Quest for Corn Oil

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Long-Term Strategic Relationships in Place for Sourcing of Distillers Corn Oil (DCO) Raw Material

Partner to DCO Producers

- In 2008, Trucent launched COSS technology for extraction & separation of Distillers Corn Oil
- COSS technology is employed at 95+ installations in North America
- Trucent provides ongoing sales and service for COSS to the Corn Ethanol Producers
- Trucent chemical laboratory is a ‘Center of Excellence’ for DCO analytics and performance data
- DCO producers rely on Trucent for process optimization and coproduct utilization efficiency improvements

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What is DCO?

- Distillers corn oil (DCO) is a coproduct of corn ethanol production.
- Light reddish-orange colored liquid that displays the general physical characteristics of common corn oils.
- It is a high-quality fat that can be utilized as an animal feed ingredient.
- Intended for non-human consumption only
    - **G**enerally **R**ecognized **A**s **S**afe (GRAS)
    - Can use GRAS ingredients without FDA approval

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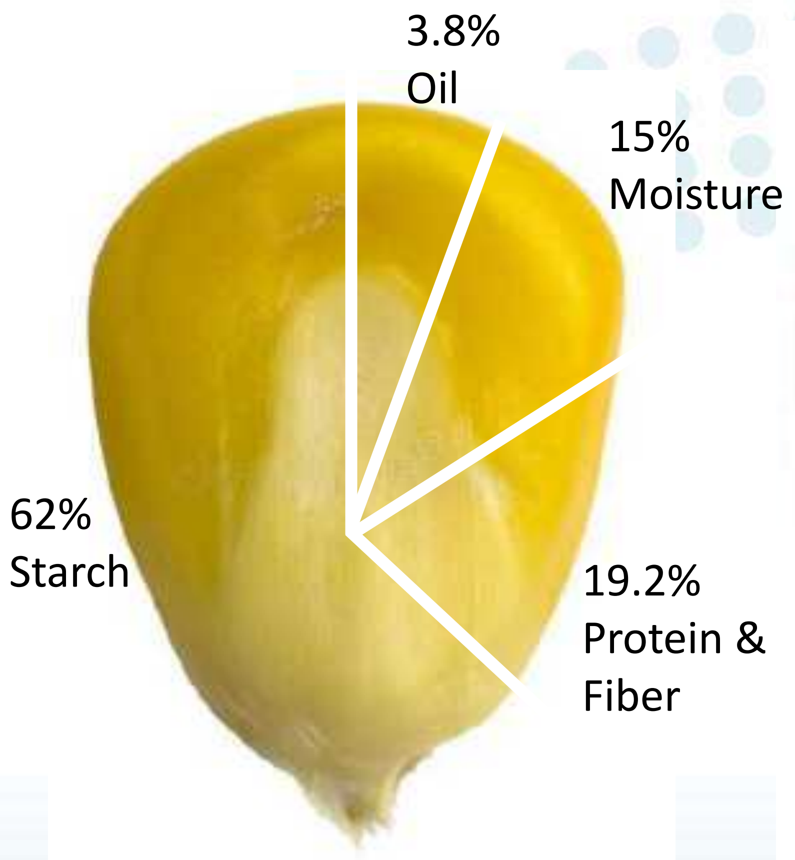
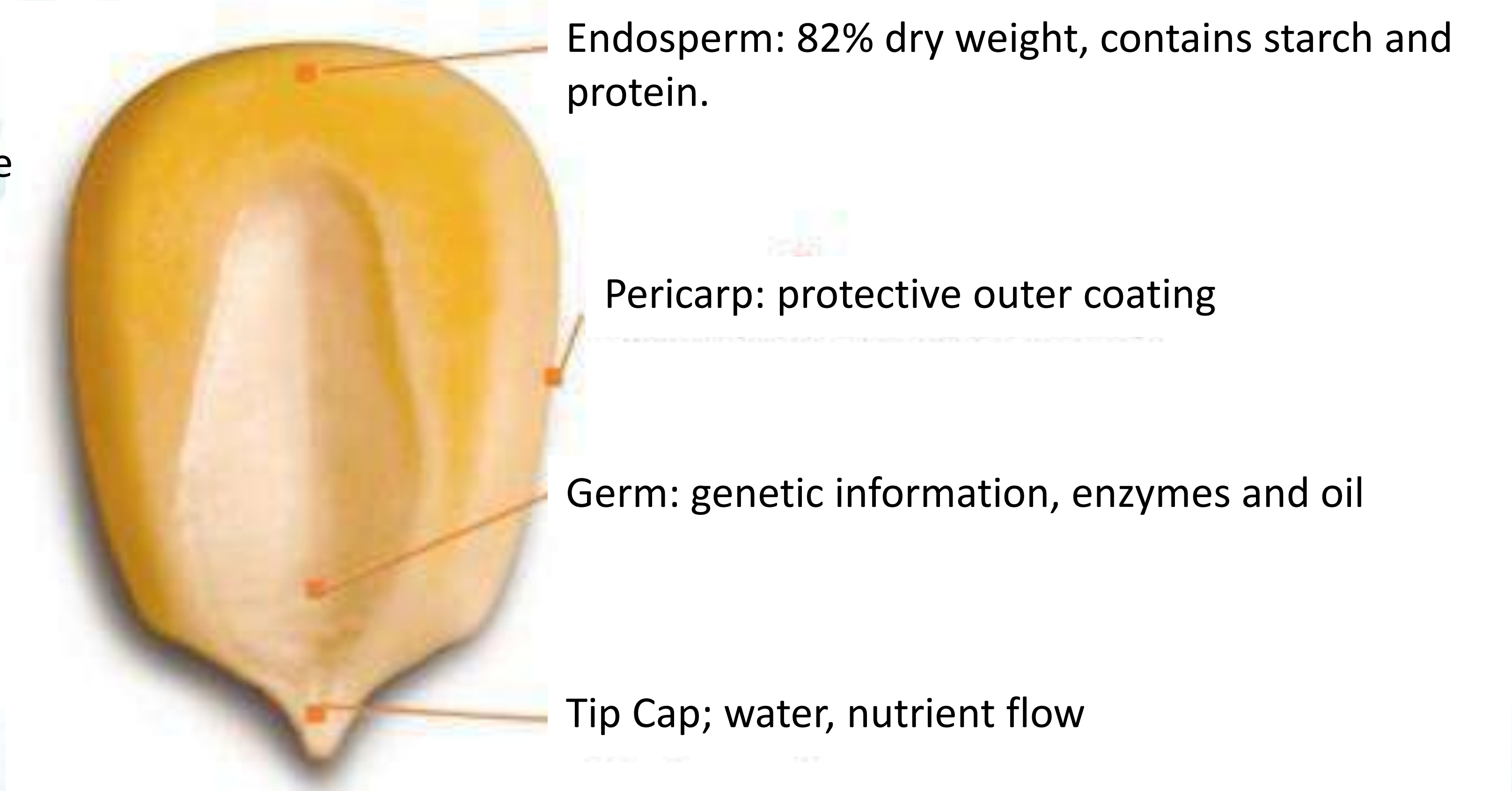
What is DCO used for?

- Main markets for DCO are
  - Renewable Diesel
  - Biodiesel
  - Animal feed industry, and
  - Export market.

What is DCO?


3.8%
Oil
15%
Moisture
62%
Starch
19.2%
Protein &
Fiber

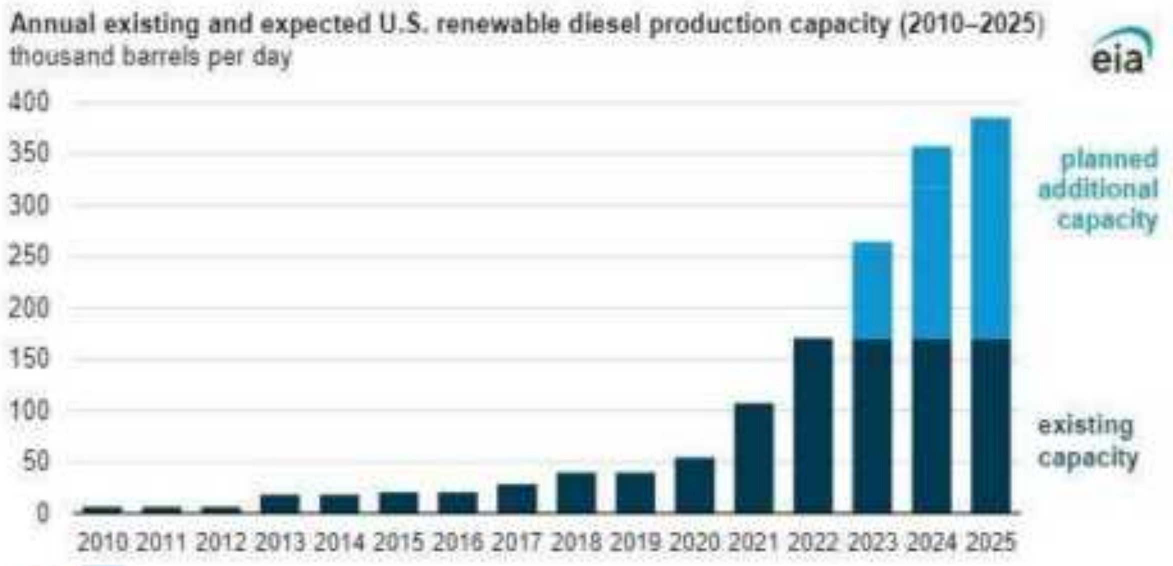

Endosperm: 82% dry weight, contains starch and protein.
Pericarp: protective outer coating
Germ: genetic information, enzymes and oil
Tip Cap; water, nutrient flow

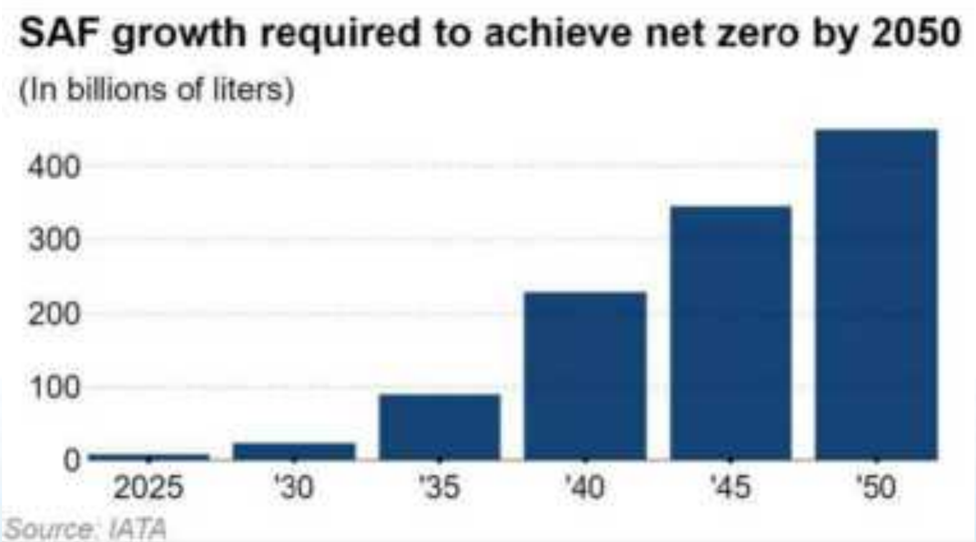
Why Recover Corn Oil?

