COLORADO SCHOOL OF MINES

A Different Perspective On The Use Of High Pressure Water Jets To Improve Performance Of Rotary Cutter Head Dredges

Rotary Cutter Head Issues

- Current advances have allowed rotary cutter suction dredges to be able to mine almost any material; however, their efficiency in doing so is limited.
  - **Bottom Losses**
  - **Material Blockages**
  - **System Inefficiencies**

Basic Function of the Cutter Head

- The cutter head is responsible for the excavation of material as well as creating a water/soil mixture suitable for hydraulic transportation by the suction pipe.
- Once the material has been excavated, it is moved toward the suction pipe by two primary forces:

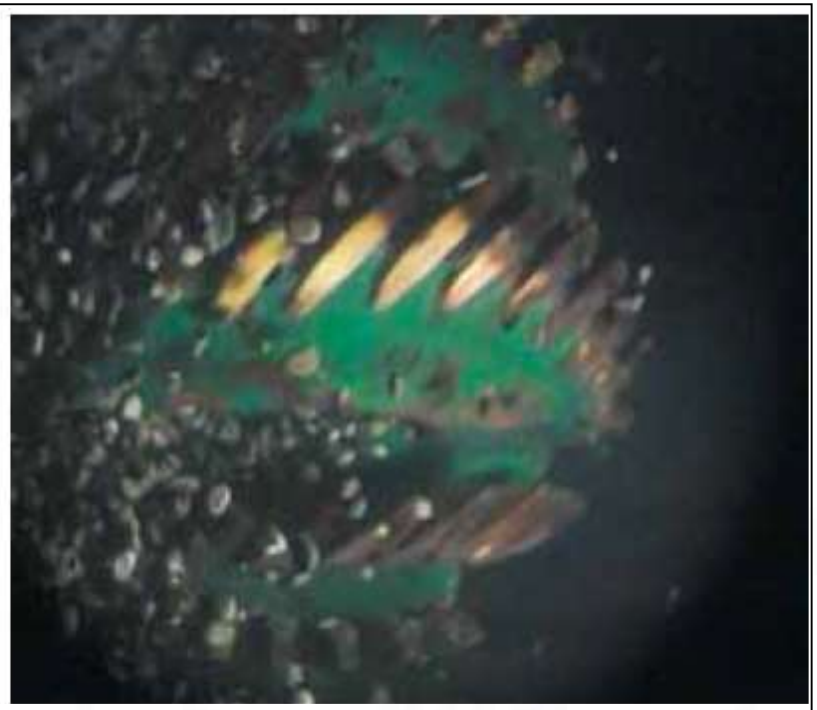
1. The velocity of water being drawn into the suction pipe, and
2. The centrifugal forces and water flows being generated by the turning of the cutter head.

Basic Function of Cutter Head *(Continued)*

- For heavy or larger particles, the intake suction flow may not be sufficient to entrain the particles until they are very close to the suction intake.
- The rotation of the cutter head assists in moving material towards the suction
- At certain rotational speeds, the centrifugal forces and pump effect is greater than the suction intake and material is expelled near the cutter ring.

