The Effect of Removing Dust from Backup Stuccos on Shell Properties

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Purpose of this Study

A recent trial of Virginia Mullite™ 20x50 stucco product generated a comment on the amount of dust coming out of the rainfall tower.

Kyanite Mining Corporation (KMC) was asked if lowering the amount of fines was possible

After several operational changes, a stucco with less -50 mesh particles was produced

KMC wanted to evaluate this new material to determine if removing the fines would have a negative effect on the properties of the shell

Outline

Creating a new 20x50

Historical Data

Test Setup

Results and Discussion

- Screening
- MOR
- Shell Thickness
- Permeability

Creating a new 20x50-The Starting Point

KMC has had both a 20x50 and 50x100 Virginia Mullite™ stucco for many years

While the nomenclature suggests a tight closed-screen product, there has always been a large amount of -50 mesh in the 20x50 and -100 mesh in the 50x100

Historical data shows that the amount of fines in these products, defined as either -50 or -100 mesh particles, averaged between 20-30%

KMC decided to attempt to create a new product that had a much tighter limit on the number of fines to reduce nuisance dust when using either stucco

Creating a new 20x50-Target Specifications

The production plant was given a task to create a new 20x50 product with less -50 mesh particles

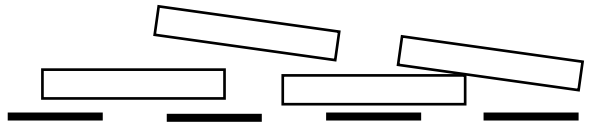
	Retained on Screen (%)			
	20m	40m	50m	pan
Old 20x50	1	27-42	30-50	30 max
De-Dusted 20x50	<1	93 min		<6

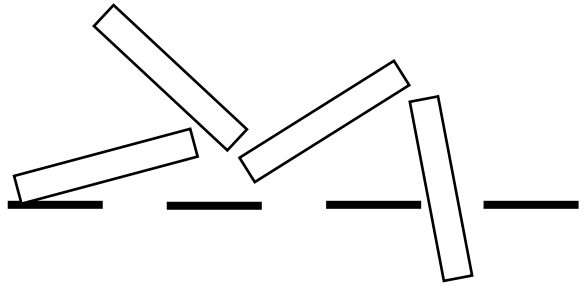
Creating a new 20x50-Production Difficulties

1st Attempt: Lower Feed Rate to reduce the amount of product on the screen-increase screening efficiency

Result: Caused higher amount of vibration on screens

- Mullite is an acicular crystal with a high aspect ratio
- In normal screening, the crystals lay flat with the long axis in contact with the screen
- As feed rate was decreased, the weight on the screen decreased
- This caused the crystals to jump on the screen
- Now, some mullite crystals could pass through the screen on their ends
- Led to decreased recovery of 20x50 particles





Creating a new 20x50-Production Difficulties

2nd Attempt: Change the Bottom Screen-Changing the bottom screen should allow the fines to pass through more easily

Result: In order to get <6% in the pan, the bottom screen had to be made more coarse than desired, i.e. 40 mesh screen

- This also resulted in a significant decrease in 40x50 recovery from the product stream

Creating a new 20x50-External Assistance

The production facility tried every screen and feed rate trick and never could make a better 20x50 product at a suitable rate

KMC reached out to two screen suppliers for help

Product was sent for screening offsite at each supplier’s lab

Creating a new 20x50-Changes for Success

After working with the screening companies, the following changes were made:

1. Changed the size of the bottom screen to allow the fines to pass more easily-not nearly as drastically as KMC tried previously
2. Added an additional screen in the middle of the screen stack. This helped to reduce the load on the final screen and improve screening efficiency
3. Adjusted the position of counterbalance weights to control the bounce of the product and retention time on top of the screen
4. Ultimately, a new screening device will be purchased for increased load and efficiency