Product	Value	$/lb
Ethanol	$1.66/gal	$0.25
DDGS	$154/ton	$0.08
DCO	$0.51/lb	$0.51

Rising Demand for DCO[1]

2024 Market Value- $6.12B
2030 Market Value- $8.15B





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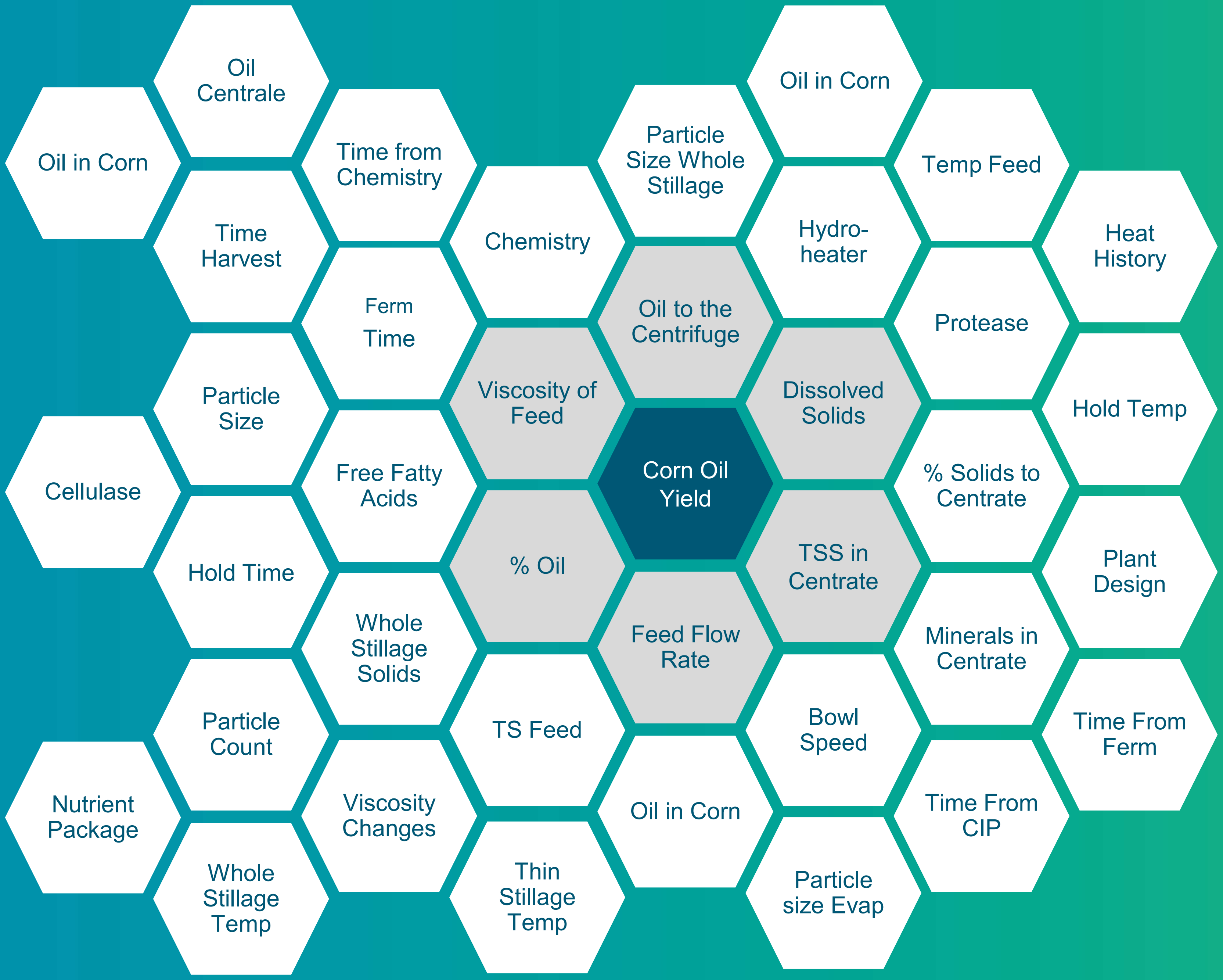
1: Mr. Karan Chechi, Research Director of TechSci Research LLC., https://www.techsciresearch.com/news/15488-global-distillers-corn-oil-market.html



Maximum Variable Evaluation

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Capturing Untapped Potential

Potential found through evaluation of three key variables

Efficiency

Corn

- Oil Content
- Defines Oil Available
- Sets Expectations

Decanting of Stillage

- First Partition
- Centrate or Wet Cake
- Potential for Oil Loss

Extraction of DCO

- Second Partition
- Recovery Rate of Oil
- Determines Efficiency

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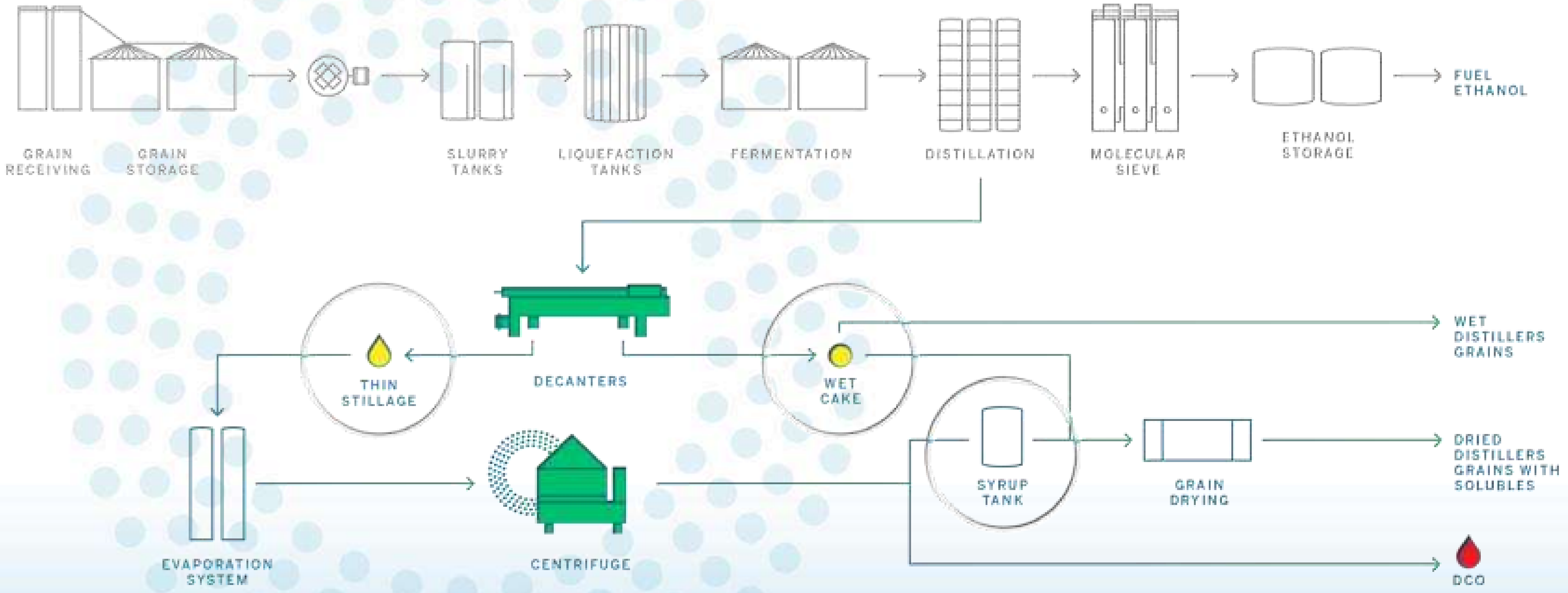
Trucent: Process + Mechanical Expertise & Understanding



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Industry Report Card

A closer look - corn oil production is impacted by:

- Corn oil content (How much oil is available to extract?)
- Decanter operation (How much oil partitions to the centrate?)
- Corn oil extraction (What is the efficiency of extraction at the centrifuge?)

	LOW PERFORMER	INDUSTRY AVERAGE	LEADER CHART
CORN OIL CONTENT	1.7 LBS/BU	1.9 LBS/BU	2.1 LBS/BU
DECANTER OPERATION	45%	60%	75%
CORN OIL EXTRACTION	75%	89%	96%

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Separation Theory – Key Terms

Feed – Mixture of solids, water, and oil being fed into the separator (stillage or syrup).

Light Phase – Liquid obtained in separation, having a density lower than the inlet product. (DCO)

Heavy Phase – Liquid obtained in separation, having a density higher than the inlet product. (Thin Stillage)

Separation Zone - The interface in the bowl which determines the separation of the light phase and heavy phase.

