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SCIENCE ENGINEERING DESIGN

Biomass – Material Handling Considerations

Overview of the Efforts in Feedstock & Materials Handling - Key Technical and Economic Challenges Identified for Different Processes Biorefinery Optimization Workshop October 2016 DOE

Carrie Hartford, P.E.
Senior Project Engineer
chartford@jenike.com

BIOMASS "FLOWABILITY"

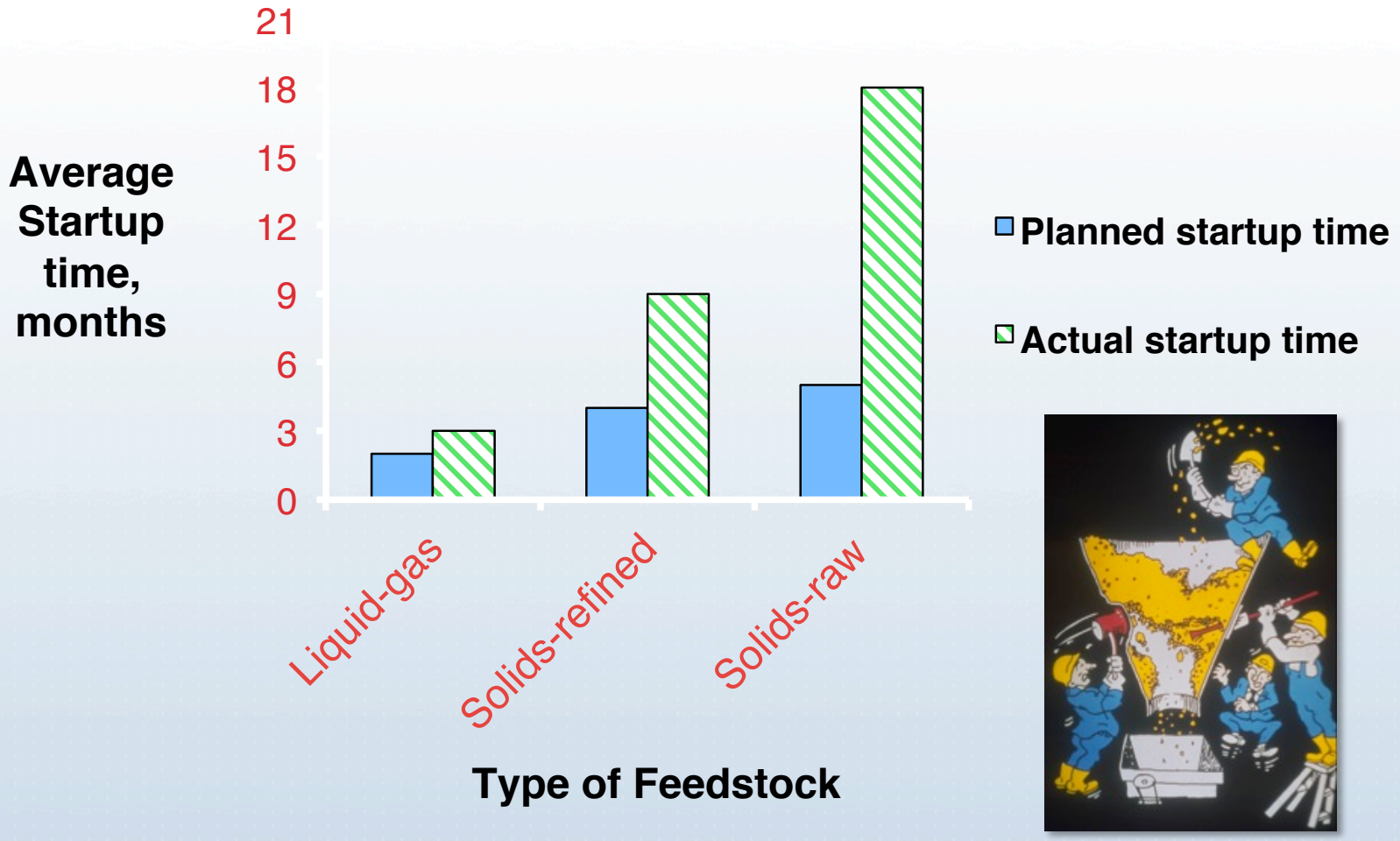
Biomass types can vary significantly!

