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Characterisation of proppants for use in hydraulic fracturing

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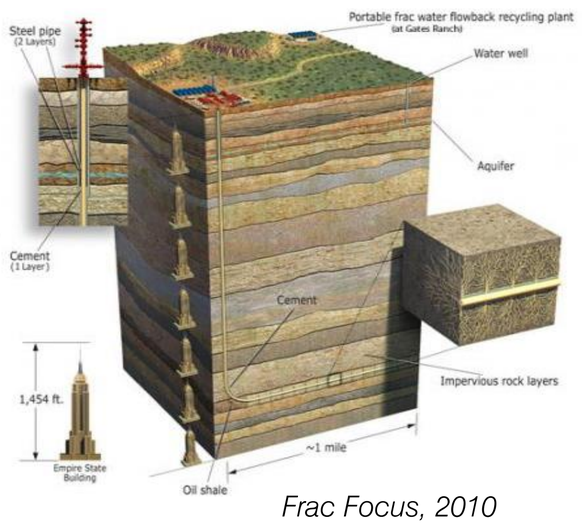
What is hydraulic fracturing?

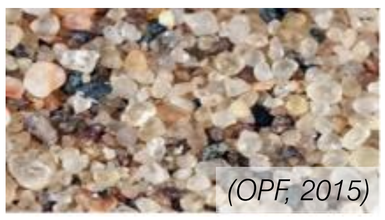
Hydraulic fracturing, also known as "fracking" is a technique used to stimulate hydrocarbon production within subterranean formations. It can be achieved by:

- Injecting fluid at a sufficient rate and pressure through a wellbore
- The pressure created causes fractures.
- Granular material, termed ***"Proppant"*** is pumped into the fractures.
- Proppant keeps the fracture opened in the formation allowing continuous oil and gas production under high closure stresses.



Frac Focus, 2010

Proppant types



Frac sand (not tested)

Resin coated proppant (CB)

Ceramic Proppant (CE)

Proppant	Shape	Strength	Conductivity
Frac sand	Irregular, angular, rough	~ 40 MPa	Low
Resin-coated	Irregular, smooth, rounded	~ 60 MPa	Medium
Ceramic	Spherical, rounded, uniform	~ 100 MPa	High

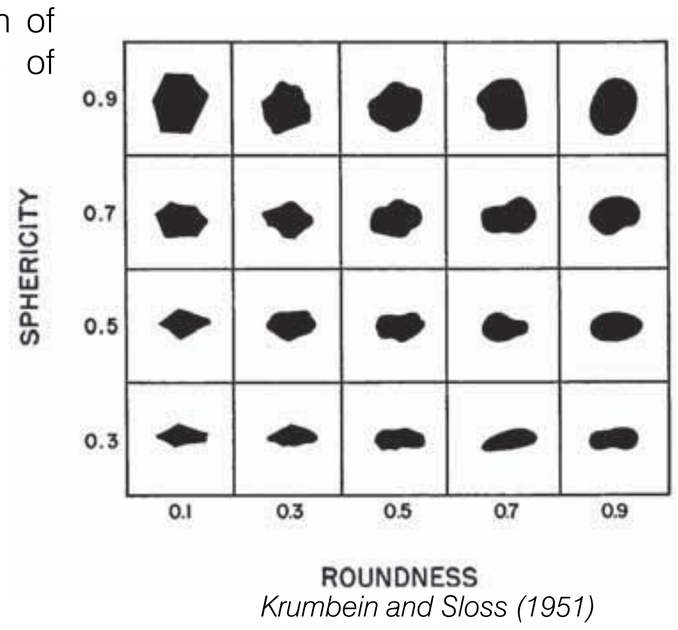
Ideal proppant must have smooth surface, uniformly sized spherical shape for optimum hydraulic conductivity. Ceramic proppant (CE) and resin coated proppant (CB) of size 20/40 (212-420 μm), 30/50 (300-600 μm) and 40/70 (420-850 μm) were tested

How do we quantify sphericity?