Effects of Cutter Rotational Speed

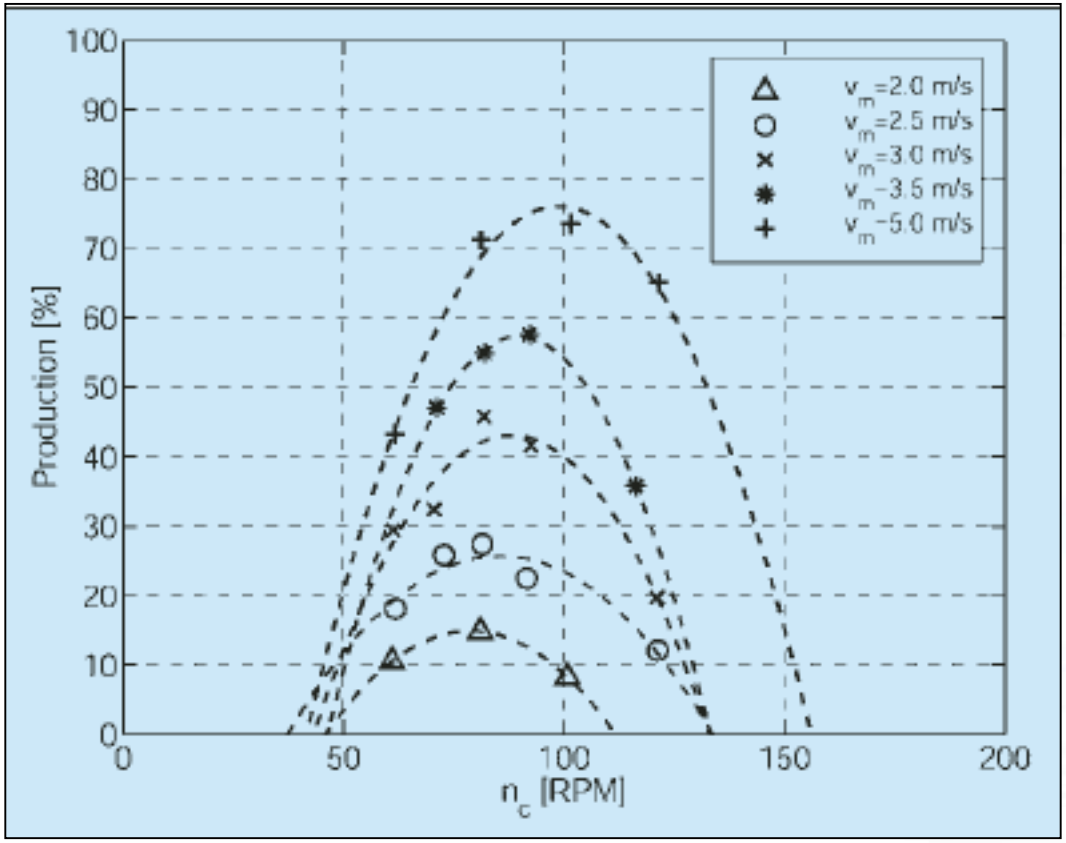
Cutter Head 1 RPM
Note: material not advancing towards the suction



Cutter Head 90 RPM
Note: Particles being thrown out near the cutter ring and before suction intake

Source: Burger M., Design Aspects for Cutter heads related to the mixture forming process when cutting coarse materials., Terra et Aqua Number 98 March 2005