Literature Review-Changes in Stucco Size

Existing literature was searched to predict how changing the sizing of the stucco would affect the performance of the shell

- There has been a lot of work done in the past on changes in particle size distribution on slurry rheology, but not a lot done on the stucco

Most of the work done to examine stucco effects was done on fused silica

- Little data on changes in stucco size of aluminosilicate stuccos was found

Literature Review-Changes in Stucco Size

Studies showed that increasing particle size of the stucco typically led to three things:

1. Weaker post-fired MOR
   - Coarser stuccos typically lead to a narrower particle size distribution (PSD)
   - Wider distributions are known to create a ceramic body with better particle packing
     - Small grains able to fill in void space between larger grains
   - Fine mesh particles also have a larger amount of surface area than coarse particles
     - Higher surface area=more surface energy
   - A combination of better particle packing and higher surface energy leads to improved sintering, and therefore a stronger post fired MOR

Literature Review-Changes in Stucco Size

Studies showed that increasing particle size of the stucco typically led to three things:

2. Thicker shells/faster shell build
   - A coarser stucco means larger particles, increasing the thickness of each layer
3. Increased permeability
   - Smaller particles filling in void spaces reduces the amount of unblocked passageways, reducing permeability

Literature Review-Stucco Application Method

While researching for how stucco size effects shell properties, it was found that several papers have investigated the effect of stucco application technique on the properties of the shell

Since KMC has customers that use rainfall and fluid bed stucco procedures, it was decided both should be utilized while testing this new stucco

Literature Review-Stucco Application Method

A review of the literature showed the stucco application method effects the following properties of the shell:

1. Rainfall sanding produces a shell with higher MOR Values
   - The stucco gains kinetic energy as it falls
   - The increased kinetic energy allows the stucco to penetrate deeper into the slurry layer
   - This coats the stucco grain more thoroughly with slurry and creates a stronger bond

Literature Review-Stucco Application Method

A review of the literature showed the stucco application method effects the following properties of the shell:

2. Fluid beds produce a thinner shell than rainfall methods
   - This is due to the deeper penetration of the stucco into the slurry layer due to the increase in kinetic energy
3. Fluid beds create a more permeable shell than rainfall methods
   - This can also be attributed to the better bonding between particles due to increased stucco penetration into the slurry layer

Hypothesis

Samples made with the new de-dusted stucco will have:

- A lower post-fired MOR
- Increased shell thickness
- Increased permeability

Test Setup-4 Testing Conditions

To test for any negative effects on shell performance due to the particle size change, 4 conditions were tested:

1. “Old RD”- Old stucco applied with a rotary drum sander
2. “Old FB”- Old stucco applied with a fluidized bed
3. “DD RD”- New De-Dusted stucco applied via a rotary drum sander
4. “DD FB”- New De-Dusted stucco applied with a fluidized bed

Test Setup-Slurry

The slurry was kept constant throughout the build

- 200 mesh Virginia Mullite™ slurry
  - 80% solids
  - Large particle colloidal
  - Latex polymer
  - Surfactant to aid in wetting the wax
  - Sufficient antifoam to combat bubbles
- Viscosity held to EZ5=20 seconds

Test Setup-Shell Build

Wax coated metal bars were used to create MOR bars and permeability samples

8 layers of slurry and stucco followed by a seal coat

Bars were hung in a temperature/humidity cabinet until dry

- Minimum of 4 hours

Excess stucco was removed before each dip

Test Setup-MOR

MOR Testing

- ASTM C133-97
- 6x1 inch bars
- Green and post fired at 2400°F (1315°C)
- Flat wax surface facing downward in tension

Test Setup-Permeability

Samples tested at Buntrock Industries Inc. Technology Lab

The test method used was a permeability test presented by Branscomb at the 52nd ICI Technical Conference and Expo

Tests done on green and post-fired bars-2400°F (1315°C)