Current method: Visual comparison of particle shapes with 2D images of Krumbein reference chart (1951).

Disadvantages

- Very long and tedious process
- Not quantitative measure of shape parameters
- User subjective results
- Subjective to elongation
- Not appropriate for quantifying sphericity of large volume of proppant



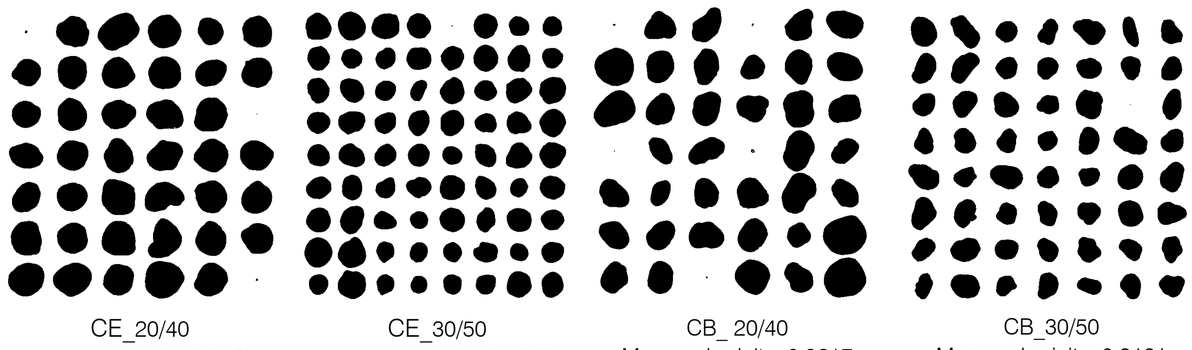
Krumbein and Sloss (1951)

QicPic

QicPic uses dynamic image analysis to quantify particle shape and size by analysing 2D particle images taken by high speed camera.

Advantages

- Large quantity of proppant can be analysed instantaneously.
- Various shape parameters can be obtained with great precision as the smallest detectable pixel size is 1 μm.
- Objective/numerical quantification of shape parameters can be obtained such as sphericity and particle size distribution (PSD).