- Particle size, shape, and moisture variation
- Differences affect material flowability

Flowability is a function of the material AND the equipment

  - "Poor flowing" material can be handled easily in properly designed equipment
  - "Easy flowing" material can present flow problems in poorly designed equipment

EXTENT OF HANDLING PROBLEMS



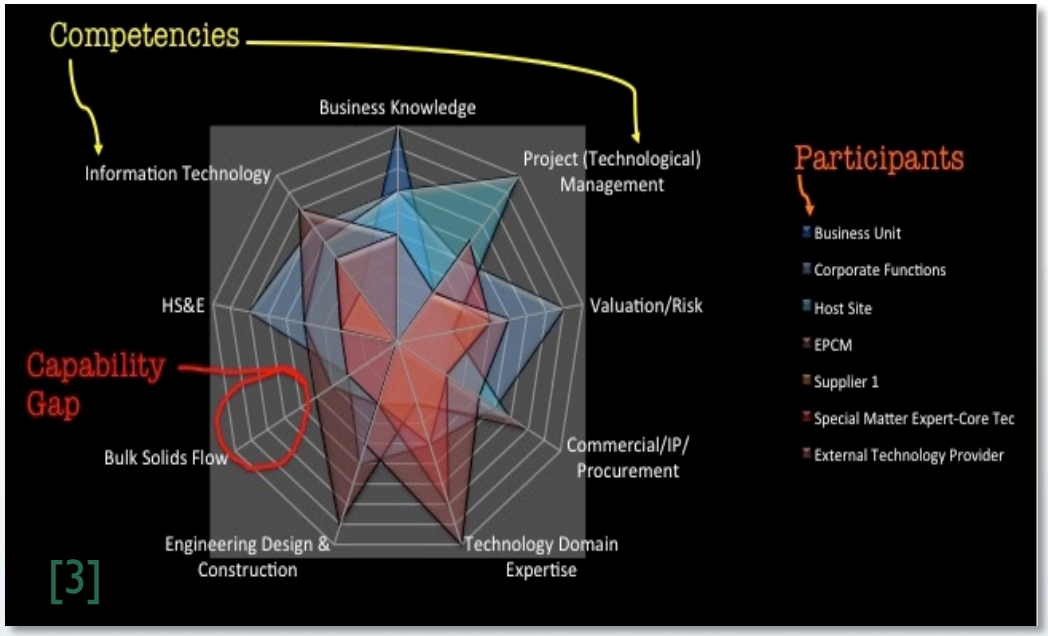
[1] Rand Study: Sample of **40 plants** in US and Canada over a **6 year** duration. Merrow, E., "*Problems and progress in particle processing*", Chemical Innovation, Jan. 2000 & Chemical Engineering; Oct. 1988, Vol. 95, Issue 15

RAND STUDY CONCLUSIONS

- 80% experienced solids handling problems
- Average startup time 18 months
  - vs. 3 months for liquids
  - Average cost per month delay ≈ $350,000[1]
- Typical performance 40 to 50% of design
- Problems related to "physics and mechanics of processes rather than to chemistry"

