Development of a novel percussion mechanism for downhole hammer drilling

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Intro

- Downhole hammer drilling increases the performance in hard rock formations by generating a percussive force on the formation, similar to a jackhammer
- Cost-efficient drilling for deep geothermal wells demands extended service life while enabling additives in the fluid (drill mud) to stabilize the drilling process
- Fraunhofer IEG develops a novel hammer run by a static valve that features
  - less relative movement between parts
  - fewer parts than in current hammers
  - no dynamic sealings or tight tolerances
- ➢ The goal: Optimizing the drilling performance to make percussive drilling more affordable for geothermal drilling

Approach

- State-of-the-art hammers use a mechanical valve to actuate the weight
  - Friction and erosion on surfaces wear the parts down and demand frequent maintenance
  - Sealings and tight tolerances make the use of drill mud nearly impossible
- This valve is substituted by a fluid-driven oscillator, also called a fluidic switch
  - The fluid itself performs the oscillation, which makes the part less vulnerable to friction and erosion from relative movement (Figure 1 left):
  1. The Coandă-effect pulls incoming fluid (1) into one piston chamber (4) only
  2. The piston weight moves and reaches the end position, a pressure impulse sets off and travels back through the fluid into the feedback channel (3)
  3. The incoming jet is pushed to the other side of the piston chamber (2)
  4. Exhaust fluid exits the device through the vents (5) and the cycle repeats

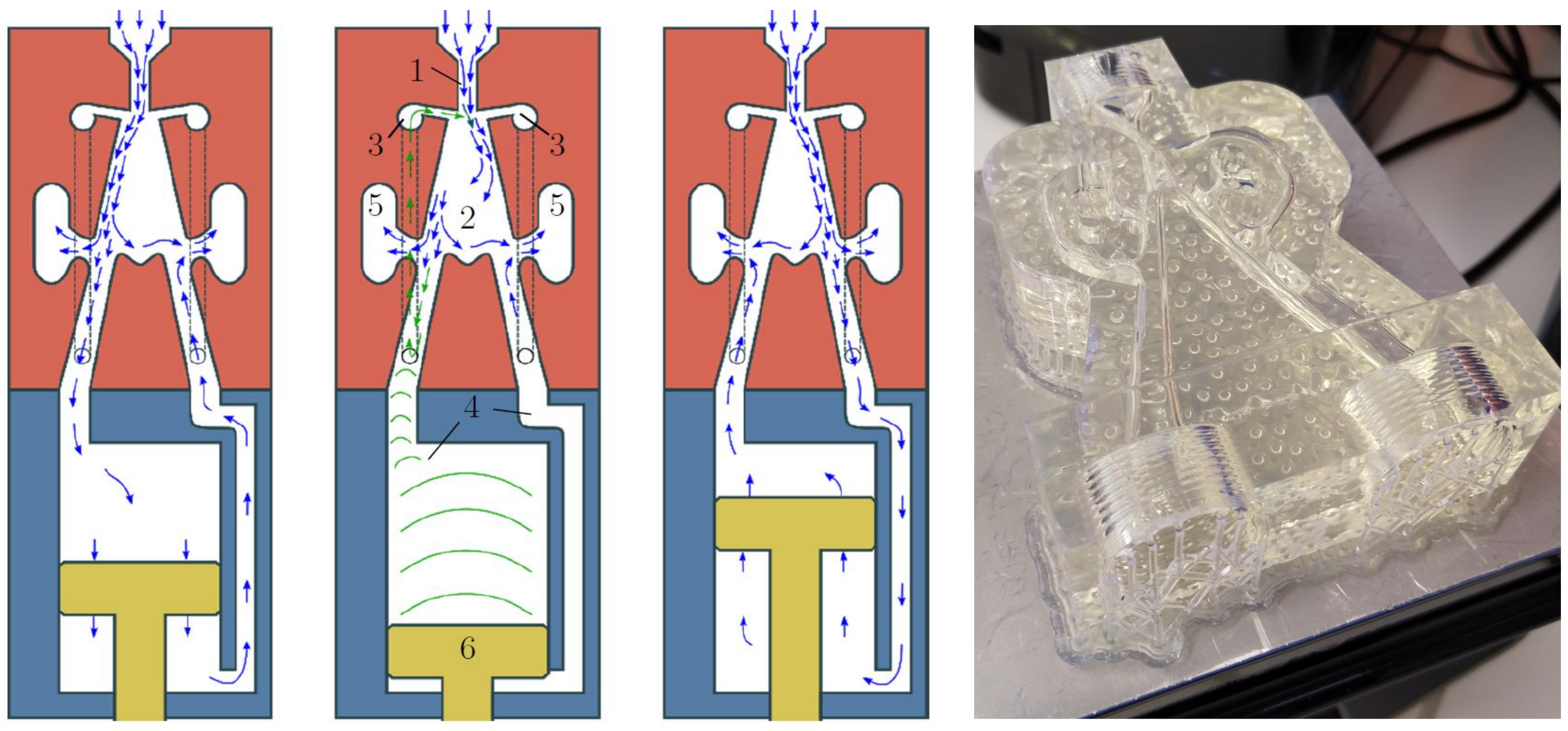

Fig. 1: Schematic of fluidic DTH hammer [2] (l.), 3D-printed fluidic switch (r.)