CE_20/40
Mean sphericity: 0.9353

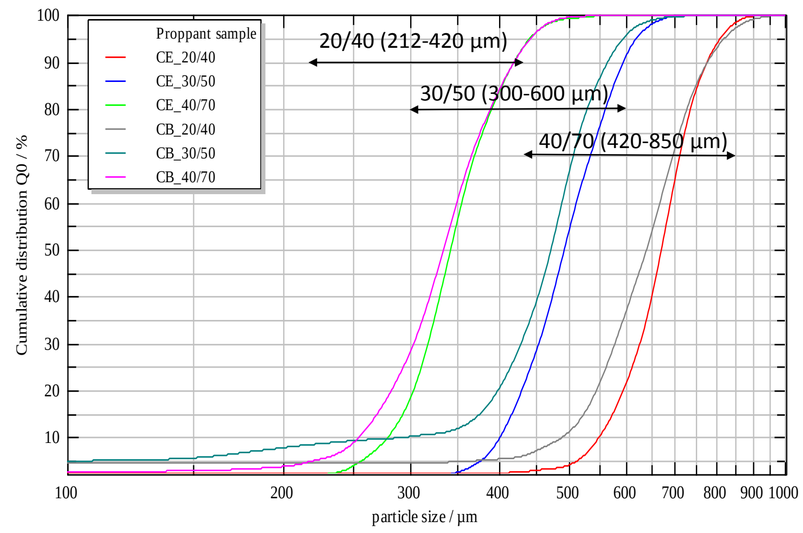
CE_30/50
Mean sphericity: 0.9349

CB_ 20/40
Mean sphericity: 0.9217

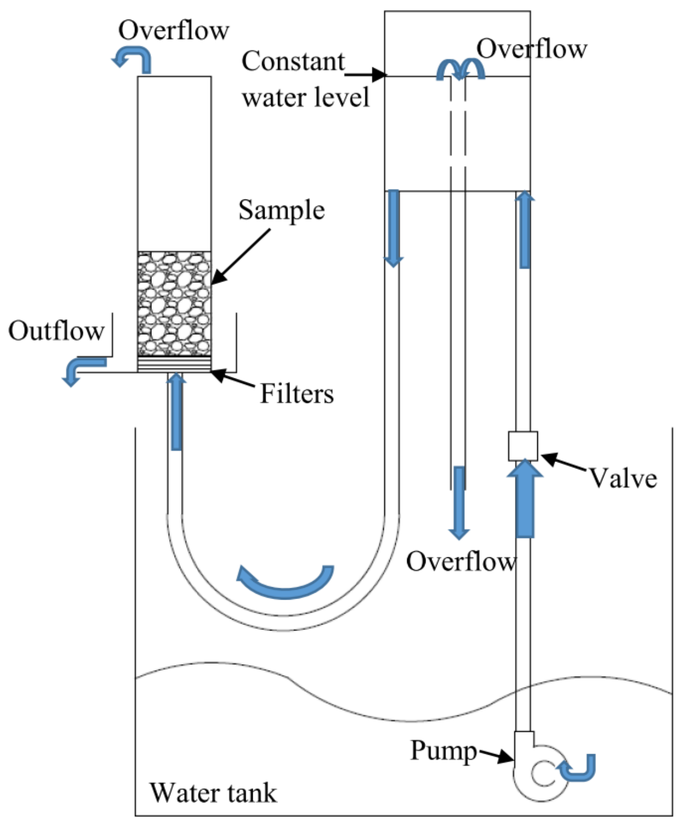
CB_30/50
Mean sphericity: 0.9131

Shape parameter results of various proppants

- All proppant types have high sphericity (> 0.91) where ceramic proppants have generally higher sphericity than RCP.
- PSD of proppants are very high ranging from 1.20 – 1.31
- Increase in particle size (D_{50}) and sphericity decrease the e_{max} and e_{min}.



