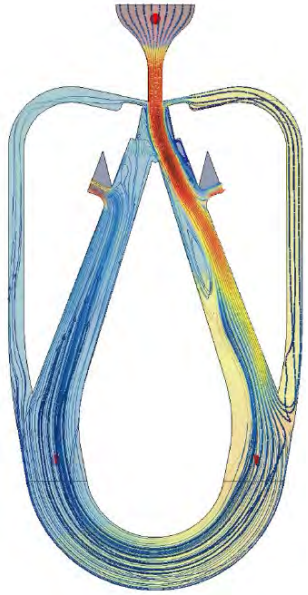


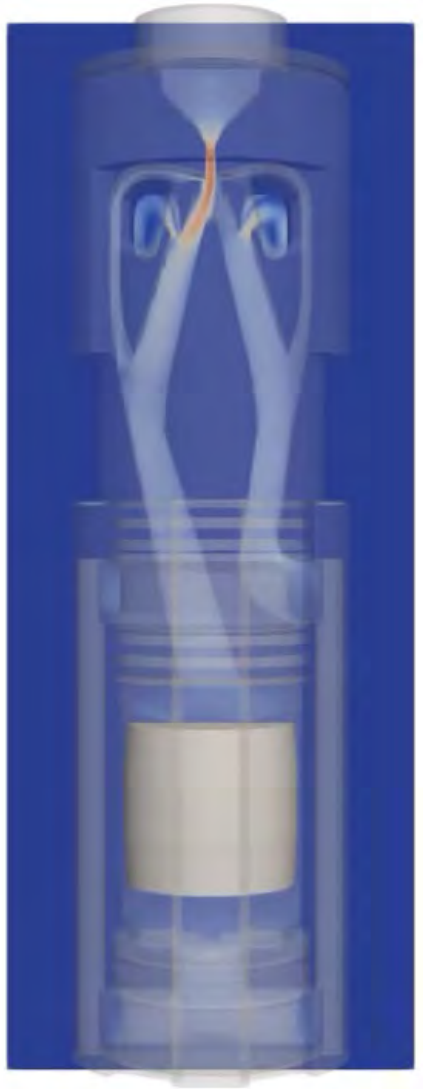
https://hartrusion.com/en/

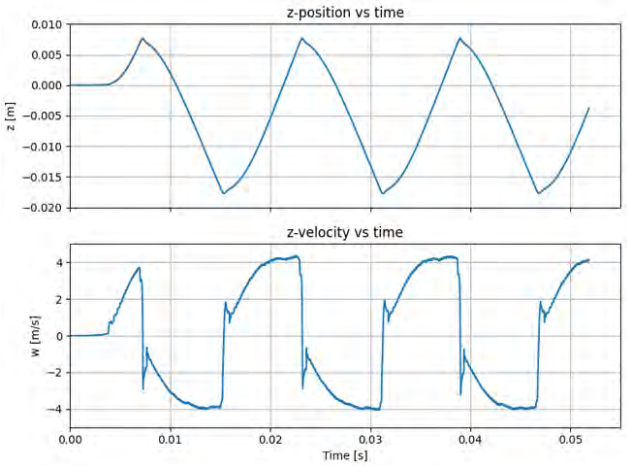
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internal design and fluid Simulation - Switch and Piston interaction -









- Parameterized 2D Simulation
- Fully functioning 3D Simulation

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4 in Prototype runs at IEG drilling simulator and drill rig / test site

- Drilling simulator for in situ drilling with

  Borehole conditions down to 5 km depth

- > 20.000 m drilled with DTH Hammers





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Hammer hydraulics, drilling and fluid quality

- numerous prototypes (4 inch) were built and tested
- up to 500 L/min + 180 bar
- appr. 36 Hz initially