[1] $350,000 in "1988 dollars"; today's value ≈ $1,000,000

CAPABILITY MAP

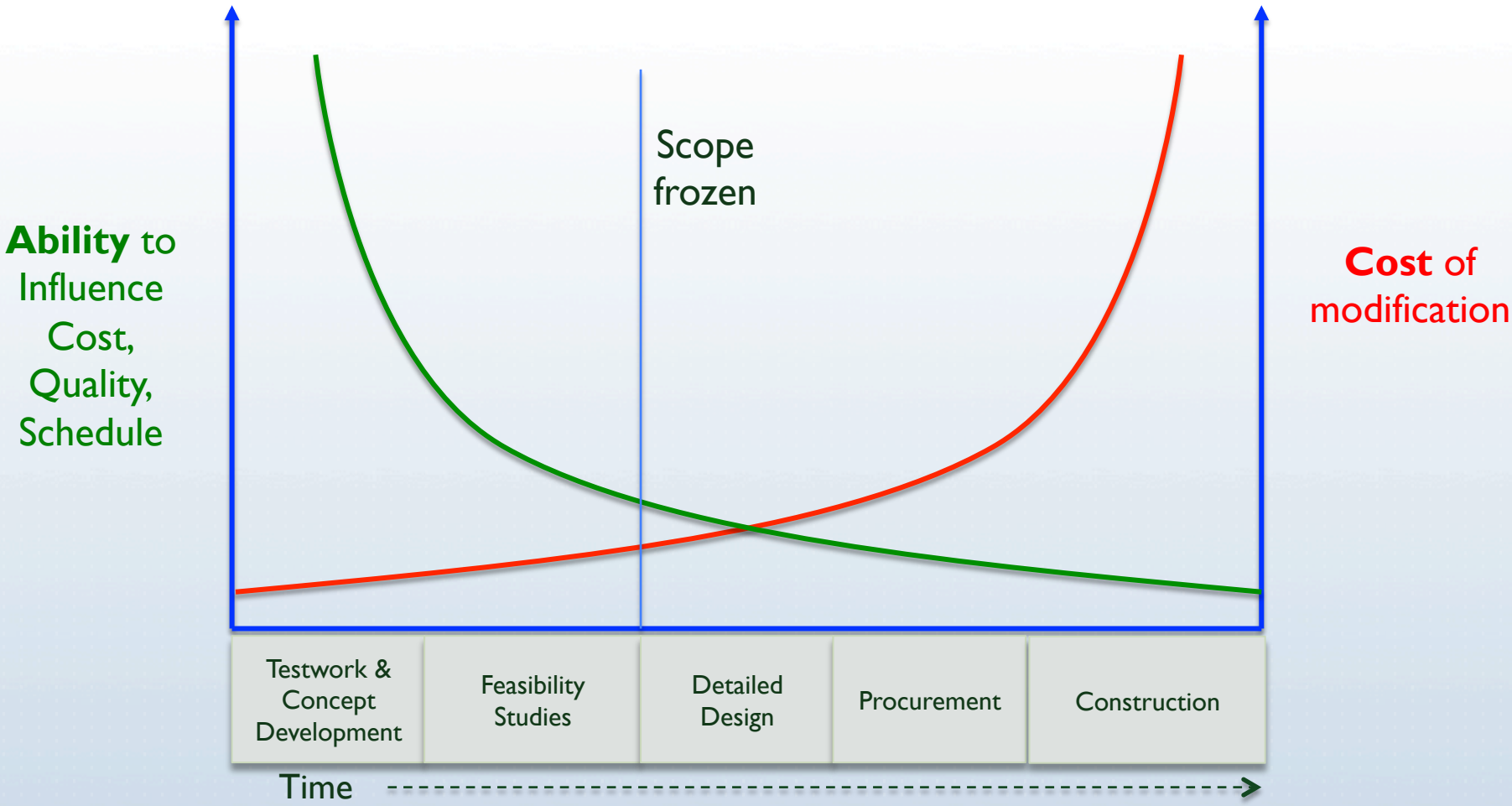


Key reasons that specific technology development programs fail are[2]:

- Lack of strategic alignment with business → lack of adequate support and resources
- Lack of a disciplined phasing during development → projects progress that should not
- Lack of a corporate champion to maintain momentum over the years
- Not bringing the best possible minds and experience to the program

[2]Twigge-Molecey, C. "Knowledge, Technology and Profit" 2003 - Cobre 2003; Fifth International Conference; Santiago; Chile; 30 Nov.-3 Dec. 2003. pp. 41-57. 2004
[3] Wellwood, Grant. "Fail to plan?; Plan to fail!-The case for Capability Mapping", LinkedIn Post March 2016.

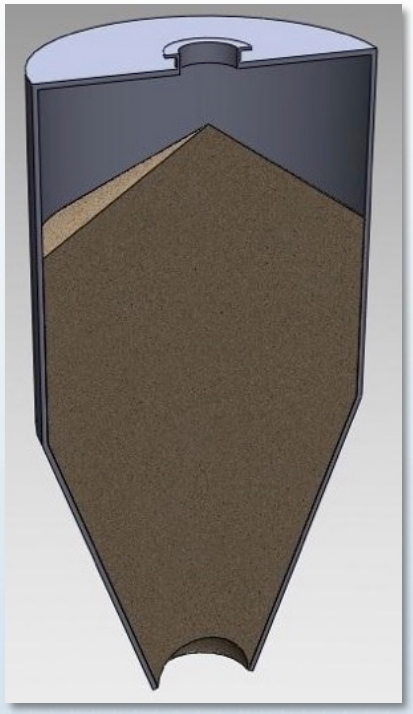
COST OF MODIFICATION



Kennedy, M., Harris, C., MacRaw, A., (2013); Risk-weighted cash flow: a communication tool for engineers and financial professionals on new technology projects, *CIM Journal, Vol. 3, No. 4,* 2012.

