
Design of Extruder Bore Inspection Rover

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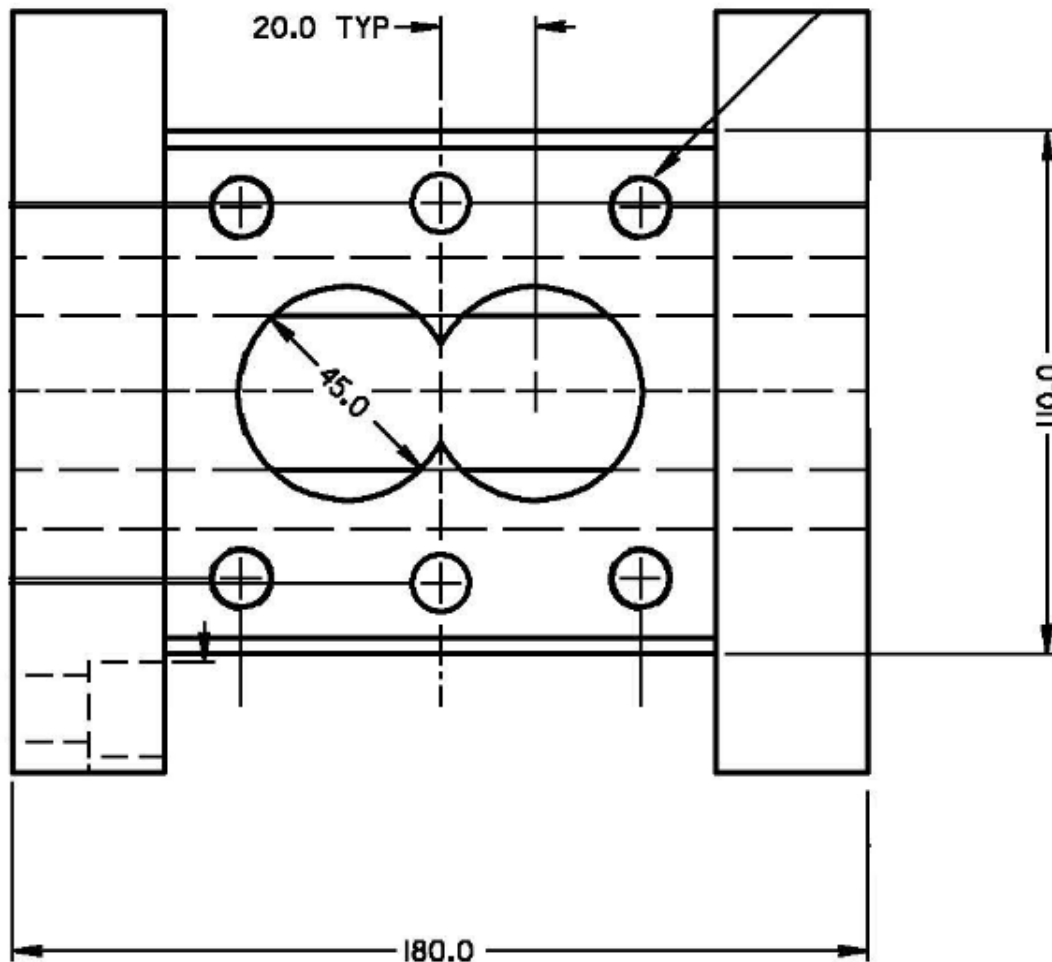
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- Customer: Eastman Chemical Company
- Need: Ability to analyze deep blind extruder bores
- Problem: Existing technology is too wide to fit into bores and travel the full depth
- Importance: Bores must be analyzed for consistency:
 - Runout
 - Circularity
 - Diameter