Productivity Limits



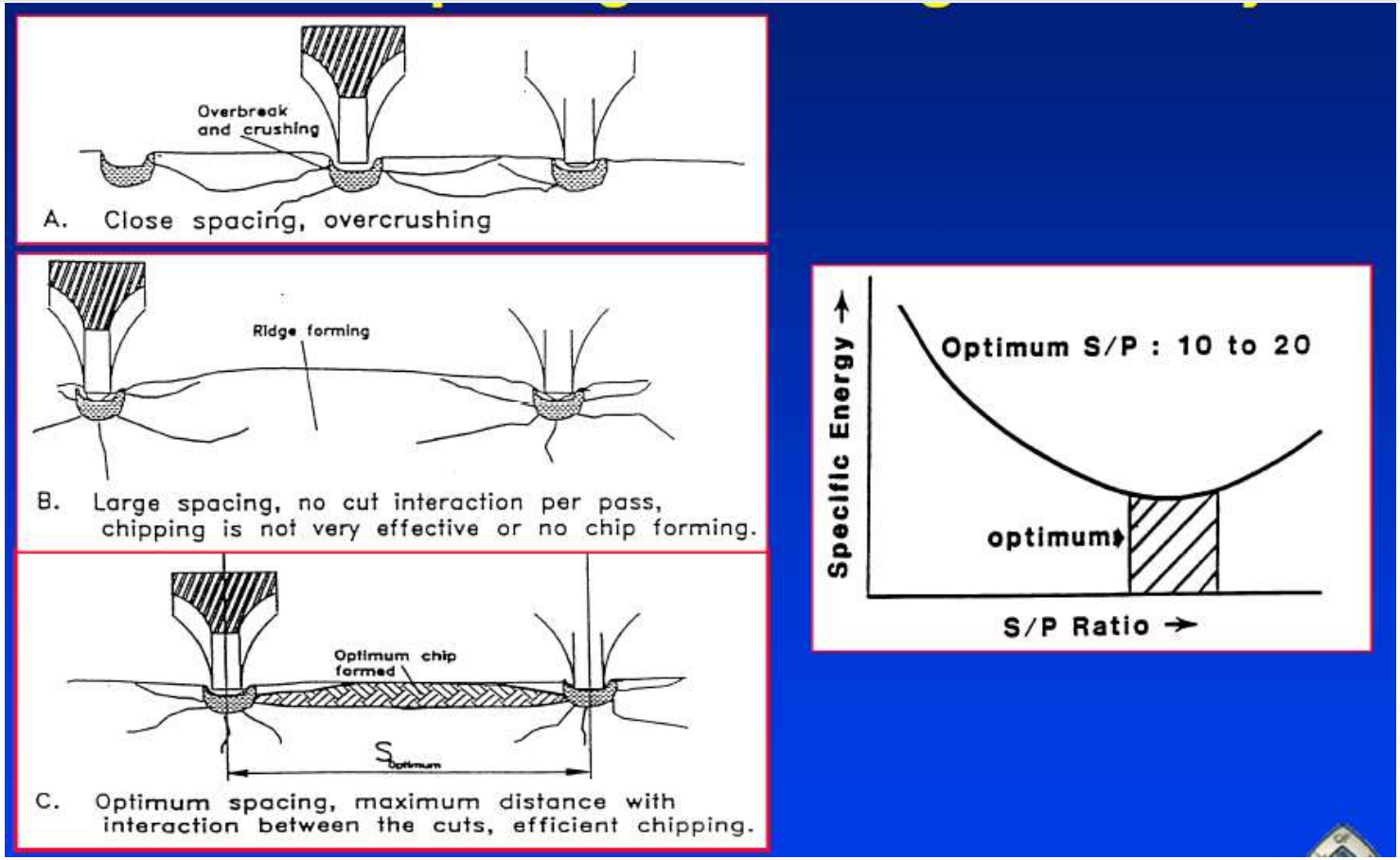
Production versus RPM of cutter head for different mixing suction velocities

Source: Burger M., Design Aspects for Cutter heads related to the mixture forming process when cutting coarse materials., Terra et Aqua Number 98 March 2005