GRAVITY FLOW SYSTEMS

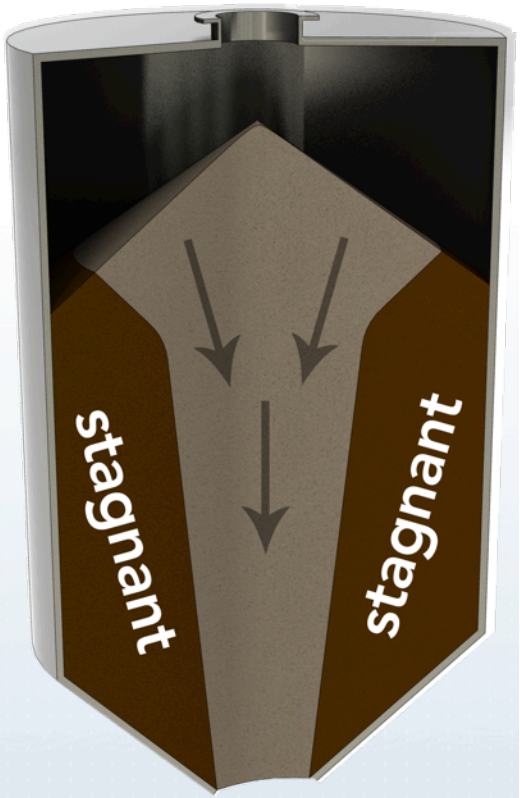
FLOW PROBLEMS – NO FLOW/ERRACTIC FLOW



Arching

Ratholing

FUNNEL FLOW



Issues

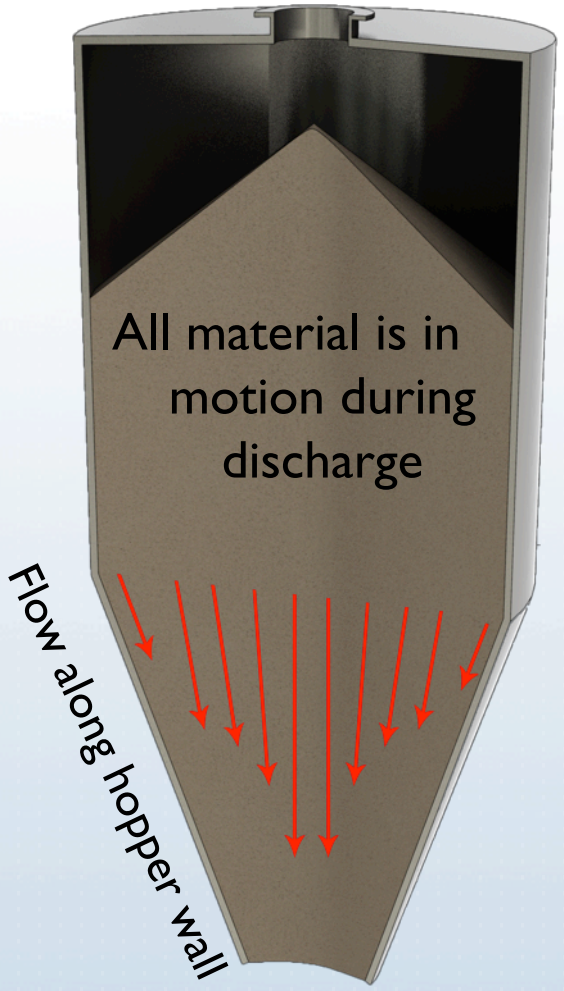
- Some material is stagnant
  - Biomass may oxidize, ferment/have runaway bioactive reactions, smolder, ignite
- Arching, ratholing, and erratic flow can occur
- Limited live capacity
- Varying bulk density

Features

- Low headroom
- First-in, last-out
- Ratholes may develop
- Fine powders will flood

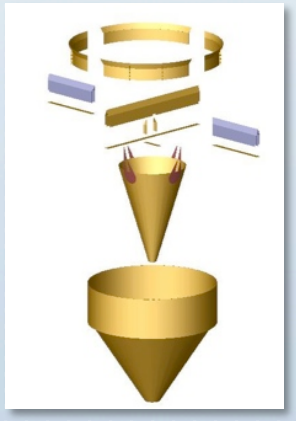
MASS FLOW

- Allows for uniform velocity of the material
- Can design for even distribution of air injected into the moving bed of material
- Constant bulk density at the outlet
- Reliable flow