Method

- Numerical model used to optimize the percussion unit for different geometries via a numerical mass-spring-damper model (e.g. diameters, weights, stroke)
- CFD simulation revealed crucial areas in the principle design and possible improvements for better pressure preservation were derived from there
- Experimental investigations with adapted dimensions at dedicated positions
  - 3D-printed resin models (Figure 1 right) allow pressures of up to 180 bars

Realization

- Figure 3 shows the full-scale 3D-printed PLA prototype investigated with water under laboratory conditions
- Current investigations focus on the realization of the final prototype in metal to generate a functioning tool (Figure 2)
- First proof of concept with a steel piston was already successful, the final prototype will be tested on-site at Fraunhofer IEG at the beginning of 2023

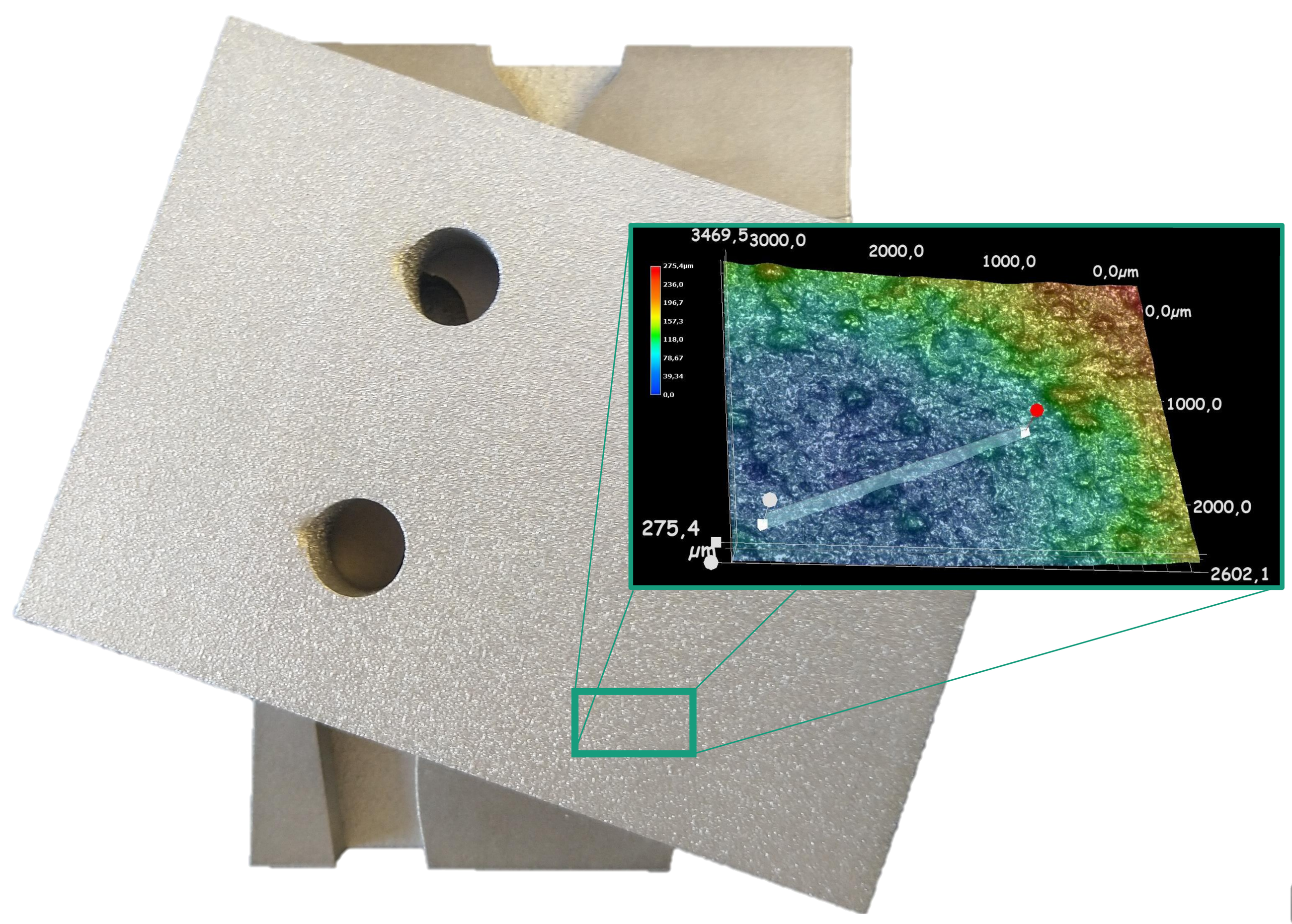

Fig. 2: 3D-printed fluidic switch from 316L stainless steel with a max surface roughness of R_z = 56 µm

Fig. 3: 3D-printed PLA prototype

Results

- Optimization of the geometry increased the reliability of the mechanism and the frequency to over 30 Hz with a moving mass weight of 12 Kg
- The mechanism works without dynamic sealings or narrow tolerances and consists of only five main parts; this all results in higher durability when operated with drill mud
- A metal unit that fits a 4-inch hammer housing has been constructed and will be tested under real drilling conditions in 2023

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