Sediment – Solid particles that accumulate in the external part of the bowl called sludge chamber. (Corn solids, yeast bodies, etc.)

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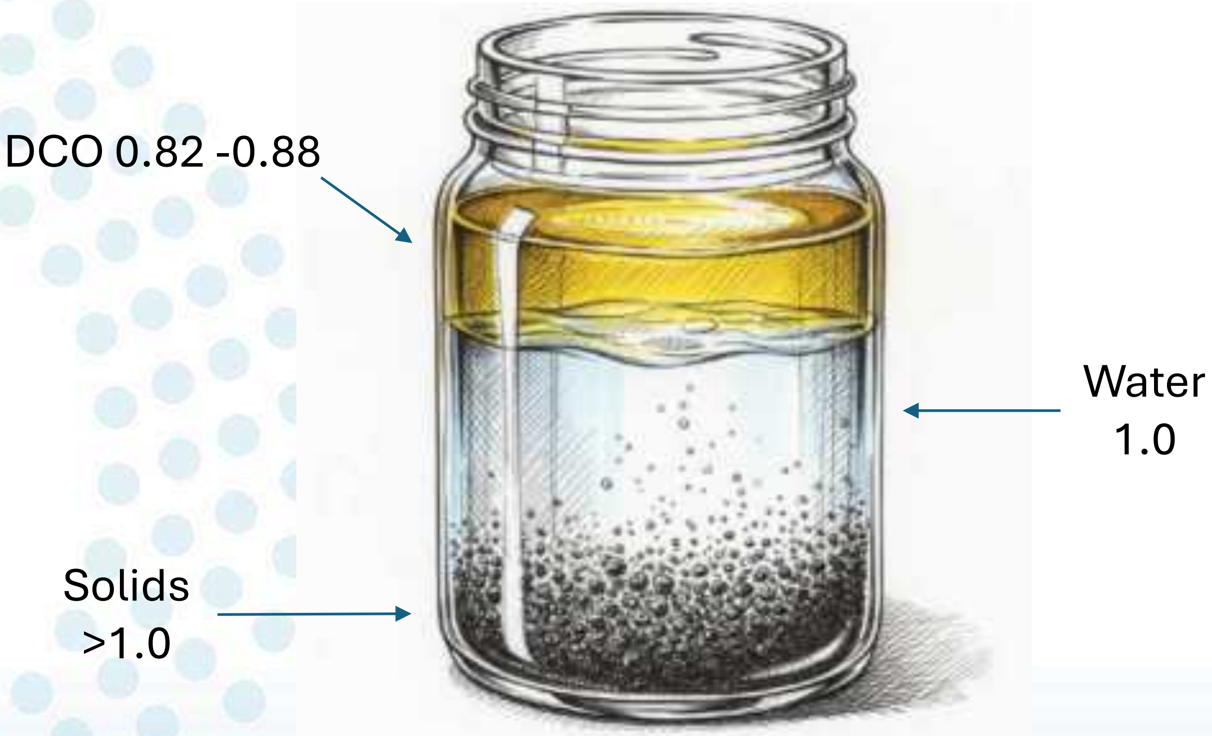
Separation Theory – Specific Gravity

Specific gravity is just a simple score for density, where water always equals 1.

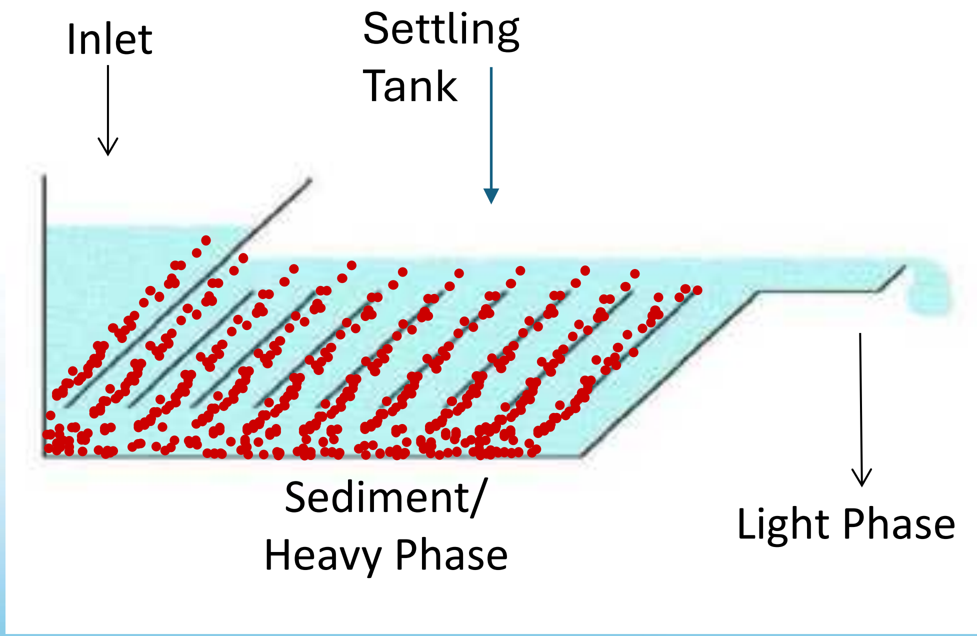
Think of it like this:
The specific gravity number tells you exactly how much denser or less dense an object is compared to the same amount (volume) of water.

- Corn oil has an average specific gravity of 0.85. This means it's ~85% as dense as water, which is why it floats on top.
- Corn solids (kernel) has an average specific gravity of 1.3. This means it's 1.3 times denser than water, which is why it sinks.



Separation Theory

You have a mixture of oil, water, and solids. If you let it sit, the solids will eventually settle at the bottom, the water will form a layer on top of the solids, and the oil will float on the very top. This natural separation happens because these three substances have different densities. This basic principle of **"heavier things sink and lighter things float"** is the foundation of separation theory. This is measured using specific gravity.

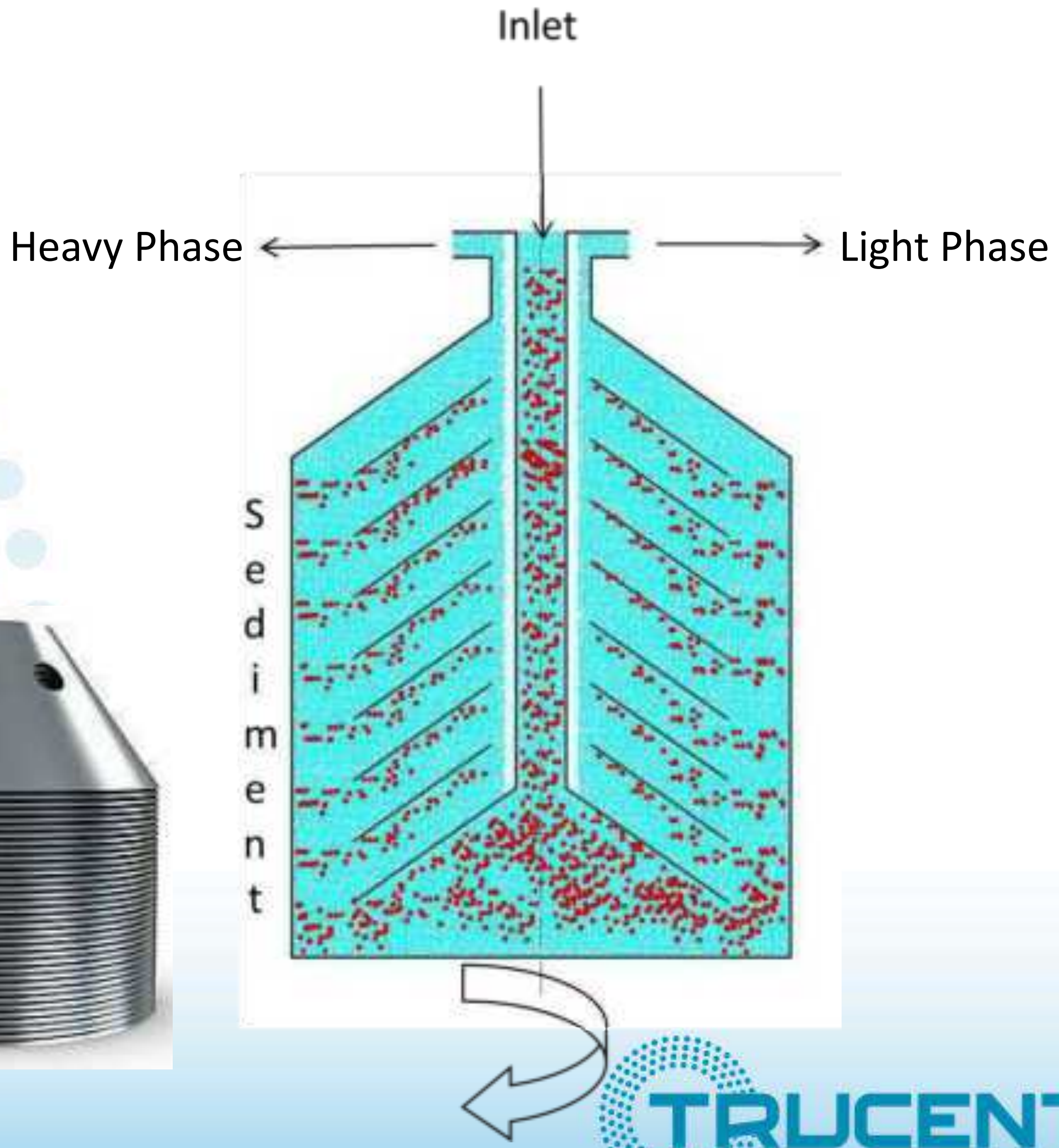


<u>Sedimentation</u>
1X Gravity Separation
with increased surface area (plates)

Separation Theory

Let's rotate the settling tank onto it's end and apply acceleration.

- **Rapid Spinning:** The core of the separator is a bowl that spins at very high speeds. This spinning creates a strong centrifugal force, thousands of times greater than gravity.
- **The Disc Stack:** Inside the bowl is a stack of conical-shaped discs. These discs are the key to the separator's efficiency. They divide the liquid into many thin layers, which drastically reduces the distance a particle needs to travel to be separated.



