PCP GEOMETRY IN HIGH-SOLIDS APPLICATIONS

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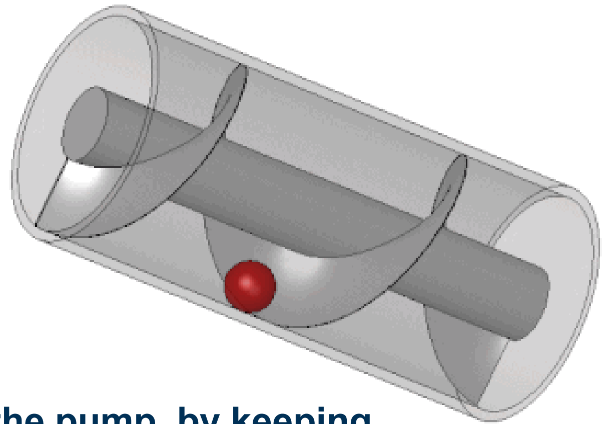
❯ OUTLINE

- What is the problem with solids and how does the pump geometry affect it?
- How is pump geometry quantified?
- Traditional wisdom
- Pros/cons of the traditional solution
- Alternative hypothesis
- Other solutions for solids problems
- Conclusions

› SOLIDS IN A PUMP



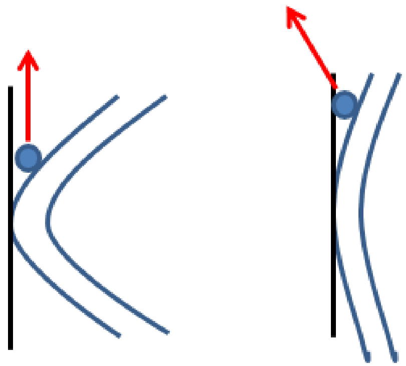
- **Solids can plug:**

  The pump intake

  The pump discharge

  The inside of the pump

- **An appropriate helix angle can help reduce plugging inside the pump, by keeping solids moving through the pump**
- **The rotor may be able to act as an auger (or screw conveyor) to move solids, if it is appropriately designed**
- **In general, a shallower angle on the helix should more effectively move solids up the pump**
- **We will look at the pump intake and discharge later in this presentation**



› PUMP GEOMETRY

- **The helix angle (sometimes called rotor angle or swept rotor angle) can be measured in different ways.**
- **All these measures reflect the pitch length – shorter pitch length means shallower angle**

Angle of the helix at the major diameter of the rotor

$$\theta_r = \operatorname{atan}\left(\frac{\left(\frac{p}{2}\right)}{\pi(D+2e)}\right)$$

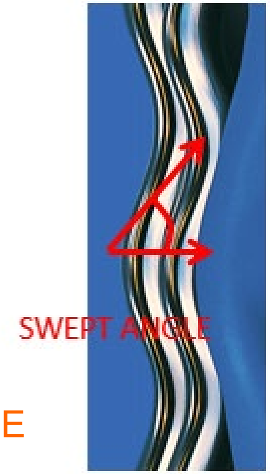
Angle of the helix at the outside edge of the stator

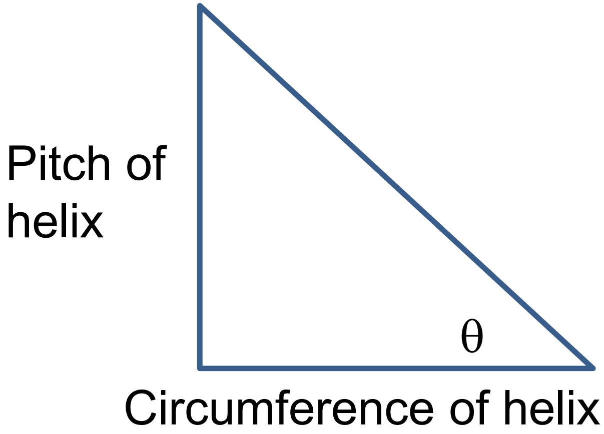
$$\theta_s = \operatorname{atan}\left(\frac{p}{\pi(D+4e)}\right)$$

