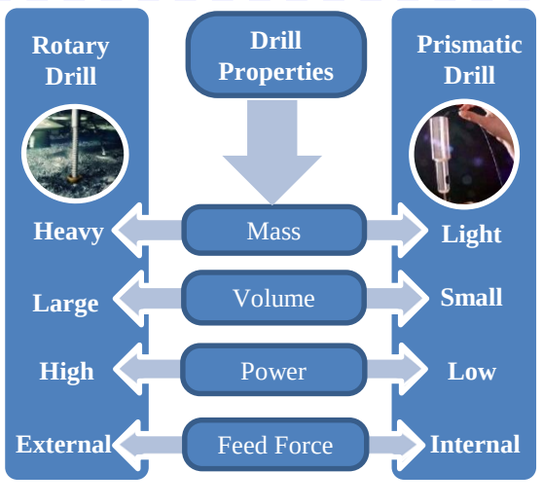
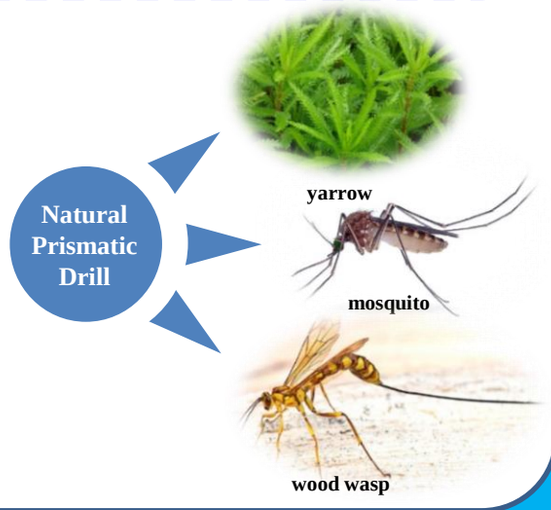
2017 International Bionic Innovation Competition

Three-valves Bionic Sampling Drill Inspired by Wood Wasp

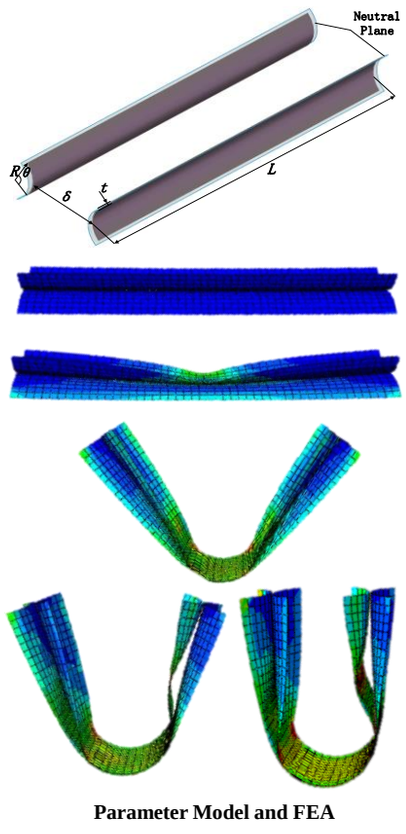
Abstract

Drilling and sampling are important in space exploration. Although rotary drill technology is mature, it is limited in low gravity environment. However, the movement of natural drill is prismatic. Wood wasp has an immensely slender ovipositor, its valves can bore through the trunk to lay their eggs. Inspired by wood wasp, we proposed a three-valves bionic sampling drill which is composed of three parts:the Retractable cabin, the flexible arm and the drill bit. By observing the muscle contraction, the 8th abdomen contractile form is isotonic contraction, the 9th abdomen is isometric contraction. A linear actuator is for muscle. It is significant for mechanism research of novel drill in space exploration.