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Separation Theory

A disc stack separator, also known as a disc stack centrifuge, is a machine that dramatically speeds up this natural separation process.

Instead of relying on gravity alone, it uses powerful centrifugal force, the same force you feel being pushed to the side when a car turns a corner sharply.

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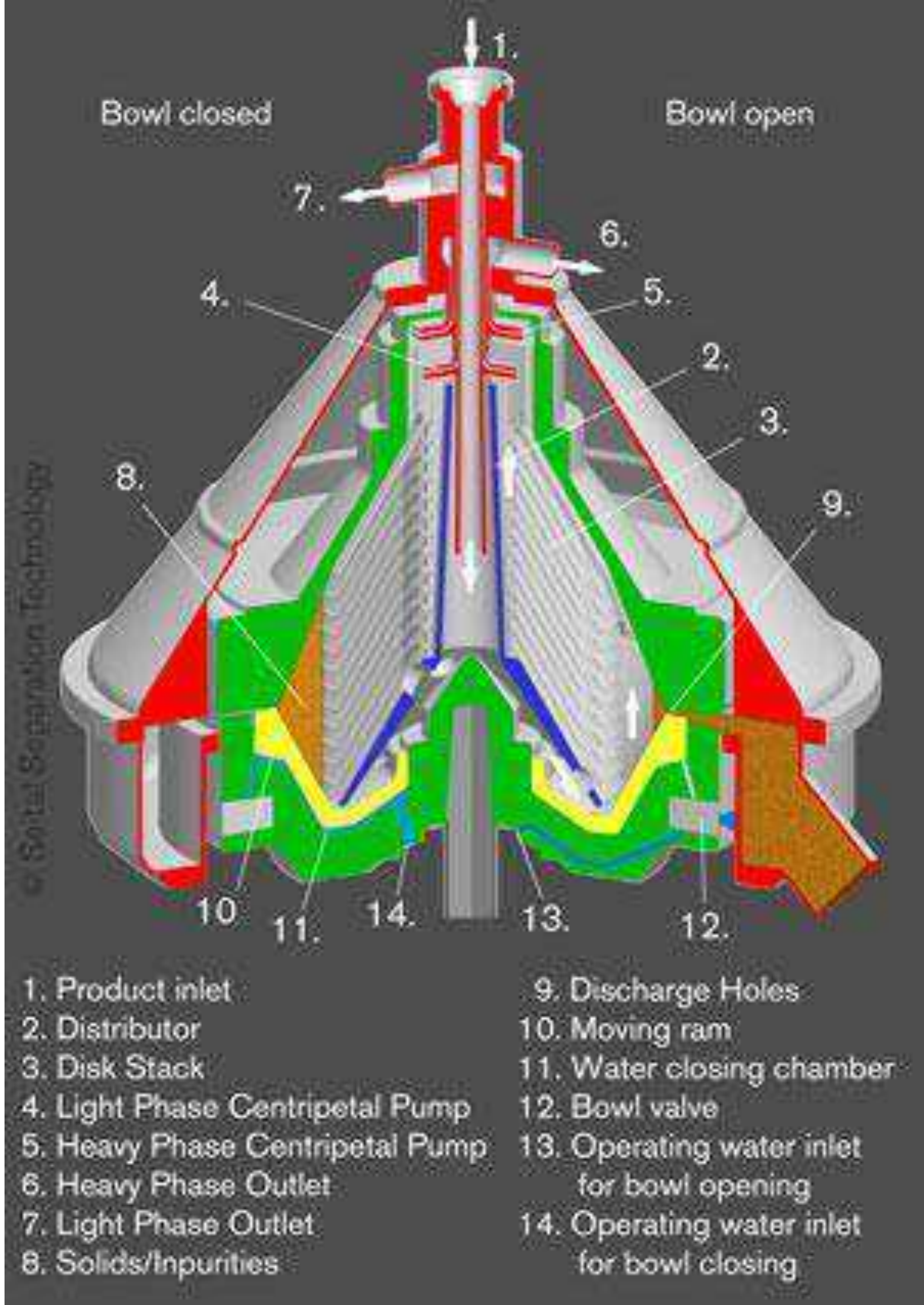
How is DCO Removed from the Process?

Gravity

Separation Theory

Separation in Action:

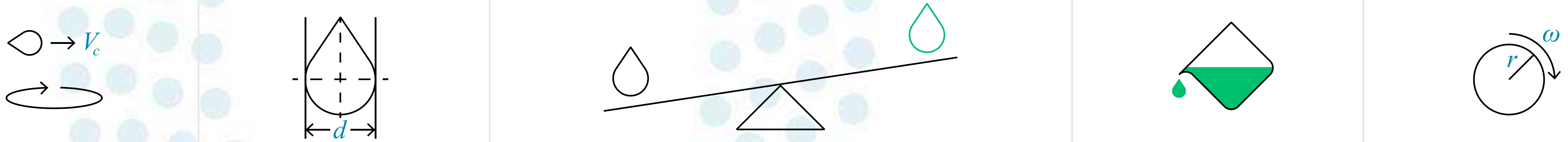
1. The mixture (feed) is fed into the spinning bowl.
2. The intense centrifugal force flings the densest particles (solids) to the outermost edge of the bowl.
3. The less dense liquids (water and oil) are also forced outwards but form separate layers closer to the center. The heavier liquid (water) will be further out than the lighter liquid (oil).
4. The conical discs guide this separation. The solids slide down the underside of the discs to the edge of the bowl. The separated liquids travel up or down the channels created by the discs to their respective outlets.
5. The separated components are then continuously discharged from the separator through different outlets.



Stoke’s Law: Our guide in the hunt for more corn oil

$$V = \frac{d^2(\rho_w - \rho_o)r\omega^2}{18\eta}$$

V_c	d^2	ρ_w	ρ_o	η	$r\omega^2$
centrifugal settling velocity (m/s)	droplet size (mm Ø)	heavy phase density (kg/m³)	light phase density (kg/m³)	continuous phase viscosity (kg/ms)	centrifugal acceleration (m/s²)



This process is governed by a principle called **Stokes' Law**, which essentially states that the speed at which a particle settles in a fluid depends on its size and density, the viscosity of the fluid, and the force of gravity (or in this case, the much stronger centrifugal force). The disc stack separator manipulates these factors to achieve rapid and efficient separation.

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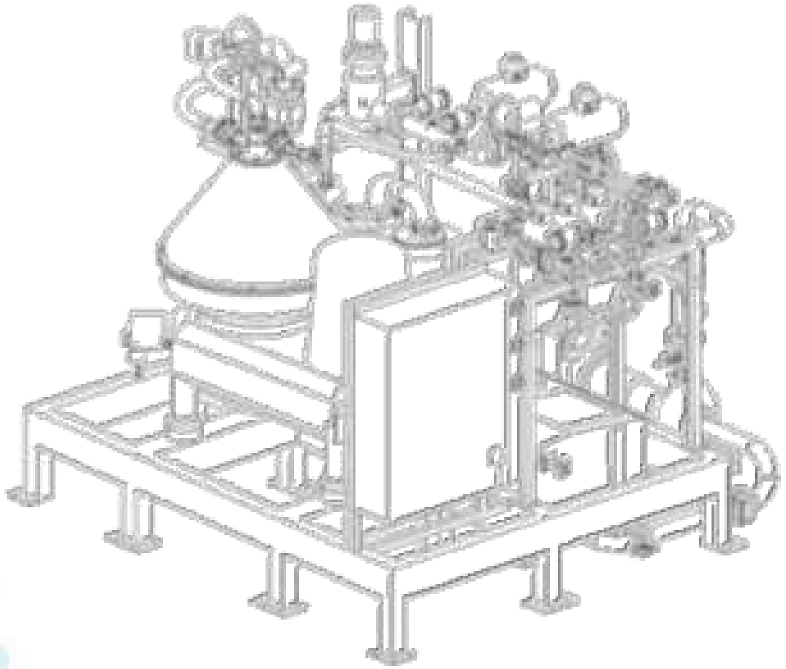
COSS-SL

for DCO Extraction

Turnkey Operation



95+ Systems in Operation in
North and South America
40+ Corn Ethanol Plants and Distilleries

650 Years of Accumulated Run Time
10.0 Billion Pounds of DCO Produced

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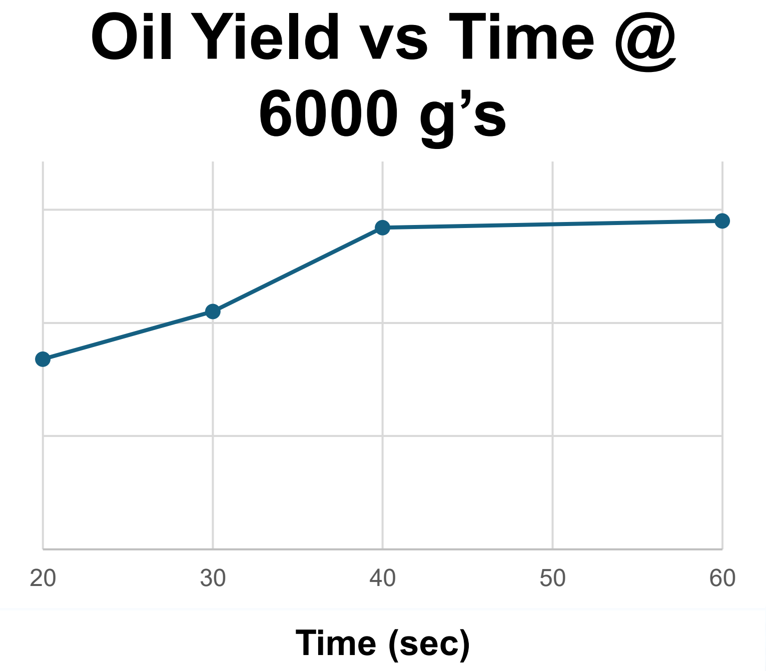
COSS–SL:

The High-Speed Advantage



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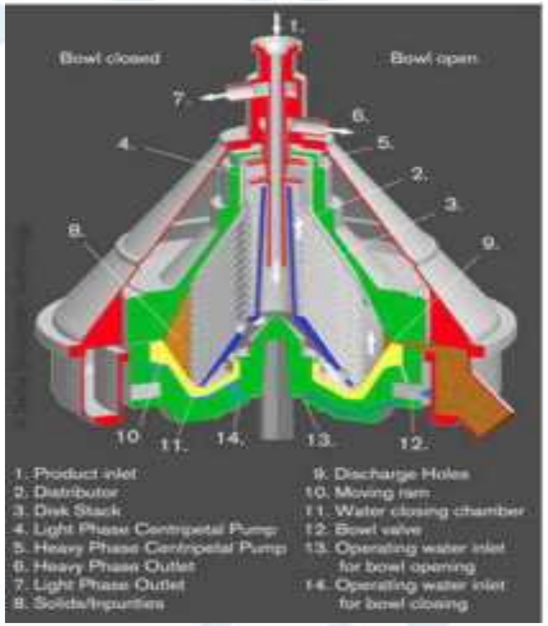
Disc Stack Optimization



$$Q = \frac{D^2 \cdot \Delta\rho}{18 \cdot \eta} \cdot g \cdot \frac{2\pi}{3g} \cdot \omega^2 \cdot tg\varphi \cdot z(r_1^3 - r_2^3)$$

- Optimized gap spacing of 40 0.8mm discs.
- Overall Equivalent Surface Area increased 8%
- Separation velocity increases 20%
- **Separation efficiency increased 3-5%.**

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Best Practices:
Overview

Pre-Treatment: Set the Centrifuge up for Success

Viscosity & Particle Management, Chemical Dosing, Heat & Hold

Process Control

Optimal Flowrate, PID Loop Tuning, Heavy Cut for Yield

Data Collection & Trending

Which samples matter and what are they telling us?

Best Practices:
Particles and Viscosity Control

$$V = \frac{d^2(\rho_w - \rho_o) r \omega^2}{18\eta}$$

Finer Grind
Lower Viscosity and Cleaner Centrifuge

Size Matters
400 – 600 µ

	Feed w/o Chem. No Heat	Feed w/ Chem. No Heat	Feed w/ Chem. Heat 94°C	Centrifuge Feed
Particles >600µm	5,395	6,694	4,408	1,425
Particles between 420-600µm	1,124	1,103	902	338
Total particles >100µm	8,905	9,602	7,268	5,019
Viscosity at 40°C (cSt)	1843	1542	1442	345
pH	4.14	4.79	4.54	4.08

	Reduction
Particles >600µm	74%
Particles between 420-600µm	66%
Total particles >100µm	40%
Viscosity at 40°C	80%

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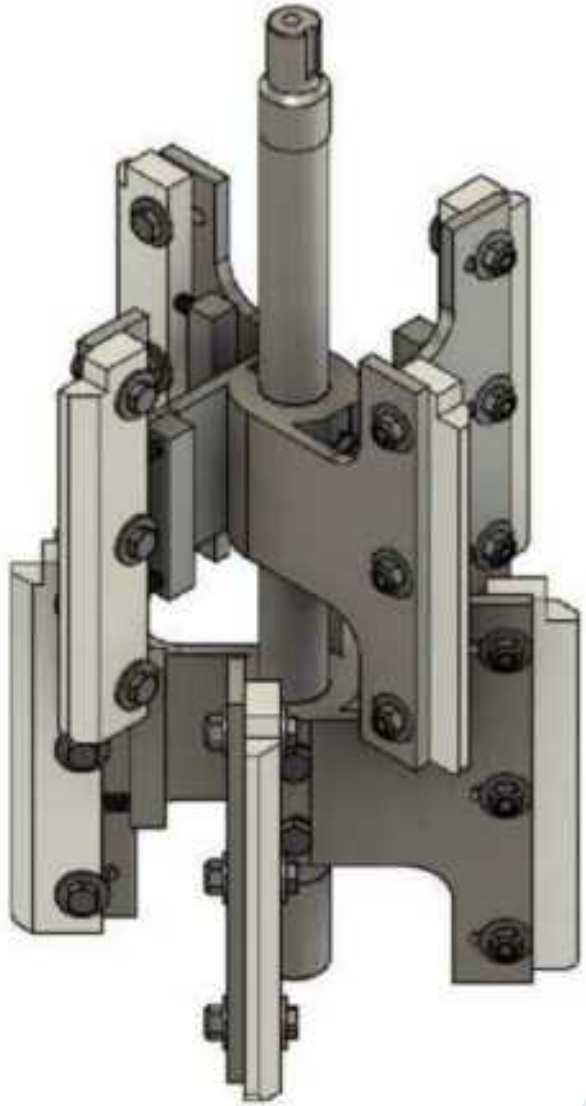
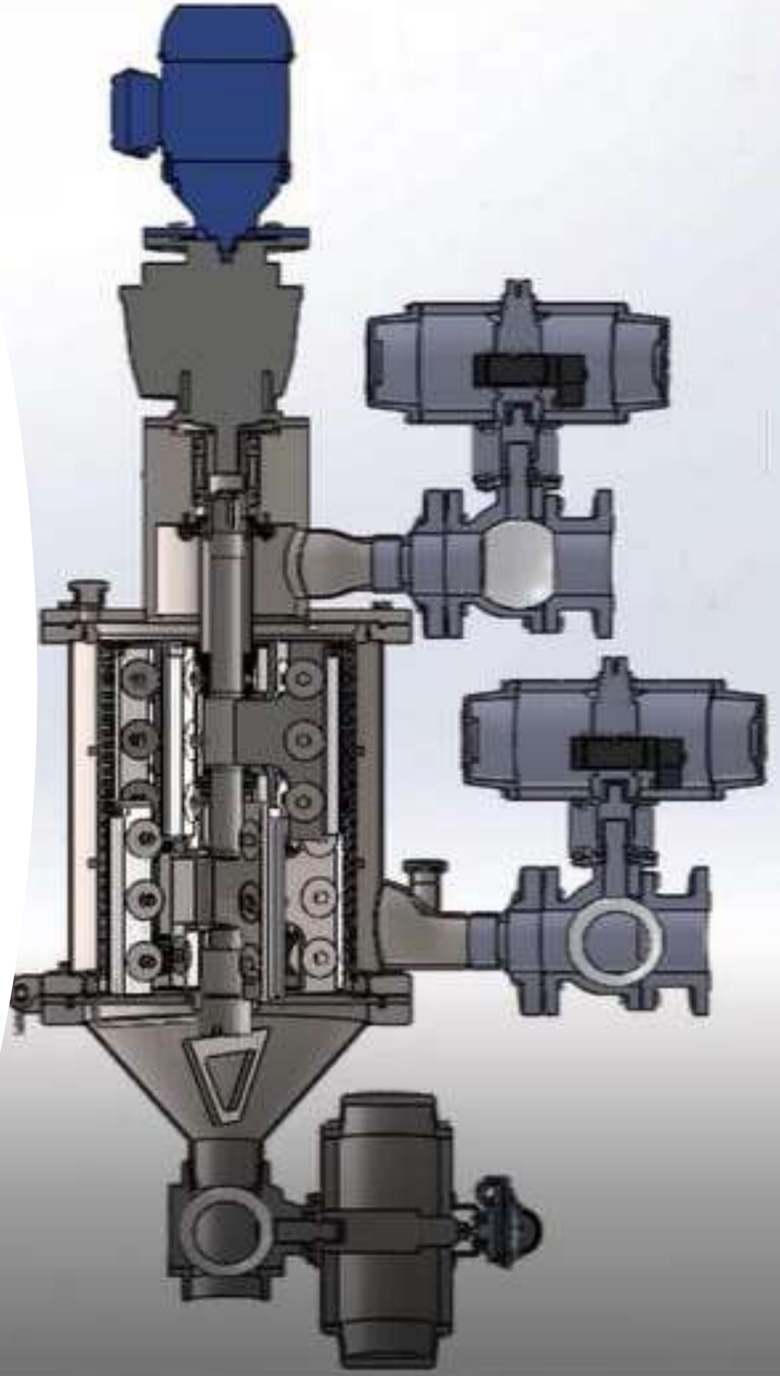
Brush Strainer
TruShield

- Brush Strainer Improvements
  - Wipers
  - Steady bearing
  - Increased drive motor power
  - Tighter screen options

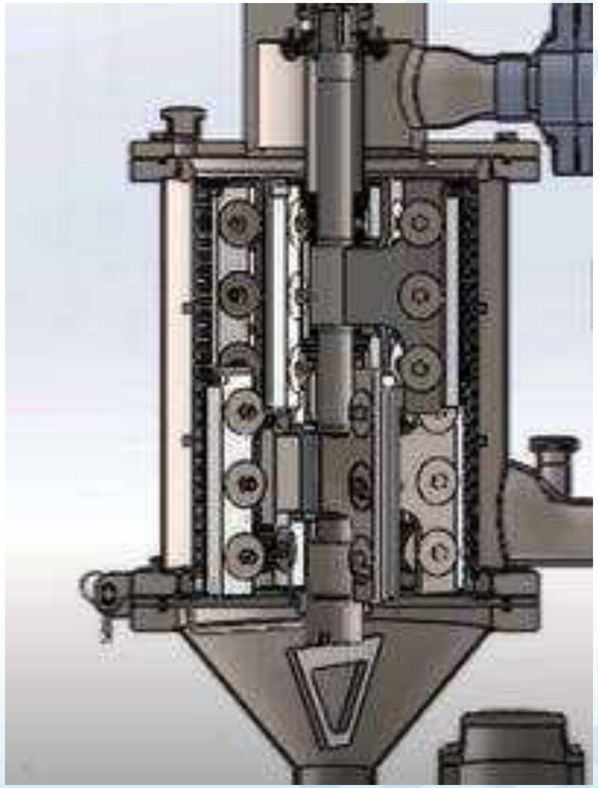




TruShield Optimization

Screen Size

Large Particle Removal and Viscosity Reduction



Average Total Particles >420µm	41%
Average Viscosity Reduction	26%

Plant	Viscosity Reduction	% Oil Yield Improvement
A	33%	7%
B	50%	5%
C	20%	4%

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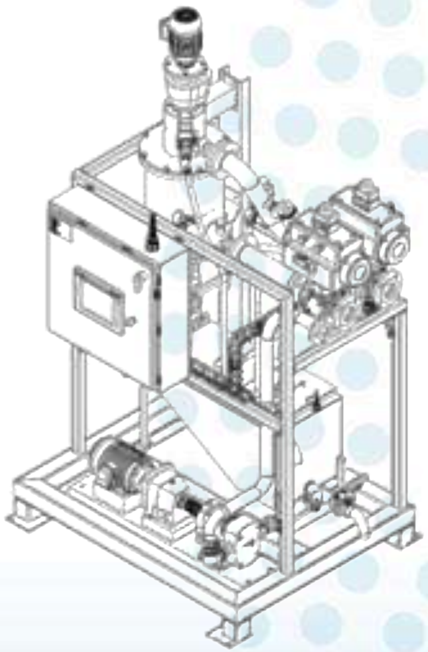
TruShield-SC