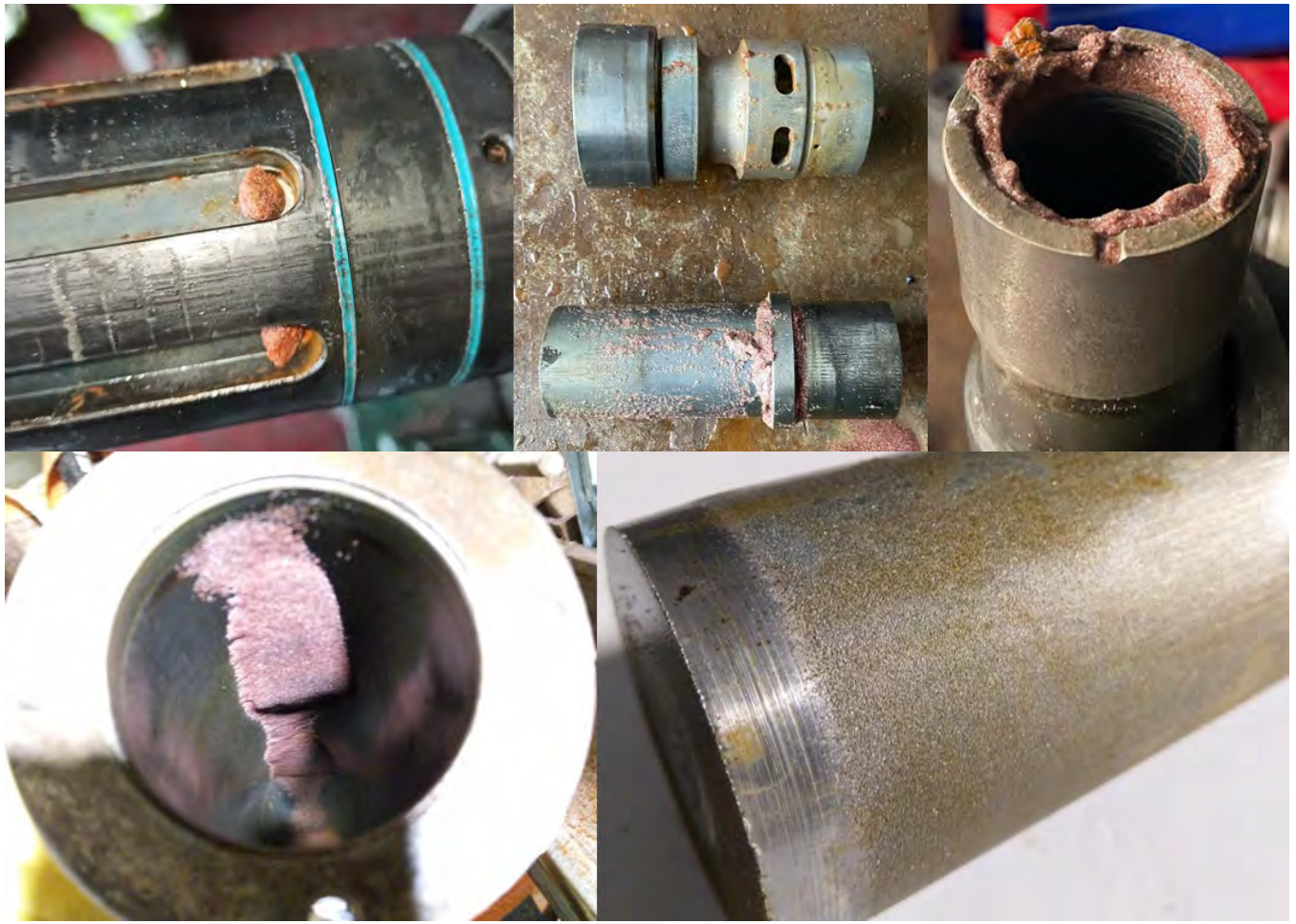


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extreme solids Testing with Corundum type sand up to 5%

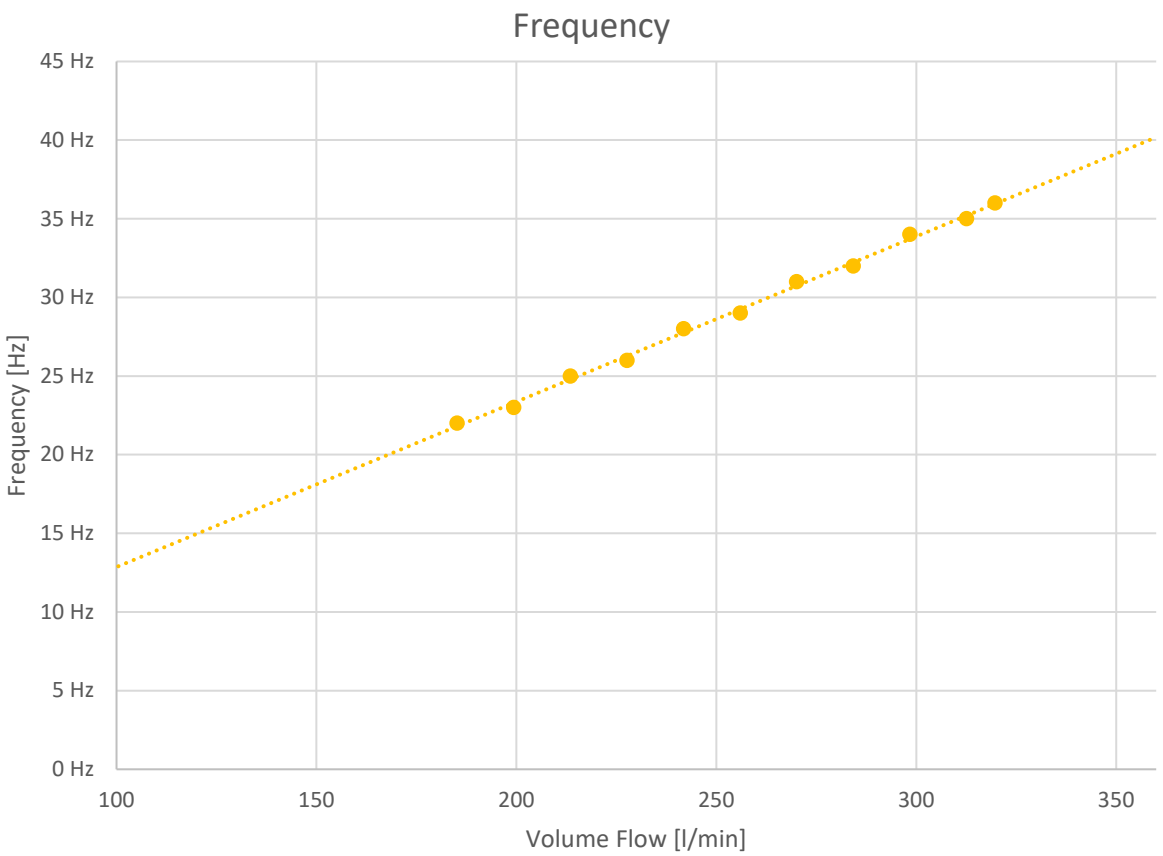
- Wassara type hammers:
  - Instantaneous clogging