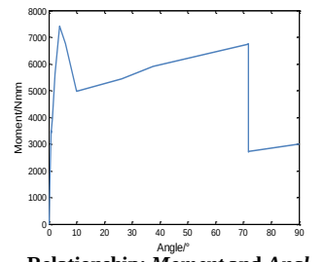




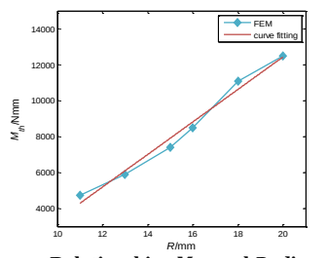
Simulation: Flexible Arm



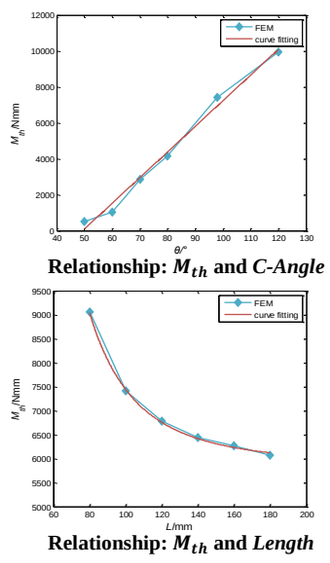
Parameter Model and FEA



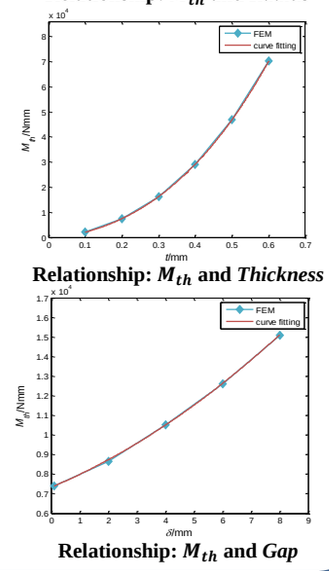
Relationship: *Moment* and *Angle*



Relationship: M_{th} and *Radius*



Relationship: M_{th} and *C-Angle*

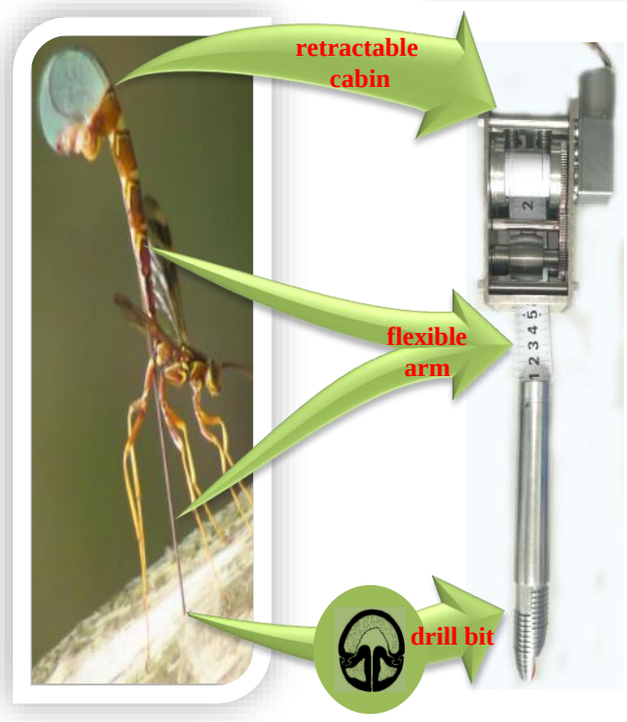


Relationship: M_{th} and *Thickness*

Relationship: M_{th} and *Length*

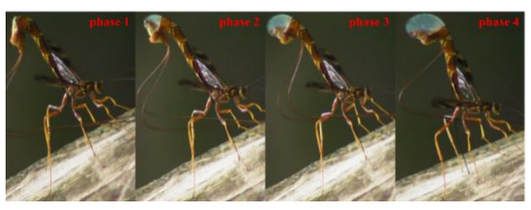
Relationship: M_{th} and *Gap*

Sampling Drill



Three-Valves Bionic Drill

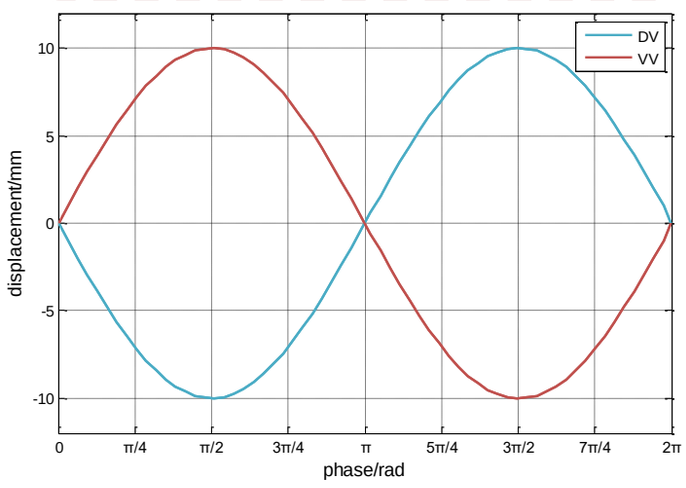
Ovipositor Stretching Process



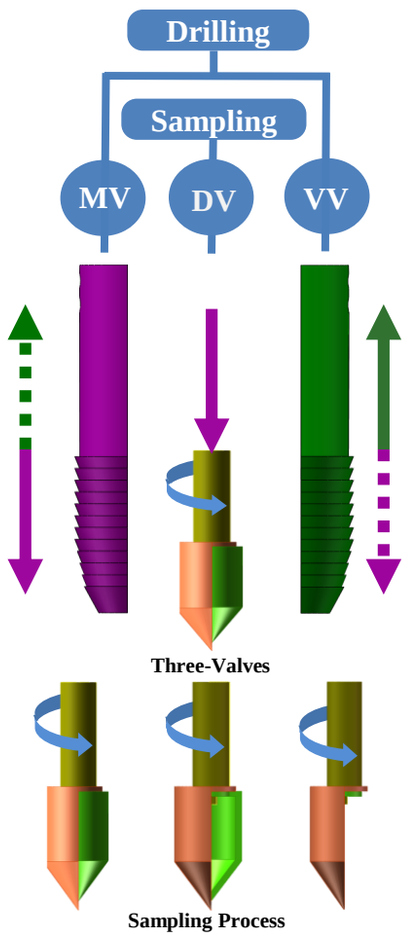
Ovipositor Contracting Process

Three-Valves
- **MV**: Middle Valve
- **DV**: Dorsal Valve
- **VV**: Ventral Valve