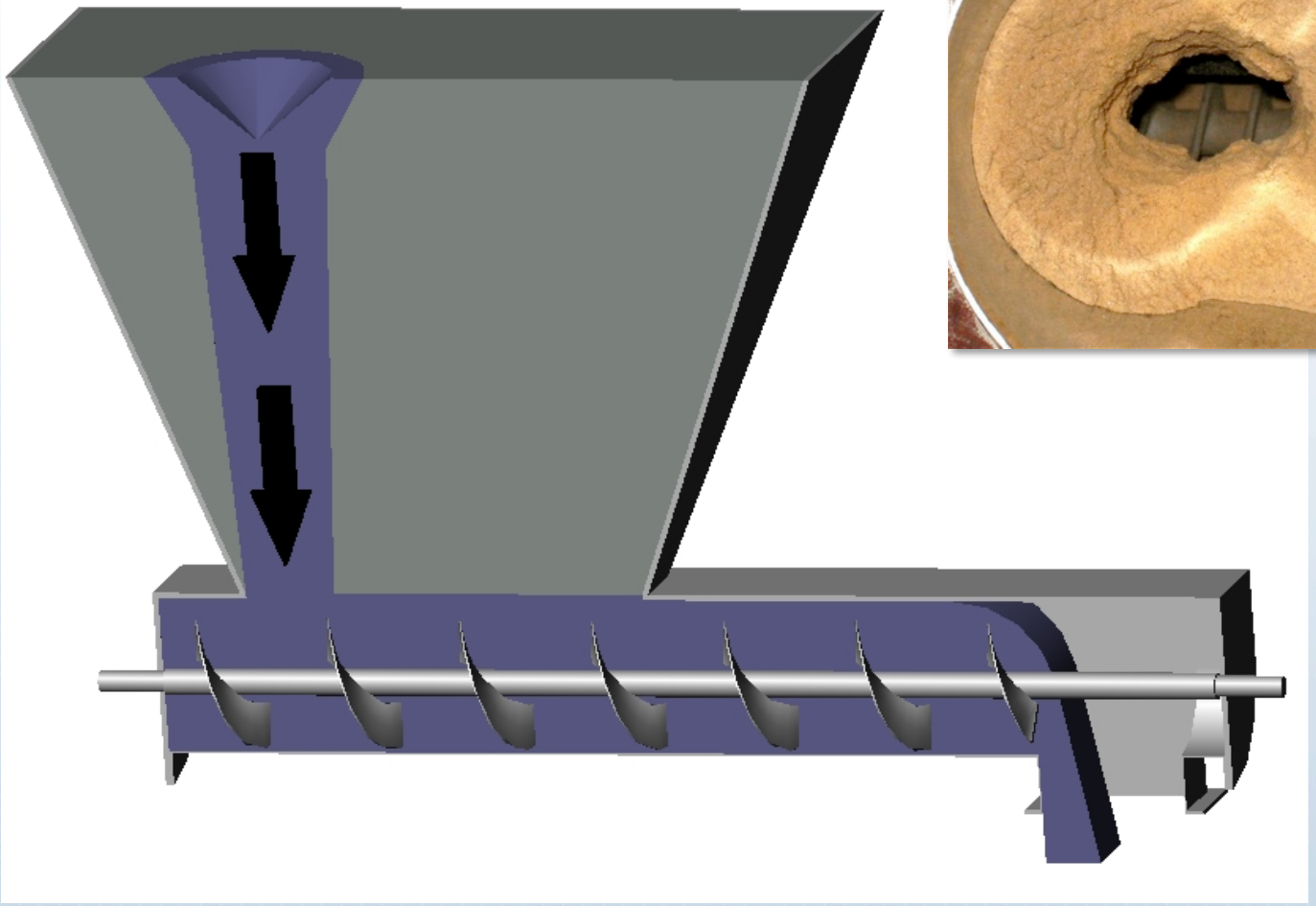


TEST & DESIGN

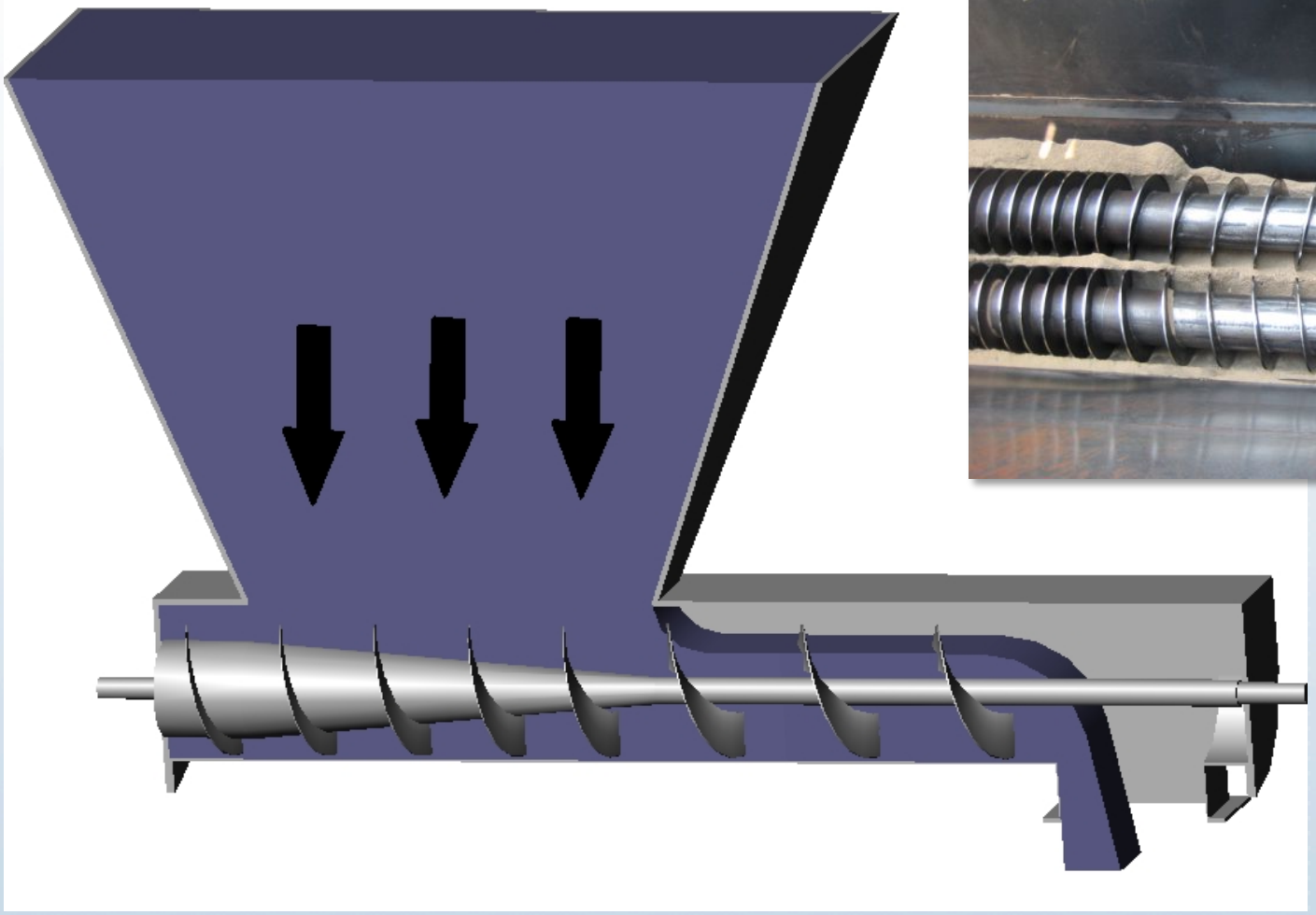
- Test to measure relevant properties
- Set design spec window of acceptable material
- Determine appropriate flow pattern
- Use proven design methodology
- Consider different approaches if gravity flow is not possible
- Consider processing and storing in one bin design (purge vessel)



CONSTANT PITCH SCREW FEEDER



MASS FLOW SCREW FEEDER



Be aware of insufficient torque!

CONCLUSION

- Set aside sufficient money and time to measure the flow characteristics.
  - If material changes mid project – test again!
- Establish an acceptance criteria for incoming material
- Reliable handling silos can also act as a processing vessel
- Don't forget the feeder design!
- Get a bulk materials expert involved early on

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Carrie Hartford, P.E.
Senior Project Engineer
+1 805 541 0901
chartford@jenike.com