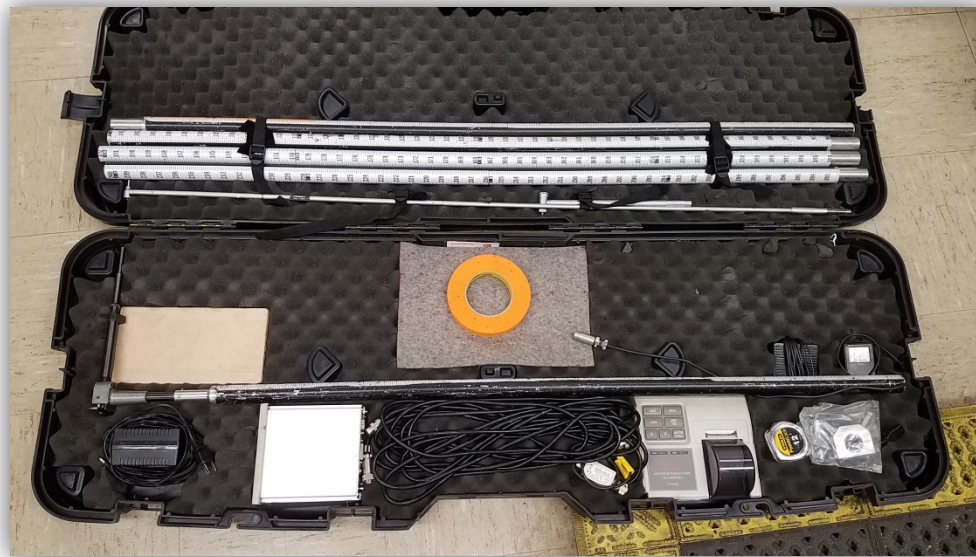
Extruder Bore Example

3/16
2017.11.28



Diameter	Depth
1-9/16"	38"
1-7/8"	52"
3-5/8"	129"

- Manual Bore Gauge
- FARO Ion Laser Tracker



- Manual Bore Gauge
- FARO Ion Laser Tracker



FARO Laser Tracker Balls

Diameter	Mass
.500"	5.9 grams
.875"	28.9 grams
1.500"	144.9 grams



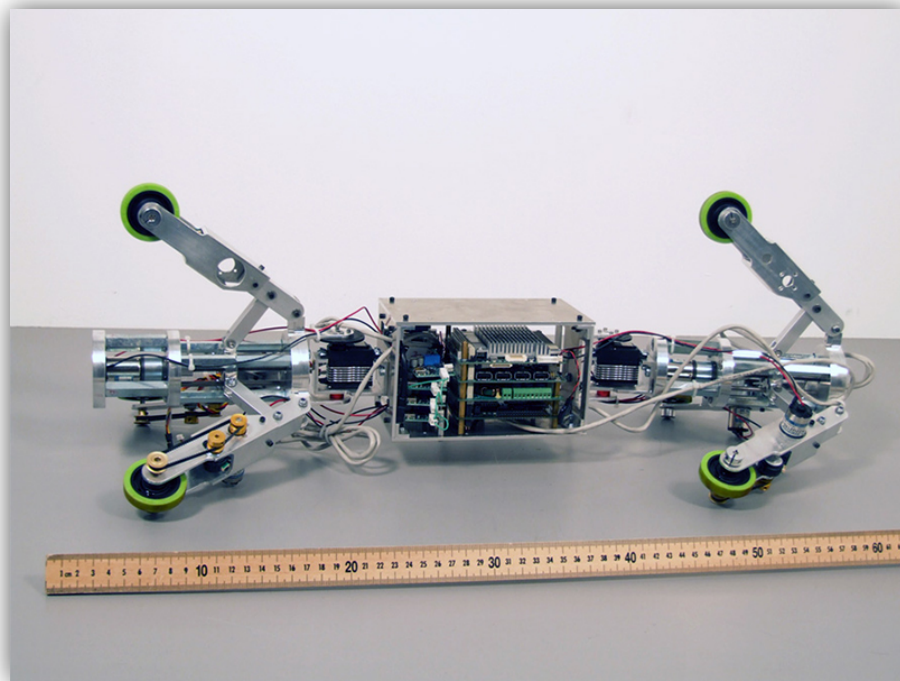
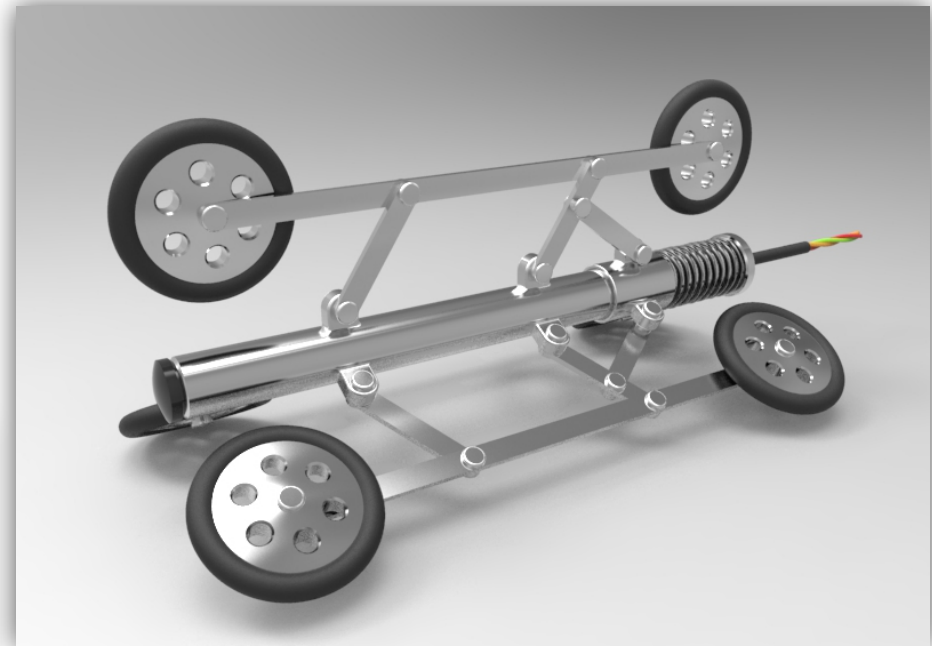
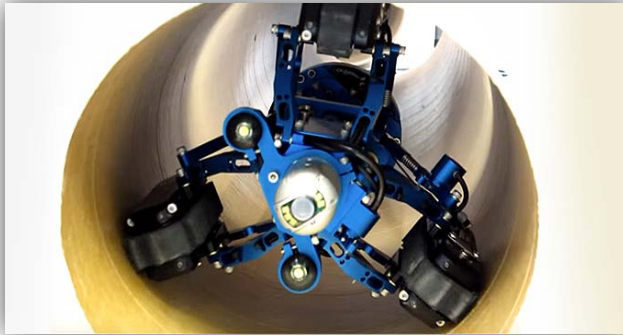
Current Process Matrix