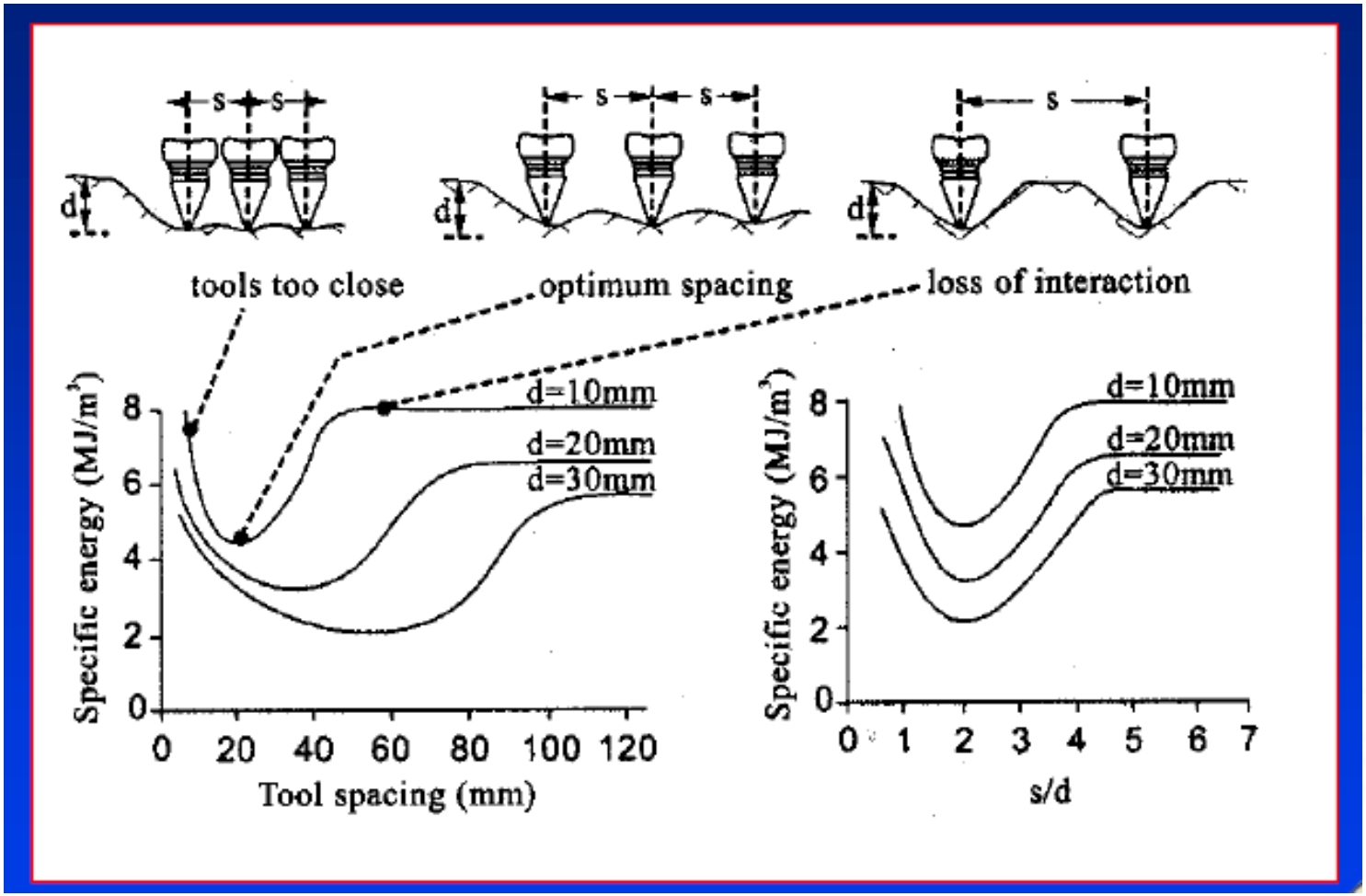
Hard Ground and Rocks

- Current methods employ strategically placed picks to break the material into pieces that can be pumped.
- The need to produce pumpable sized material may limit the depth of penetration and spacing of the picks
- To maintain production the cutter head's rotation may be increased
- Wear rate may require significant downtime to replace picks

Effect of Spacing on Cutting Efficiency



Tool Spacing and Effect on Specific Energy



Potential Improvement

- A system that utilizes a unique combination of cavitating waterjets with a standard rotary cutter dredge.