→ **Linkage Sliding Slot**

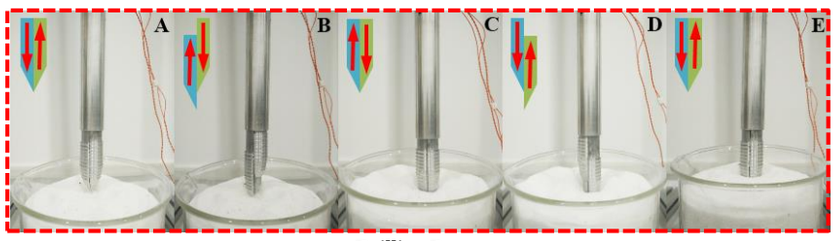


MV & VV Displacement-Phase Curve

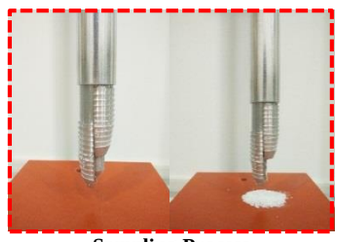


Three-Valves

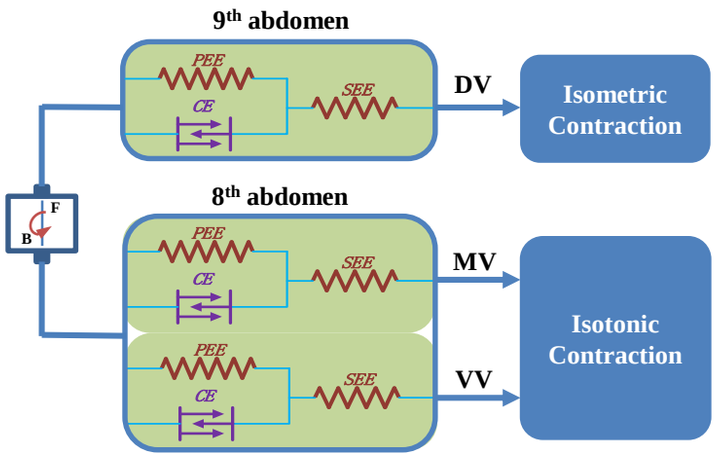
Sampling Process



Drilling Process



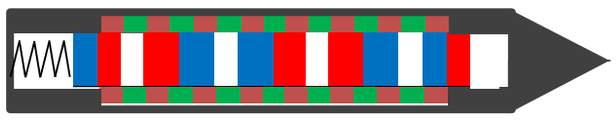
Sampling Process



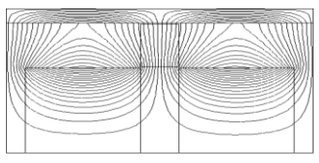
DV is connected to the 9th abdomen, its muscle based on Hill-type works under isometric contraction. MV and VV are connected to the 8th abdomen, their muscles work under isotonic contraction.

The output force of muscle is affected by the velocity, the frequency, the length and the activity of the contractile element. A linear actuator is designed for muscle, its output force is affected by the current, the frequency and the number of unit.