Hydraulic conductivity



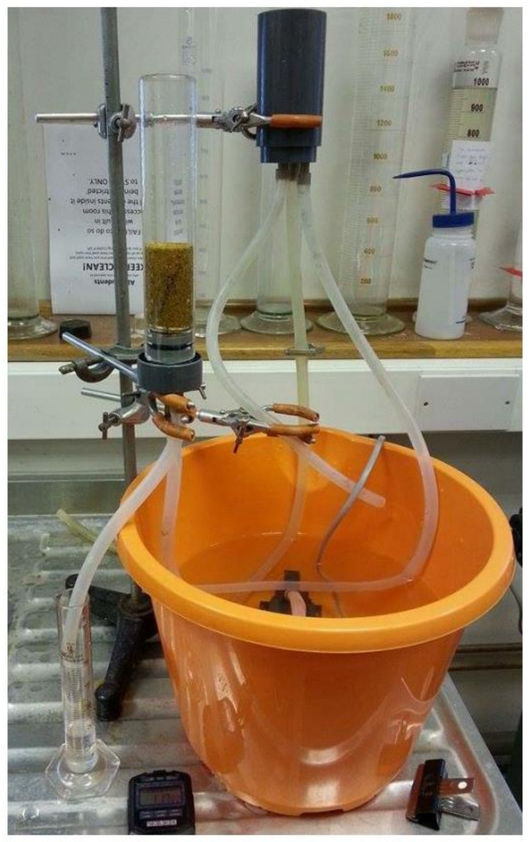
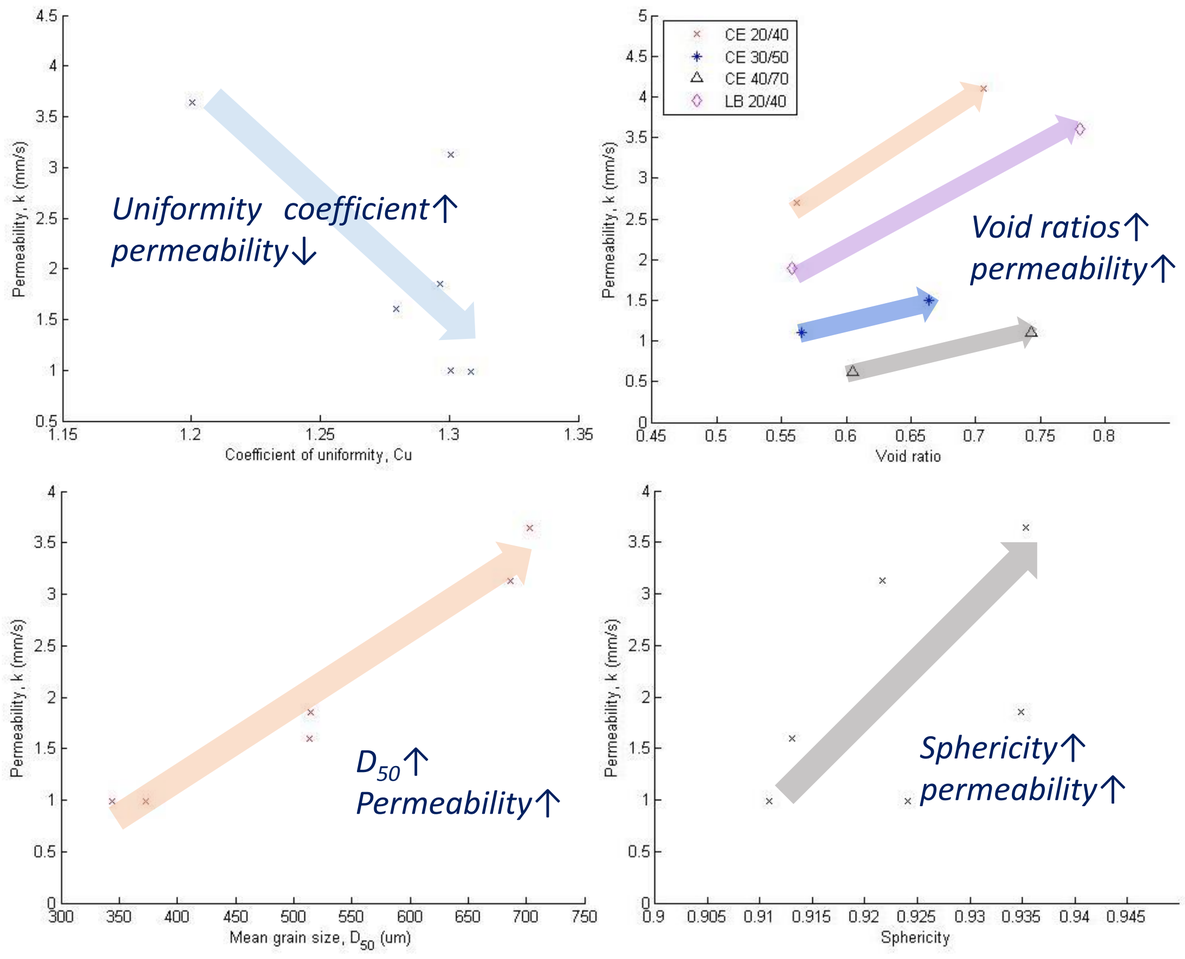


Diagram of constant head permeability test apparatus



Impact of various shape parameters on permeability of proppant

References

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Acknowledgement

I would like to thank Dr Sim Way Way for supervising my research and her continuous support, guidance and criticism throughout the dissertation and the whole four years at Imperial College. CARBO Ceramics Inc. generously offered 6 proppant samples for my research and it was such a great opportunity for me to work with actual proppants.