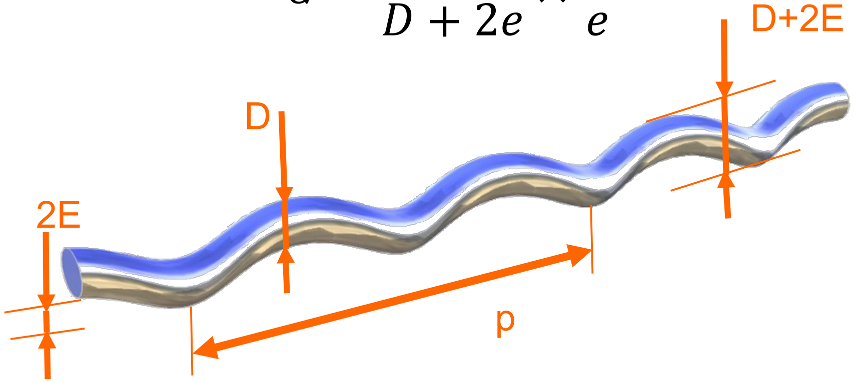
"Geometry Index"

$$G = \frac{\frac{p}{2}}{D+2e} \times \frac{D}{e}$$

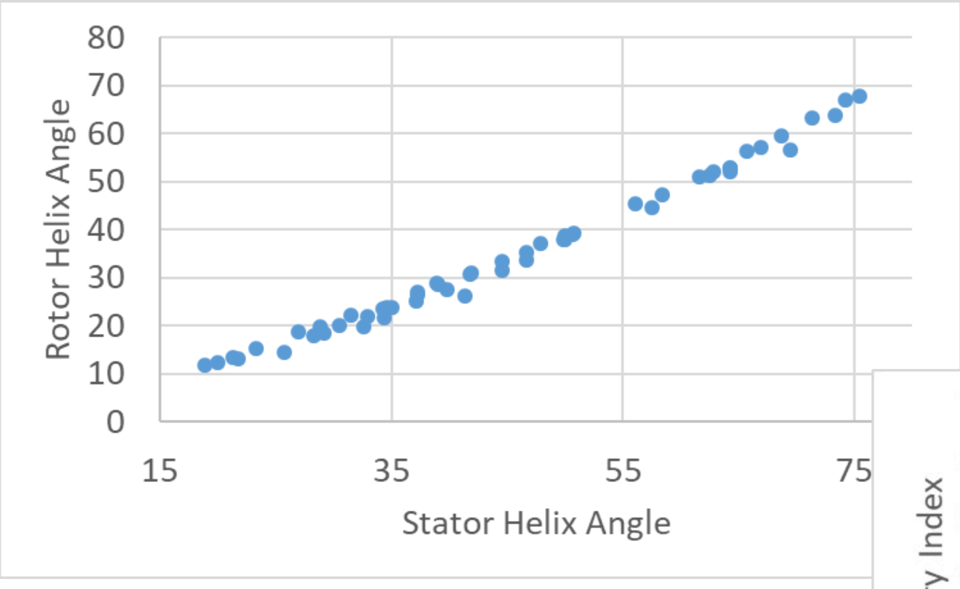
(p is stator pitch, D is minor diameter, e is eccentricity)