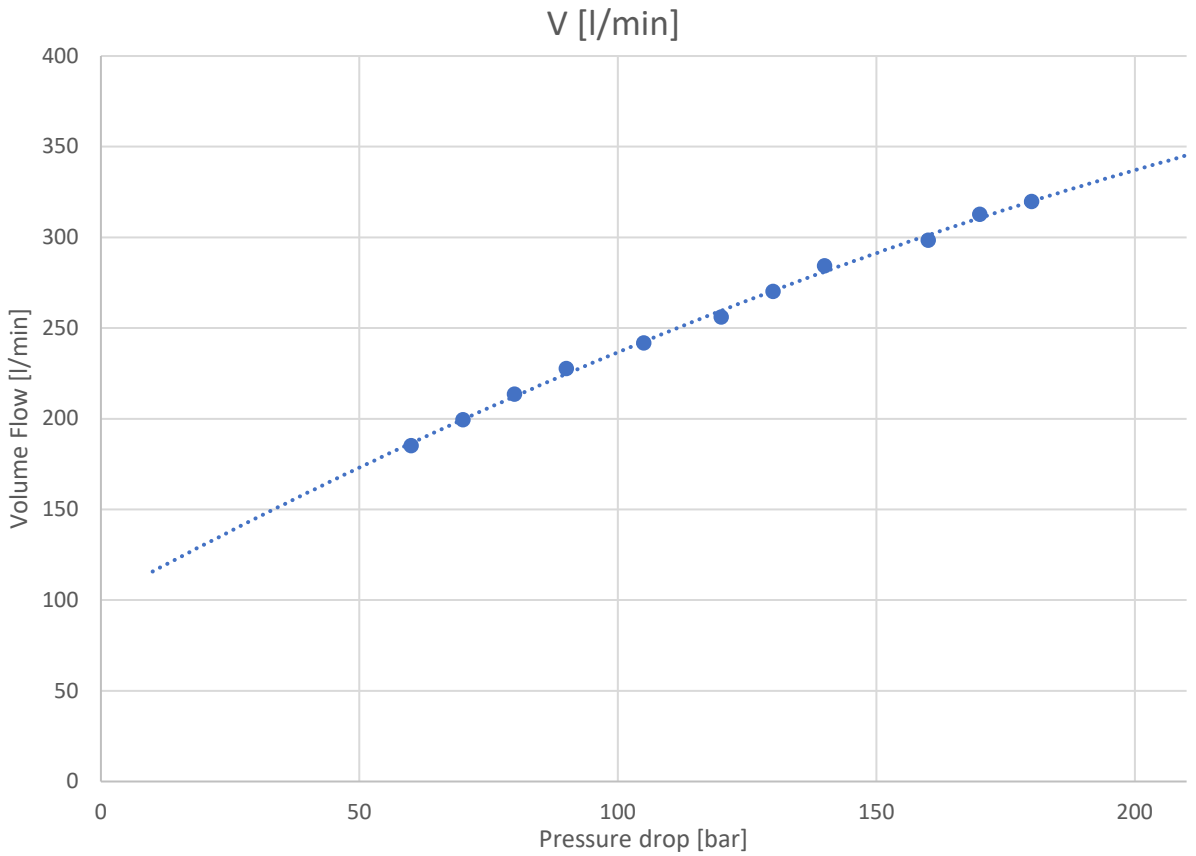
- Fraunhofer percussion engine:
  - continuous, Reliable function > 20 min



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Flow rate and diff. pressure of FRAUNHOFER percussion engine





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- Questions …. ?
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