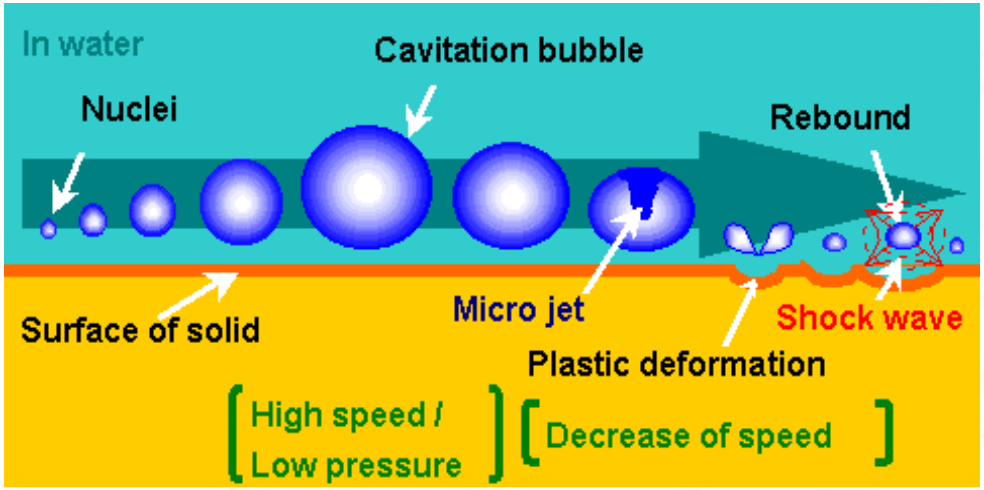
- The waterjet nozzles will not be aimed externally to the cutter head.

It is believed that the introduction of jets will perform three functions.

1. By creating a vortex flow, they will assist in moving material towards the suction intake,
2. Confine the material within the cutter head, thereby minimizing losses, and
3. Provide additional comminution by creating a cavitating zone and by increasing material interaction within the vortex.