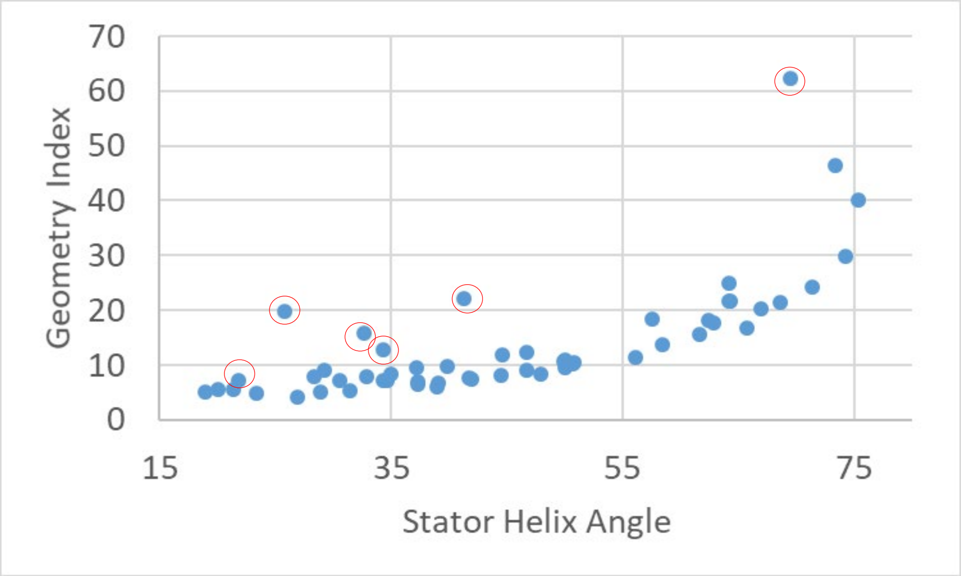




› COMPARISON



Rotor and stator angles are different, but they give the same basic information



Circled data points have D/e > 9

Geometry index gives similar information to helix angle, except when D/e ratio is high

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› COMPARISON

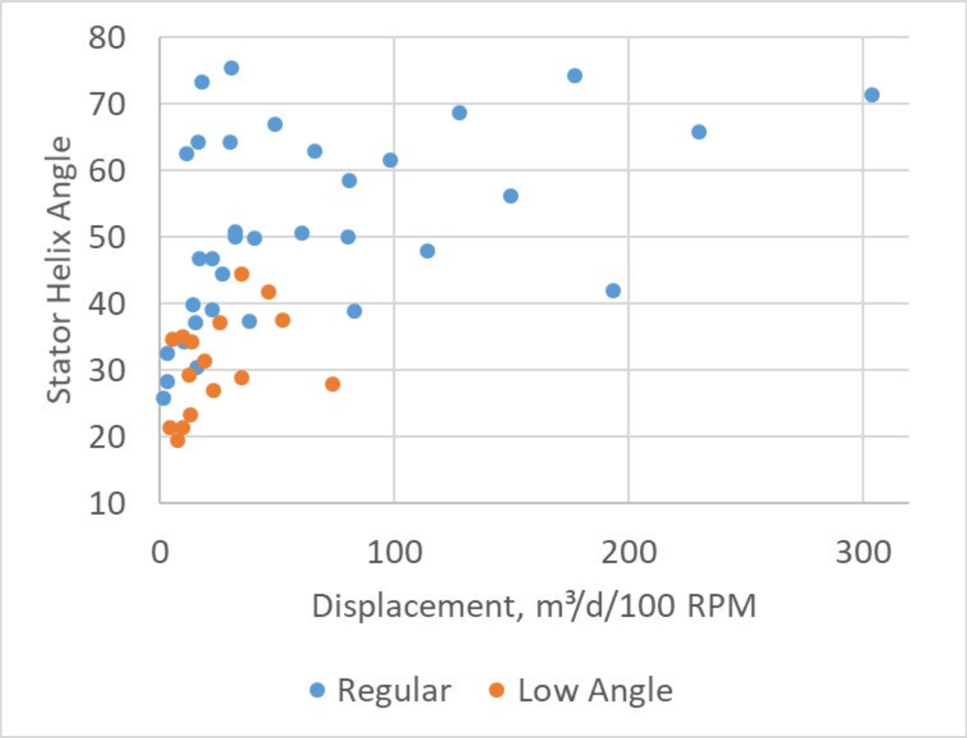
- **Two pumps with similar displacement can have very different rotor profiles and helix angles**

45E, θ_s=42°

48E, θ_s=67°

› TRADITIONAL WISDOM

- **Smaller helix angle (or geometry index) is better for solids**
- **Many manufacturers have pumps designed for solids or heavy oil, which are designed with short pitch lengths (lower helix angle, lower geometry index)**
- **At PCM, we call these “Heavy Lift” pumps. Some people call them “Fat Boy” pumps.**
- **There is not a specific “cut off” angle that we use to distinguish short vs long pitch pumps—it depends on displacement**
- **There are many years of successful field experience with these short pitch pumps in applications like CHOPS**



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› PROS AND CONS

- **Short pitch (low angle) pumps have these advantages:**

  The rotor can move solids effectively through the pump

  The internal velocities inside the pump are lower (good for high viscosity fluids)

  Shorter pitch means the pump can be shorter for a given pressure rating

- **And these disadvantages:**

  For a given displacement, the OD of the pump is usually larger

  The pressure rating per pitch length may be a bit less

  The seal lines are shorter, and may be more susceptible to damage

  There can be greater stress in the elastomer

  Friction torque may be higher (for the same displacement and pressure)