for DCO Syrup Conditioning

Maximize Your Distillers Corn Oil Potential

$$V = \frac{d^2(\rho_w - \rho_o) r\omega^2}{18\eta}$$



TYPICAL TRUSHIELD-SC DCO PRODUCTION INCREASES

	FEED RATE	BEFORE / AFTER	AVERAGE GPM OF OIL	VISCOSITY REDUCTION %
60 MGPY ETHANOL PLANT	73 GPM	WITHOUT TRUSHIELD	3.69	
	73 GPM	WITH TRUSHIELD	4.73	29.6
100 MGPY ETHANOL PLANT	95 GPM	WITHOUT TRUSHIELD	4.45	
	95 GPM	WITH TRUSHIELD	5.82	33.3
140 MGPY ETHANOL PLANT	118 GPM	WITHOUT TRUSHIELD	5.31	
	118 GPM	WITH TRUSHIELD	6.44	31.6

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Best Practices

Dosing

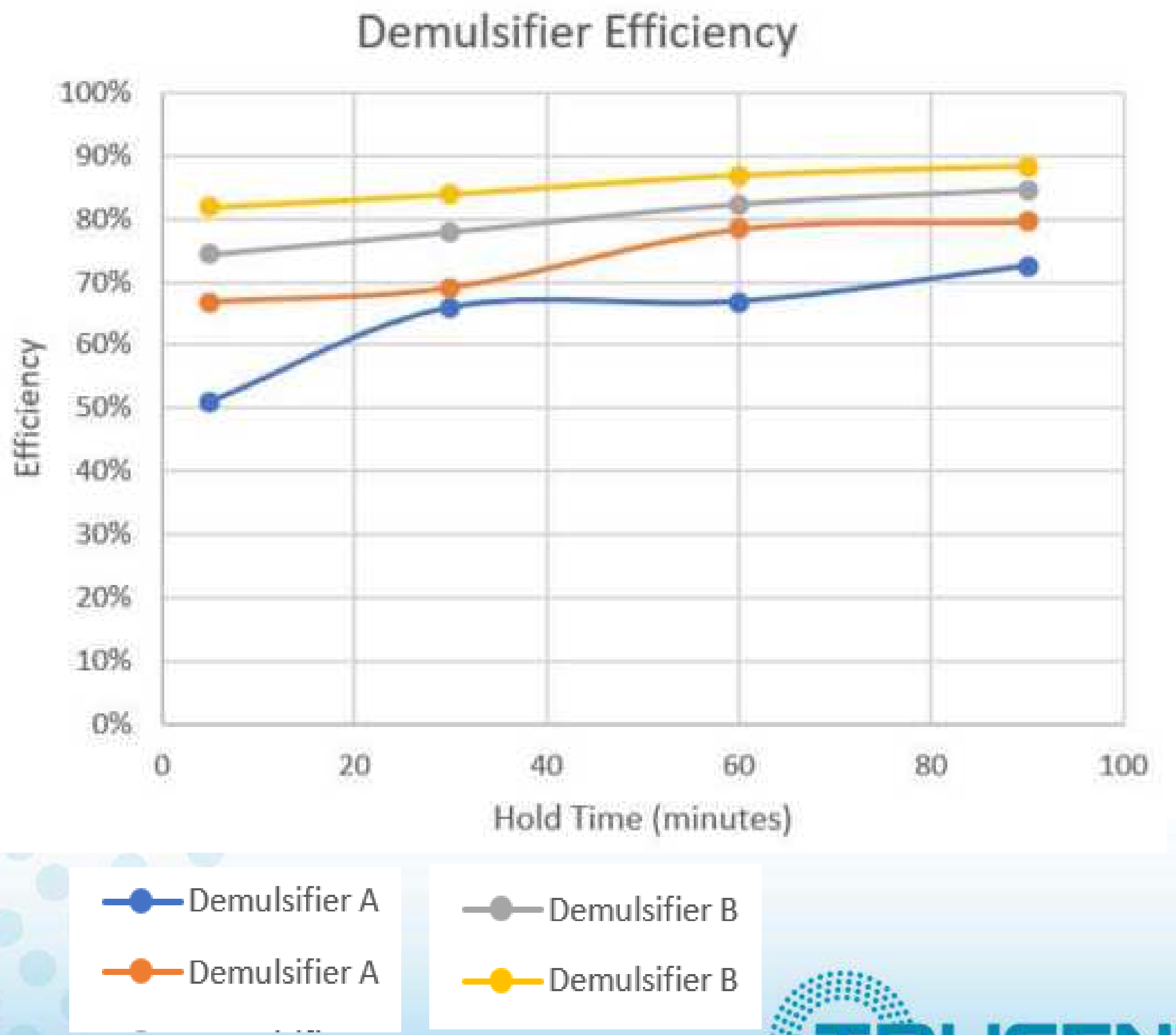
Bench Test Regularly
Test chemical type and dosage

Dispersion & Injection
Strategic injection points improve effectiveness

PPM Consistency
‘Smart’ dosing system

Stratification & Mitigation
Gentle mixing & pipe flow

pH Optimization
Higher pH may improve separation

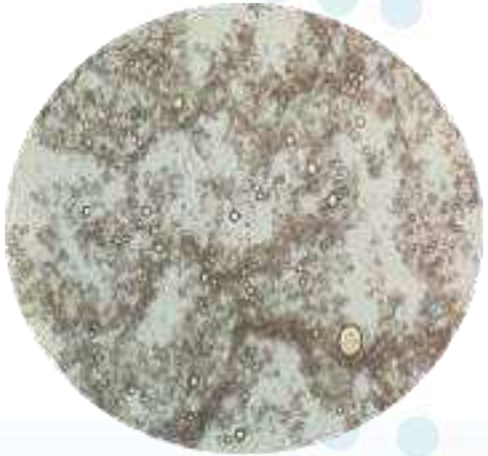


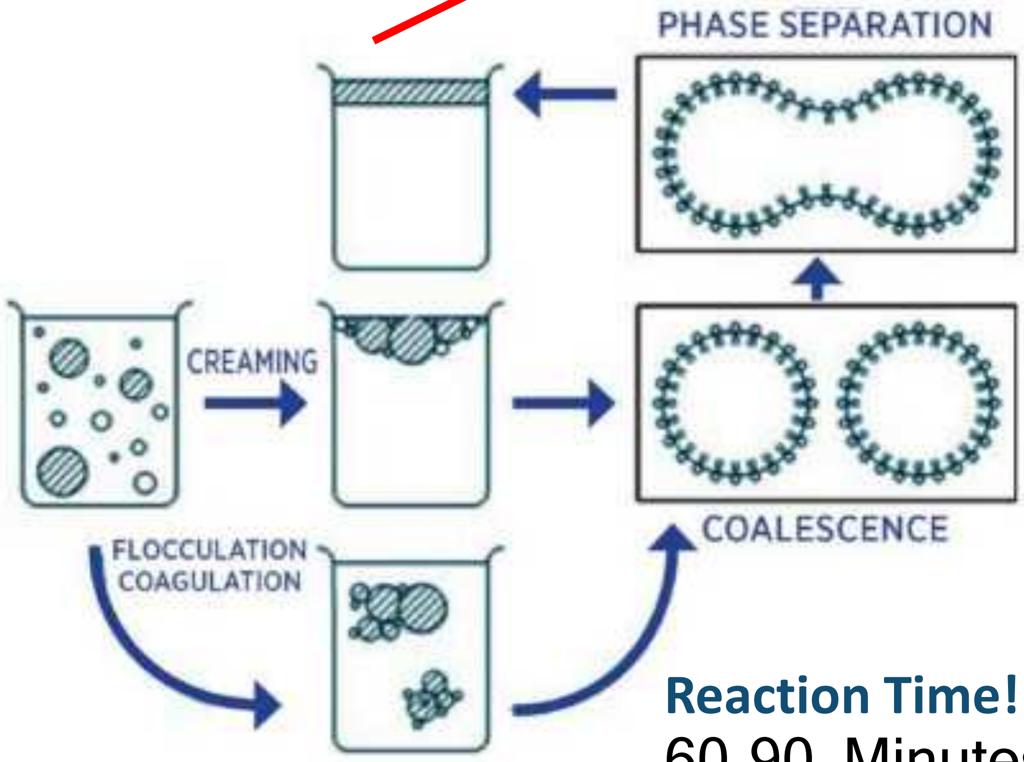
Heat & Hold

$$V = \frac{d^2(\rho_w - \rho_o)r\omega^2}{18\eta}$$

CAUTION: Oil Stratification in the Tank

Did the yield trend drop without explanation?