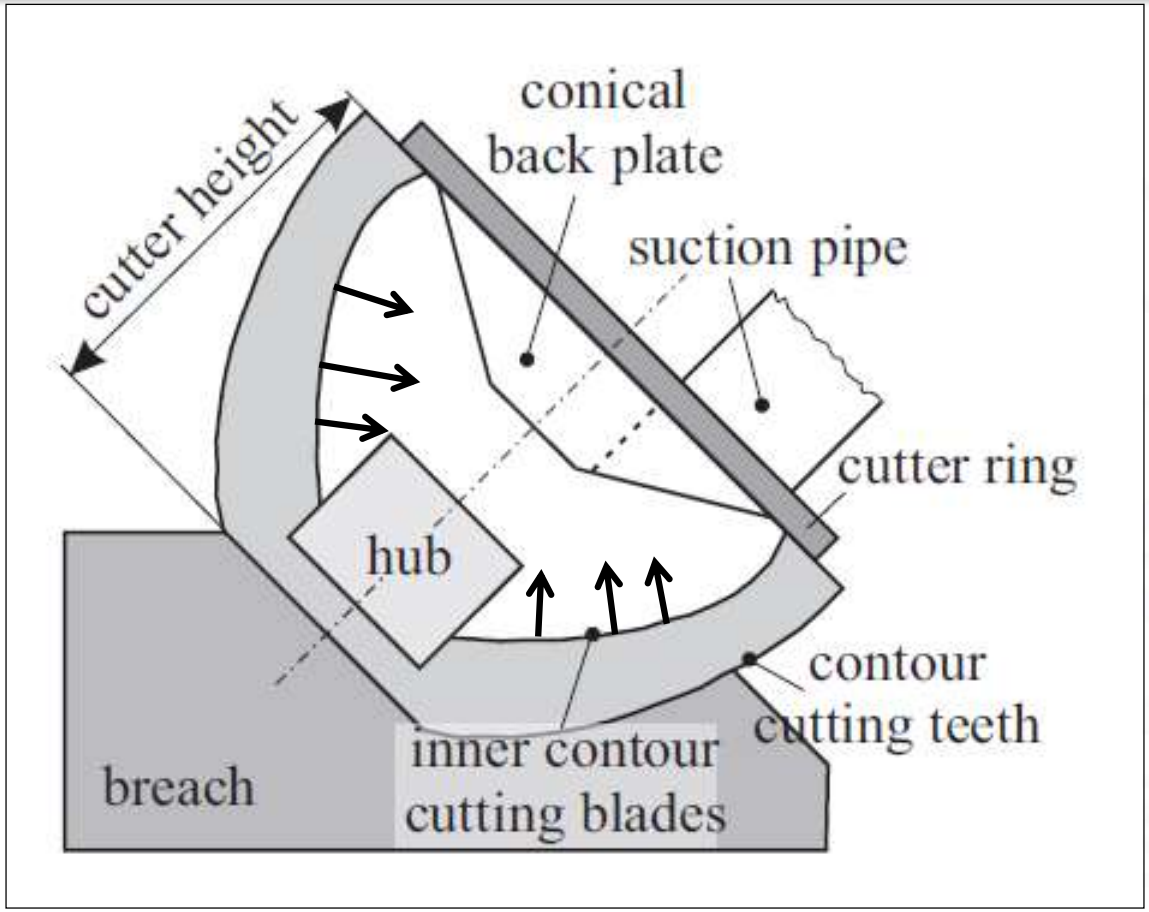
Additional Effect Of High Pressure Jets

- In addition to assisting to containing and moving material towards the suction.



The jets will create a stream of cavitation bubbles which will further reduce the particle size.

Early Conceptual Drawing



Benefits

- Reduces the amount of spillage while dredging and thereby, increasing production and recovery rates as well as reducing sediment suspension and pollution
- Creates an environment where comminution of the larger particles takes place away from the suction intake
  - Lessen the chance for partial blockages
  - Reduce comminution at the surface
  - Pump can be sized to handle smaller material
- Allows the rotation speed/torque of the cutter head to be adjusted to increase excavation productivity
- Allows improvement of pick settings (spacing and cut depths)

3 Phase Project

- Phase 1: Proof of concept.
  - Utilizing cavitating water jet spray bar within existing cutter head
- Phase 2: Custom build cutter head with cavitating jets incorporated into trailing edge of blades
- Phase 3: Incorporate cavitating jets external to cutter head to assist in liberating material.

Primary Objectives of Phase 1

1. Suspend the material such that it can be entrained in the suction intake stream with measurable differences in bottom losses and reduction in suspended sediments
2. Reduce the size of the material entering the dredge suction, resulting in a measurable size reduction in the product discharge
3. Reduction of the cutter head rotational velocity (maintaining a constant pumping velocity) while maintaining or increasing production

Phase 1

- Will be conducted at the Colorado School of Mines (CSM) and Texas A&M Haynes Laboratory
- Design and prototype testing CSM
- Trials will be run in Texas
- Compilation of results will be done at CSM
- Each University currently has a unique set of facilities to conduct the research

Excavation Engineering and Earth Mechanics Institute at CSM

- The Excavation Engineering and Earth Mechanics Institute (EMI) was established at Colorado School of Mines in 1974. Water Jet cutting facilities established 1972

- EMI has developed a suite of physical property tests, cutter and cutter head evaluation procedures for performance prediction, project costing, and design of mechanical rock excavation tools for all types of mechanical excavators.

- Areas of basic and applied research at the Institute include:

Excavation Engineering and Earth Mechanics Institute at CSM

Water Jet Drilling and Jet Assisted Cutting	Cutter and Bit Development
Continuous Miners	Road headers (axial and transverse types)
Geotechnical Investigations for Tunneling and Mining	Soft Ground Tunnel Boring Machines (EPB and Slurry)
Computer Modeling for Performance Estimation and Optimization of Mechanical Excavators	Project Scheduling and Costing for Tunneling Excavation Projects
Rock Mechanics, Ground Control and Mine-Design	Field Instrumentation of Mechanical Excavators and Drilling Systems

Long wall Drum Shearers	Mechanical Surface Miners	Mechanical Trenchers
Disc Cutter Bearing Evaluations	Micro tunneling	Mine Monitoring and Automation
Oil, Gas and Water Well Drilling	Raise and Shaft boring	Hard Rock Tunnel Boring Machine