  The pump's performance may be more sensitive to changes in pump fit

› ALTERNATIVE HYPOTHESIS

- What if it's not the rotor that moves the solids, but the fluid flow?
- Low angle pumps are good for high viscosity fluids (due to low internal velocity), and high viscosity fluid carries solids very well, even at low velocity. Therefore low angle pumps are probably still better in viscous fluids.
- But if it's the fluid that carries the solids, and the viscosity is low, a high fluid velocity would be better.
- There is little or no field experience to support this theory
- If the velocity in the tubing is high enough to carry solids to surface, the velocity in the pump (even a low angle pump) is almost always higher (usually much higher), so the fluid should also carry solids through the pump

FLUID VELOCITY IN TUBING AND IN PUMP

- **2-3/8” tubing, 7/8” rods, 50 m^3/d → 0.355 m/s**
- **2-7/8” tubing, 7/8” rods, 50 m^3/d → 0.220 m/s**
- **3-1/2” tubing, 7/8” rods, 50 m^3/d → 0.140 m/s**
- **3-1/2” tubing, 1” rods, 50 m^3/d → 0.144 m/s**

- **PCM 22E, 50 m^3/d → 1.06 m/s**
- **PCM 24E, 50 m^3/d → 0.93 m/s**
- **PCM 48E, 50 m^3/d → 0.81 m/s**

- **Fluid velocity in the pump is 2.3-7.4 times the velocity in the tubing (for the above cases) → if the solids can be carried in the tubing by the fluid, they will also be carried in the pump by the fluid.**

› PUMP COMPARISON

- **Example: If we want a pump with a displacement in the 30-40 m³/d/100 rpm displacement range, there are several options available such as:**

  32E: OD=96 mm, 3-1/2” pin, runs in 2-7/8” tubing, helix angle 44.9°, internal velocity 1.56 m/s (at 100 m³/d)

  33E: OD=94 mm, 3-1/2” pin, runs in 2-3/8 tubing, helix angle 50.0°, internal velocity 1.64 m/s (at 100 m³/d)

  35E: OD=70 mm, 2-3/8” pin, runs in 2-3/8” tubing (no orbit tube / pup joint), helix angle 74.1°, internal velocity 2.81 m/s (at 100 m³/d)

  38E: OD=109 mm, 4”NU pin, runs in 2-7/8” tubing, helix angle 37.3°, internal velocity 1.32 m/s (at 100 m³/d)

- **Helix angle is not the only thing to consider. We also need to look at:**

  Pump OD: are there casing size limitations?

  Minimum tubing size: smaller tubing allows for higher velocities to help transport solids

  Pup joint (Orbit tube): larger joint here is needed to accommodate rotor head movement—but it will have lower internal velocity, and may have solids accumulating in it

  Helix angle : Pumps with larger OD tend to have lower angle (for similar displacement)

  Pump internal velocity: pumps with larger displacement have lower internal velocity

- **What is balance between tubing size and helix angle?**

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› OTHER SOLUTIONS

- **Problems with solids at the pump intake:**

  Paddle rotors can be very effective at breaking up slugs of solids and/or fluidizing solids that are settling near the intake

  Charge pumps or reverse helix pumps keep a large volume of fluid moving in the annulus near the pump intake, to keep solids fluidized

  Deeper sumps can be helpful, but they eventually fill up

  Landing pump higher in the well can also reduce solids problems, but may introduce problems with gas in the pump

- **Problems with solids at the discharge:**

  Smaller tubing increases the fluid velocity in the tubing (to better carry solids), and reduces the volume of solids available to settle on the pump during a shutdown

  Automatic tubing drains (ATD or ADV) allow the tubing fluid to drain to the annulus during a shutdown so that solids cannot settle on top of the pump

› CONCLUSIONS

- It is generally accepted that low angle PC pumps are better for pumping solids
- There are different ways to measure this angle—it doesn't really matter which one is used, but is important to ensure the same measurement is used when comparing pumps
- We do not propose a "cut-off" value for what defines a low angle pump. However, the angle is very useful in comparing pumps with similar displacements
- The use of other technologies (such as paddle rotors, charge pumps, ATDs) can complement the use of low angle pumps in high-solids applications
- For maximum run-life there are other things to consider as well such as elastomer selection, rotor/stator fit, and pump displacement vs speed

THANK YOU

QUESTIONS?