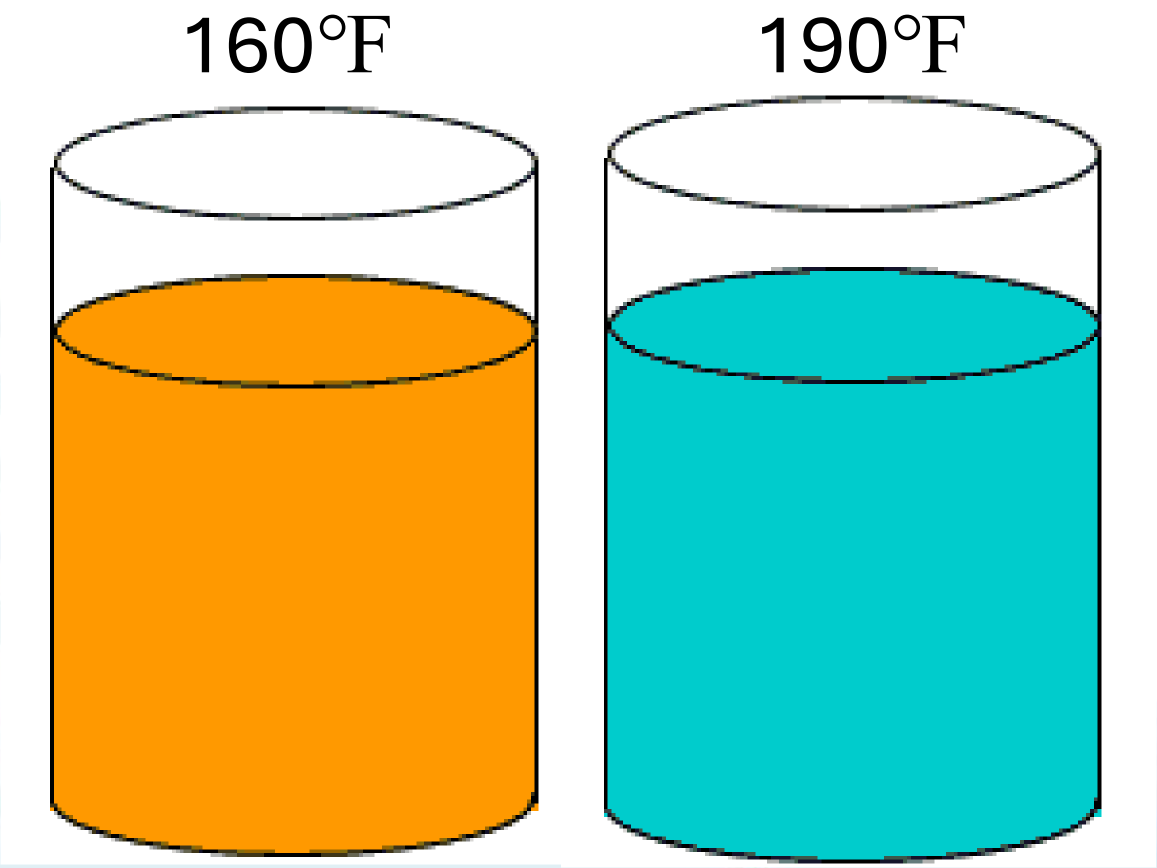
Reaction Time!
60-90 Minutes

Heat & Hold

$$V = \frac{d^2(\rho_w - \rho_o) r \omega^2}{18\eta}$$

Lowers Viscosity
Heat lowers syrup viscosity

Coalescence
Aids demulsifier action



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TruDose

Consistent Additive Dosing

Maximize Your Distillers Corn Oil Potential

- Trucent's specially designed pump, incorporated into the TruDose skid, produces a constant stream of additive dosing to the concentrated stillage stream.
- Integrating the TruDose with the customer's flow meter allows a constant dose rate regardless of changes in flowrate.
- As a result, no overdosing or under dosing occurs resulting in more consistent DCO extraction and lower additive costs.

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Automated Clean-in-Place (CIP)

Full Cleaning = Better Separation

- Counter and co-current flow.
- Full cleaning of the TruShield inside and outside of the housing.
- Cleans disc stack.
- Full light phase and decant pipe cleaning

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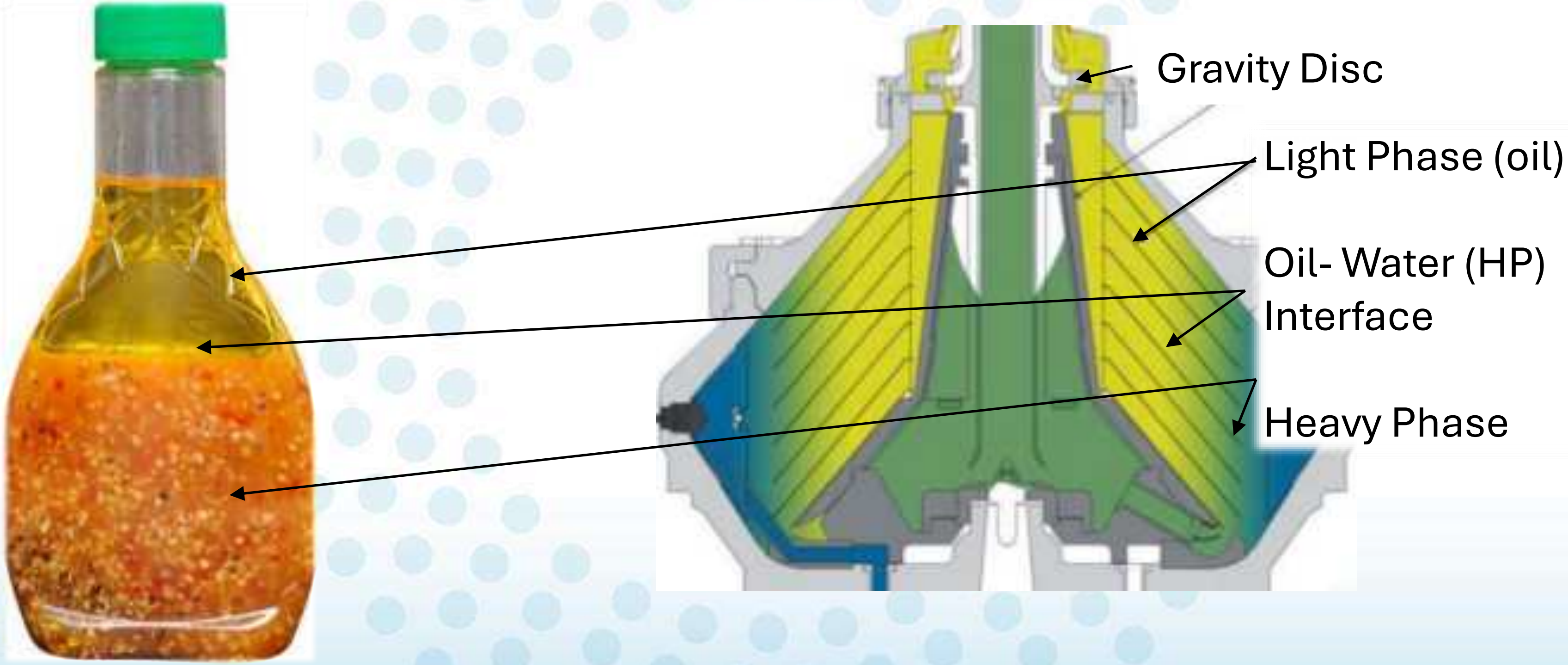
Disc Stack
with Improved Wash/CIP

Best Practices

Heavy Cut for Yield

Heavy (Dirty) Cut is Better than Missed Oil



- Adjust the gravity disc to move the interface radially inwards.
- This pushes the heavy liquid column outwards, allowing more of the heavier phase to be discharged through the light phase outlet (resulting in a dirtier cut).

TOCS

Tru-Oil Concentrator System

- The TOCS is a tank concentrating system with auto decant and CIP capabilities.
- Using proprietary programing, finished corn oil is kept from becoming static, keeping transfer pipes clean and clear, reducing the need for hydro-blasting or pipe replacement.
- Finished corn oil production is monitored and trended using industry leading equipment, resulting in 0.01% error (Tolerance limit: ±0.2%).

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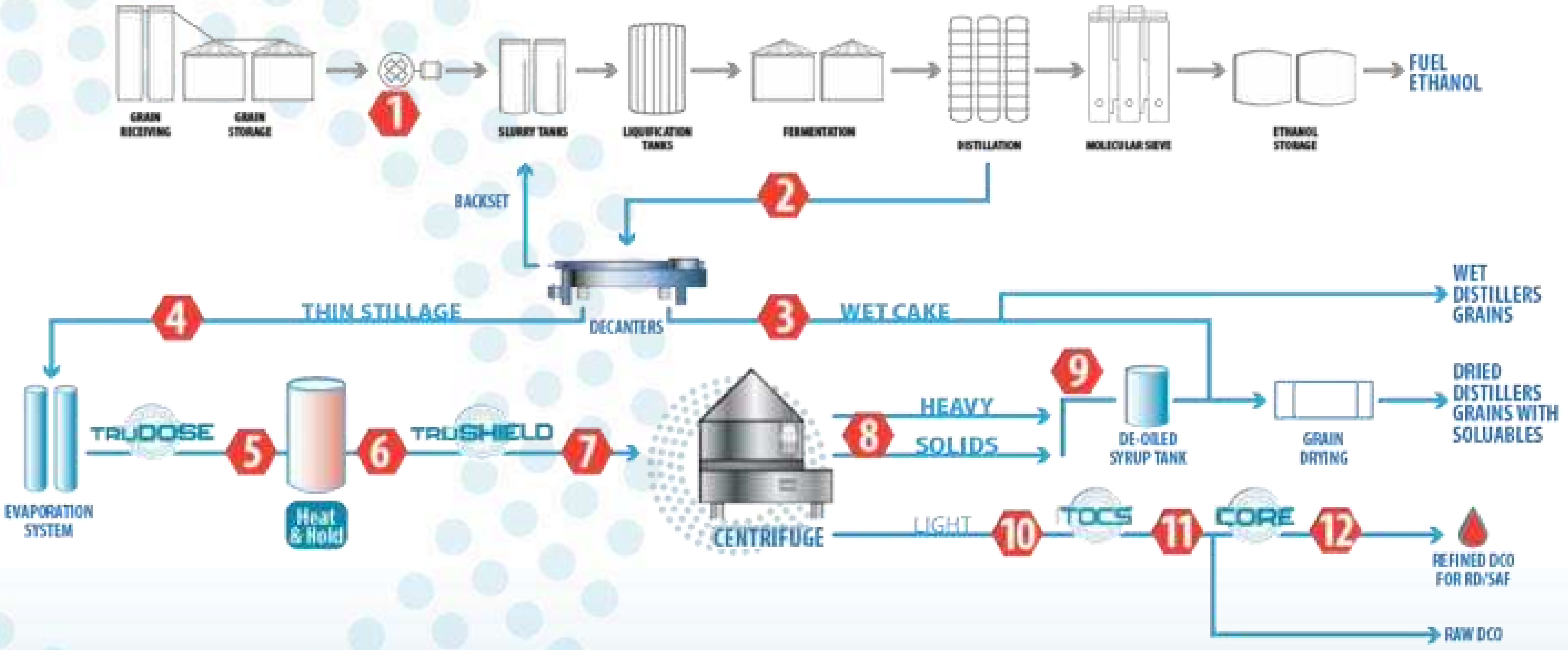
Best Practices