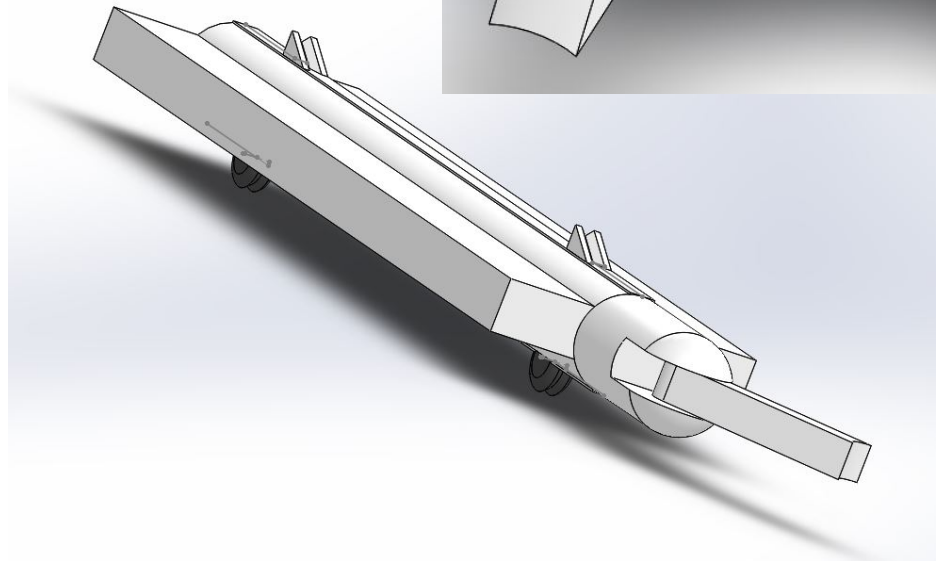
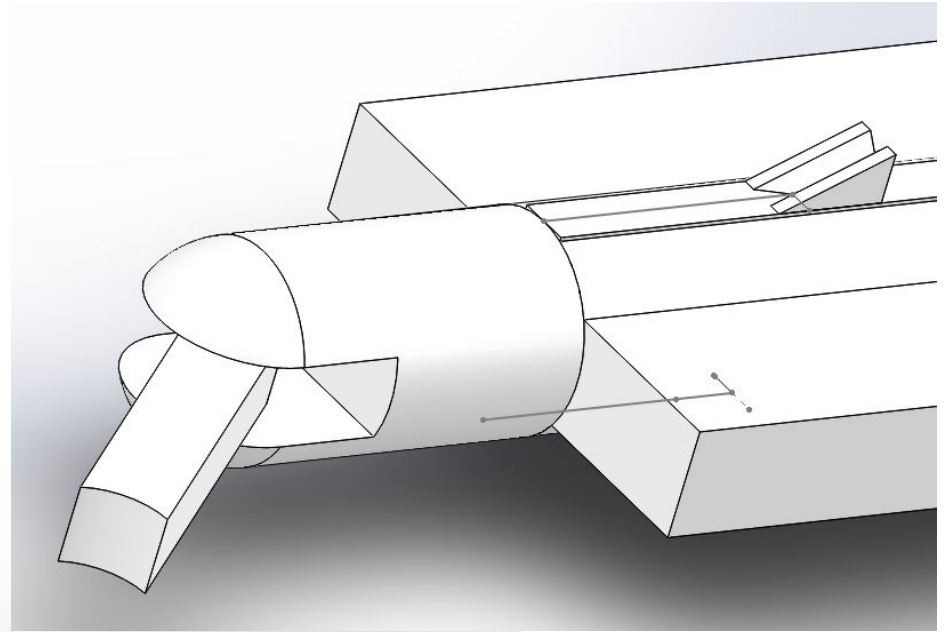
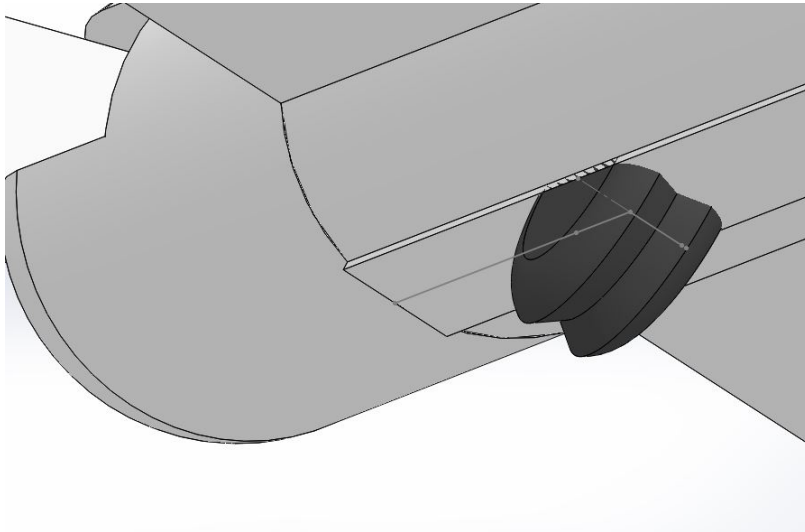
Dia/Leng.	.7-1.4"	1.4-2.4"	2.4-6"	6-12.4"	12.4-24"
0-6"	Manual--S Tip	Manual--M Tip	Manual--LG Tip	Faro	Faro
6-12"	Manual--S Tip	Manual--M Tip	Manual--LG Tip	Faro w/ Magnet	Faro
12-18"	Manual--S Tip	Manual--M Tip	Manual--LG Tip	Faro w/ Magnet	Faro
18-36"	Manual--S Tip	Manual--M Tip	Manual--LG Tip	Faro w/ Magnet	Faro
36-60"	Manual--S Tip	Manual--M Tip	Manual--LG Tip	Manual--LG Tip	Faro w/ Magnet
60-96"	Manual--S Tip	Manual--M Tip	Manual--LG Tip	Manual--LG Tip	?
96-144"	Manual--S Tip	Manual--M Tip	Manual--LG Tip	Manual--LG Tip	?
144-200"	Manual--S Tip	Manual--M Tip	Manual--LG Tip	Manual--LG Tip	?