Some CSM Test Equipment

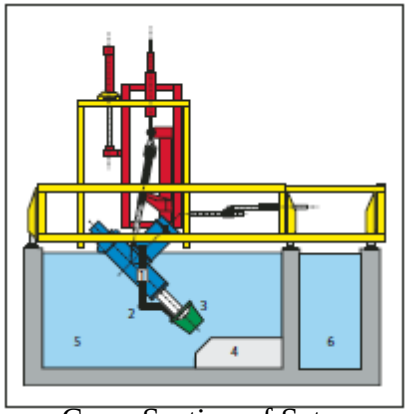
Rotary Cutting Machine (RTC)

A six-foot diameter, computer-controlled rotary cutting machine with removable cutters and cutter head performs tunnel, raise and shaft boring investigations for performance and wear evaluations Water jets may also be incorporated into the system to perform jet-assisted mechanical cutting tests.

High Pressure Water Jets and Pumps

Water jet equipment is available for high-speed drilling and slotting in rocks. These water-jet test stands are set up to provide a wide range of pressures and flow rates.

Texas A&M Haynes Laboratory



Cross Section of Setup

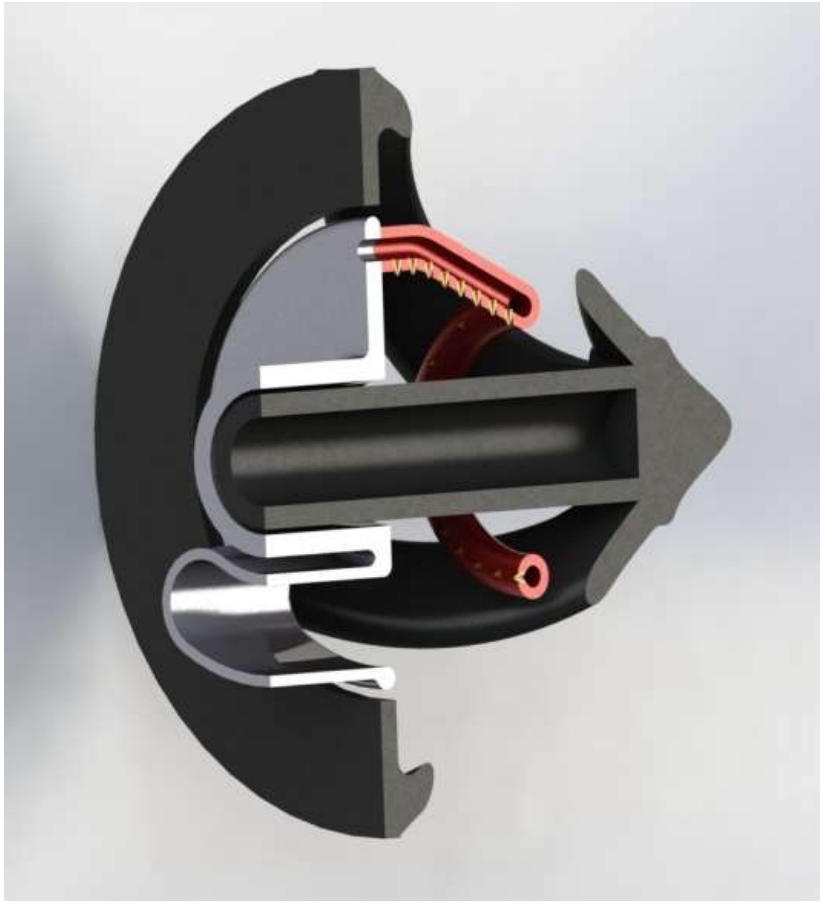
Dredge Tank and Carriage

Rotary Cutter Head Setup in Tank

Texas A&M Haynes Laboratory Cutter Head Showing Back Ring With Approximate Access Locations for Water Jets

Conceptual Phase 1 Design

Conceptual Design Placement of Jets



The End