Be Data Driven

1. Corn Flower
2. Whole Stillage
3. Wet Cake
4. Thin Stillage
5. Syrup After Dosing
6. Syrup After Heat & Hold
7. Syrup After Viscosity and Solids Reduction
8. Heavy Phase
9. De-Oiled Syrup
10. Light Phase
11. Finished DCO
12. Refined DCO

Where to Test



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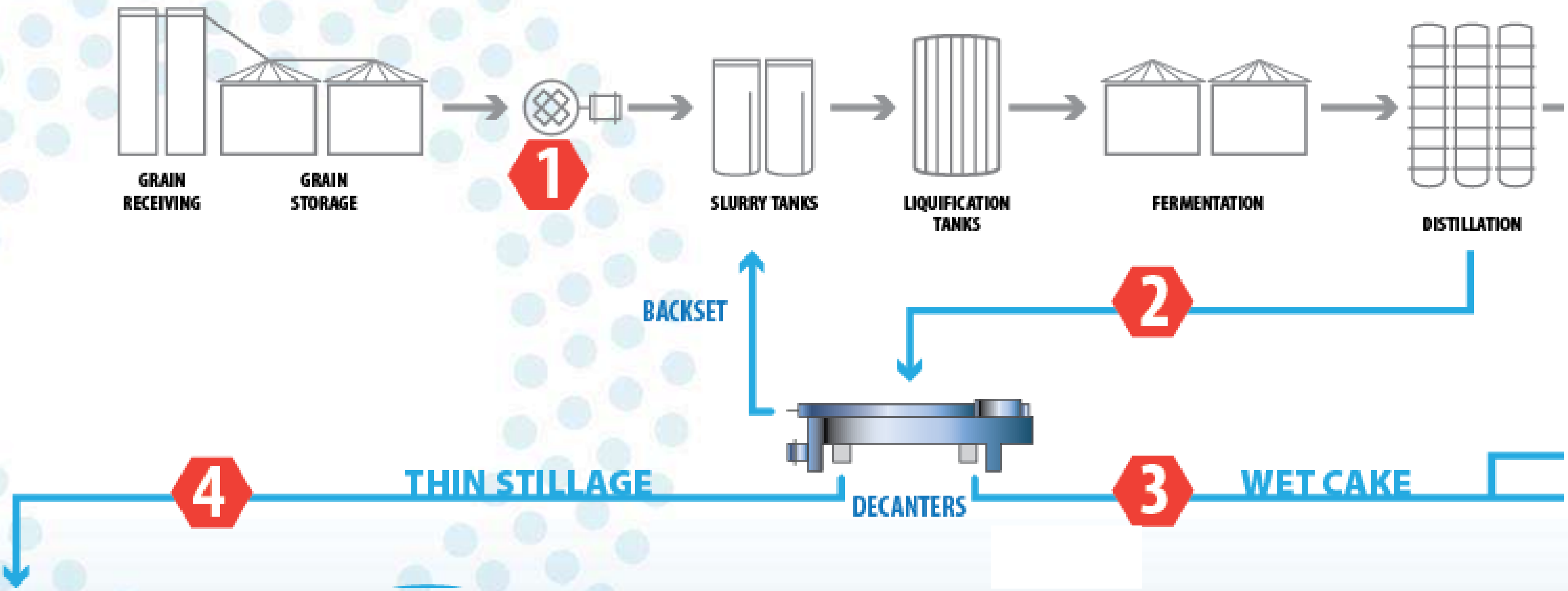
Best Practices

Be Data Driven

What to Test

1. Corn Flower
2. Whole Stillage
   A. % Oil
3. Wet Cake
   A. %Oil
   B. Total Solids
4. Thin Stillage
   A. % Oil
   B. Total Solids
   C. Suspended Solids
   D. Dissolved Solids
   E. Particle Size Distribution
   F. Volume Spin



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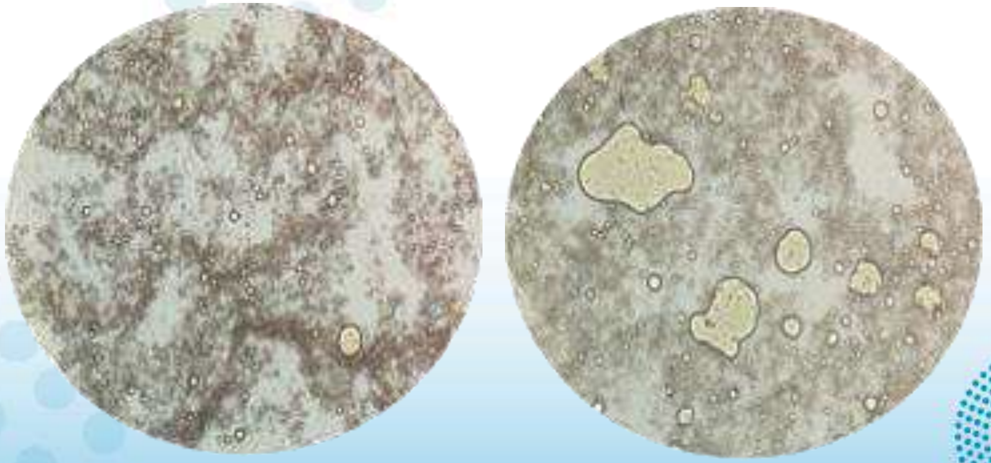
Best Practices

Be Data Driven

What to Test

5. Syrup After Dosing
6. Syrup After Heat & Hold
   a) % Oil
   b) Total Solids
   c) Suspended Solids
   d) Dissolved Solids
   e) Particle Size Distribution
   f) Volume Spin
   g) Microscope

7. Syrup After Viscosity
   and Solids Reduction (same as above and)
   e) Viscosity
   f) pH



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Best Practices

Be Data Driven

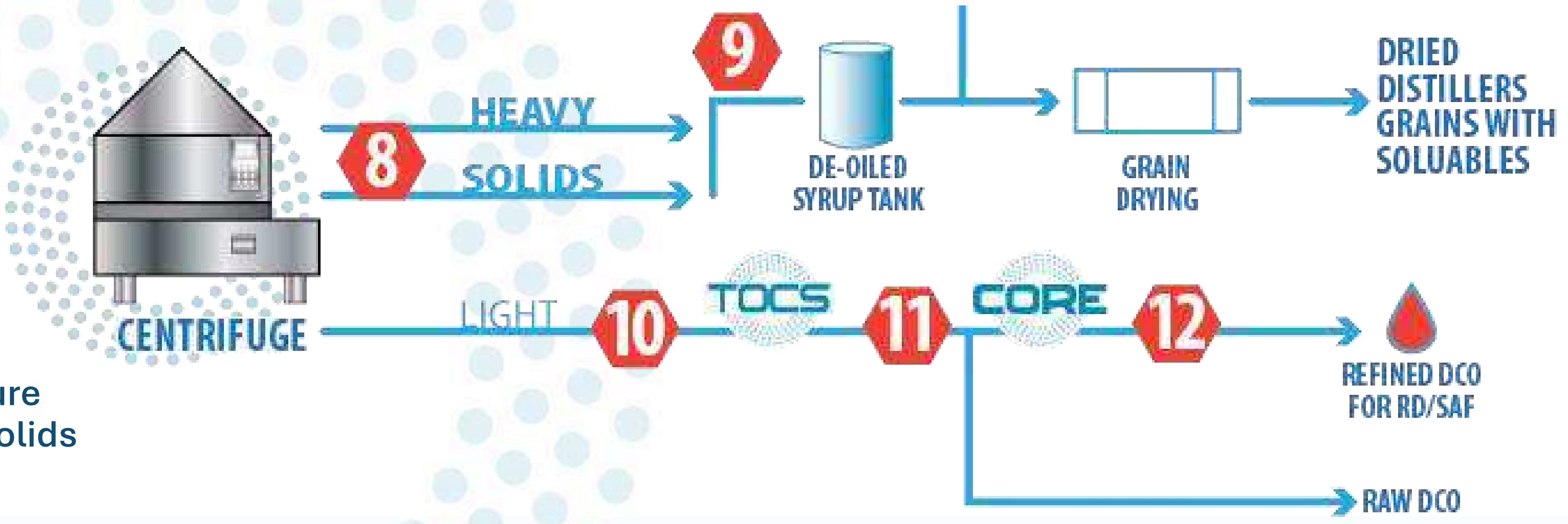
8. Heavy Phase
9. De-Oiled Syrup
    a) Volume Spin
    b) Microscope

10. Light Phase
    a) Volume Spin

11. Finished DCO
    a) Volume Spin
    b) Karl Fischer Moisture
    c) Total Suspended Solids

12. Refined DCO
    a) Volume Spin
    b) Karl Fischer Moisture
    c) Total Suspended Solids
    d) Free Fatty Acid
    e) Metals
    f) Silicon

What to Test



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Thank You!

Take your DCO potential to new heights.

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