Muscles of Three-valves



Linear Actuator as Muscle

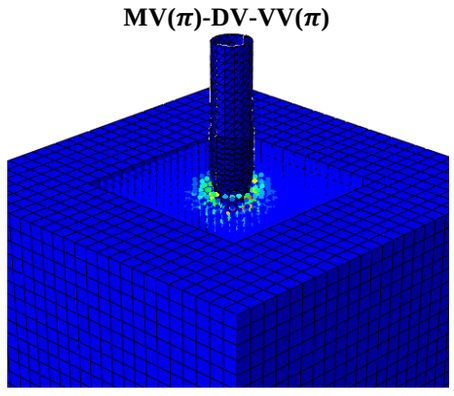


Electromagnetic FEA

SPH: Drill-Lunar Soil

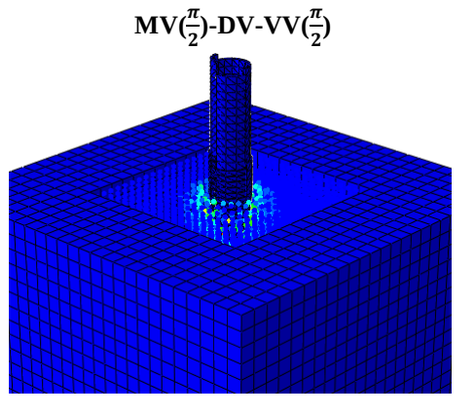
Lunar soil is composed of discrete particles, researching on the interaction between the different configuration drill bit and lunar soil by SPH(smoothed particle hydrodynamics) methods.

MV(π)-DV-VV(π)

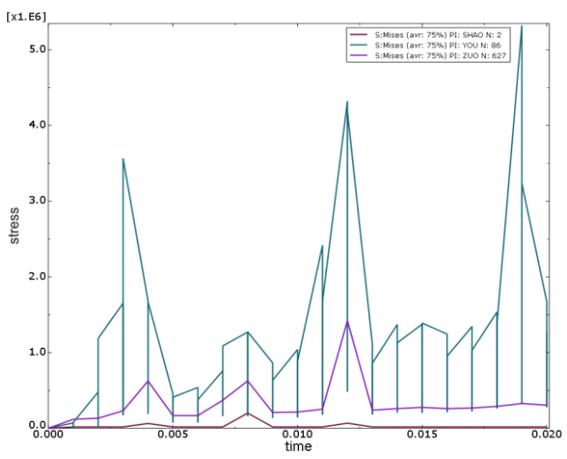


Logarithmic Strain

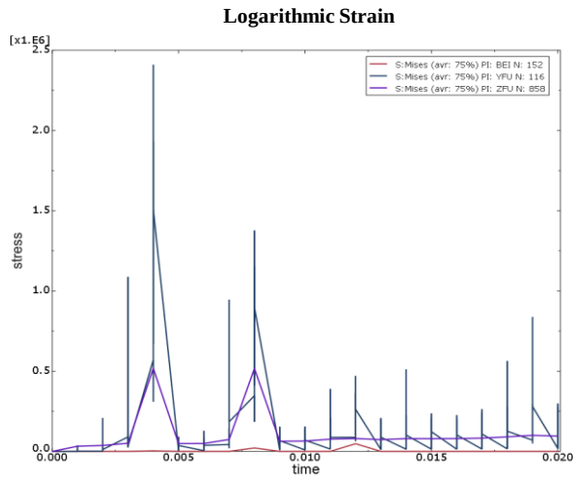
MV($\frac{\pi}{2}$)-DV-VV($\frac{\pi}{2}$)



Logarithmic Strain

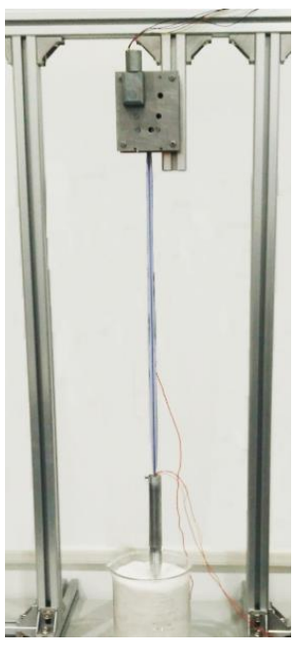


Three Nodes Stress at Three-valves



Three Nodes Stress at Three-valves

Conclusion



Prototype

Prismatic drilling, MV & VV for drilling, DV for sampling

Linear actuator is similar to a contractile element of muscle

Flexible arm with higher flexural and torsional stiffness, no bulging

Different three-valves configuration affects the drill bit force

Publications & Patents

[1] the National Science Foundation of China (51175494): Study on Spatial Expandable Structure Based on the Development Mechanism of Lepidoptera Insects

[2] A Novel Low Velocity Robotic Penetrator Based on Ampere Force[M].ICIRA.2017.

[3] Retractable Bionic Sampler.CN107036842A.2017.

[4] A Self-excited Penetrator.CN107040116A.2017.

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