- Accuracy is often lost because manual bore gauge is difficult to control at a depth of several feet
- Manual gauge requires quite a few interconnected pieces:
 - Gauge, Extensions, Display box, Printer, Foot Pedal, AC Power
- Gauge probe catches in bore crevices
- Measurements must be written and uploaded manually

- Eliminate manual readings
- Reduce analysis time
- Reduce number/weight of equipment necessary to travel with
- Create simple, repeatable, accurate process
- Possible Opportunities:
 - Manual measuring device that travels in/out of bore
 - Capable of calculating how far it has traveled into the bore
 - Outputs measurements electronically
 - Rover that carries FARO ball and simply positions it for ION Tracker
 - ION knows how far the rover has traveled
 - ION can electronically manage readings

- Develop a bore crawler
 - Will orient FARO ball against bore walls for measurement capture
 - Can capture multiple measurements at a depth
 - Remote controlled travel & ball placement
 - Two-way travel capability
 - FARO tracks depth
 - Allows for runout calculation





- Power: 5v Lithium Ion Battery
- IO Module: Arduino Micro board
- Control: 315 Mhz 4-Button Remote
- Travel: 5v Micro DC Multi-RPM Worm Gear Motor
- Positioning: 5v Micro DC Stepper Motor

Deliverable Metrics:

- Usage
 - Three extruder bores are measured twice annually.
 - 10-12 more are checked as-needed (~ every other year)
- Time Savings
- ~ 1 hour per reading
- Hidden Savings
 - Improved Accuracy
 - Less supplies to travel with
 - Extension to other applications
 - Reduction in process downtime

- <http://basicrobot.blogspot.com/2009/03/pipe-inspection-robot-4.html>
- <https://www.rec.ri.cmu.edu/solutions/energy/pipe-vision-system.html>
- <https://grabcad.com/library/request-cad-model-of-pipeline-inspection-robot-crawler-1>
- <http://russelsmithgroup.com/innovation-lives-here/robotic-crawlers-the-smart-approach-to-pipeline-integrity-management/>
- <https://www.faro.com/en-gb/case-studies/tighter-tolerances-for-tunnel-longevity/>

Questions ?