Results and Discussion-Screening

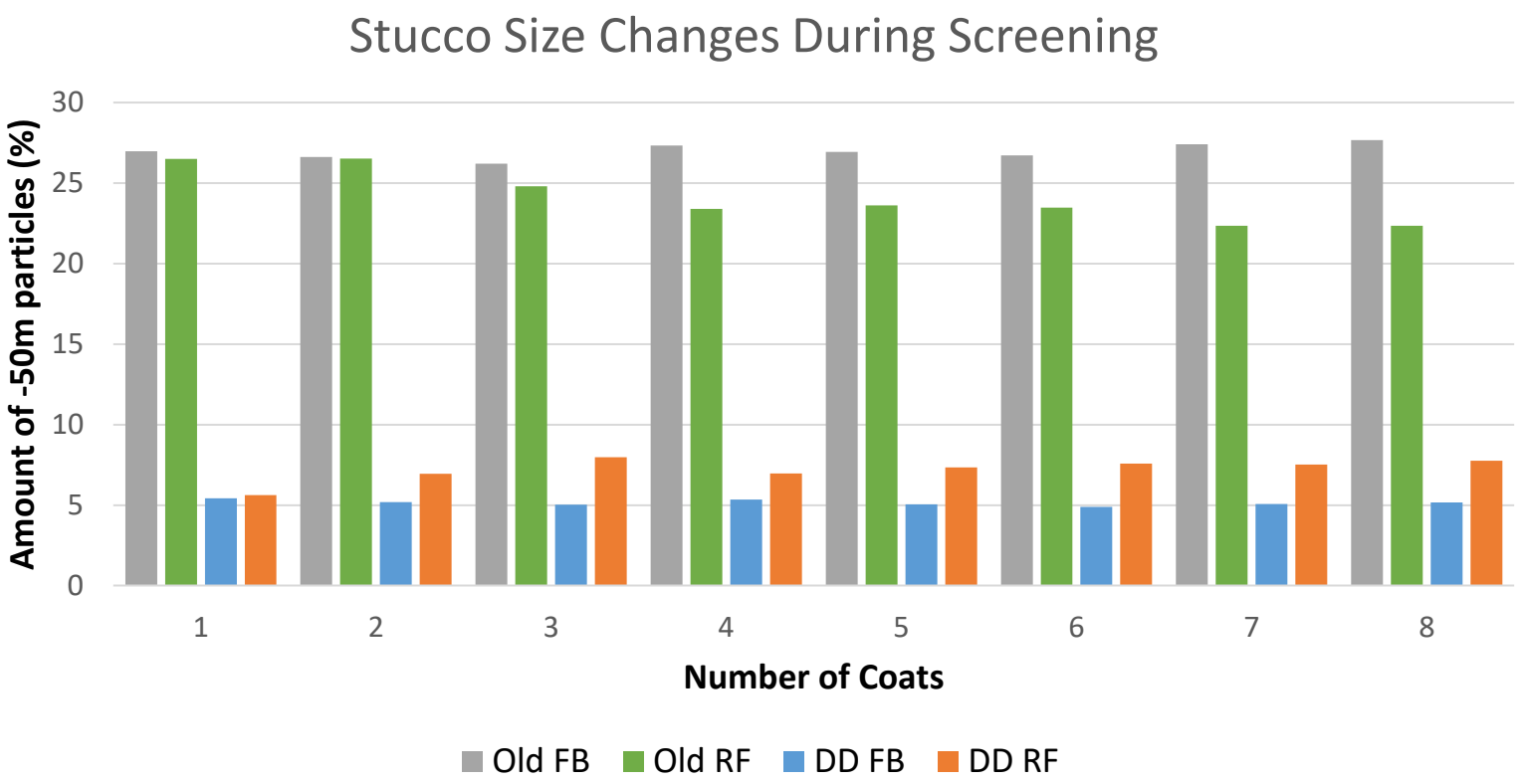
Samples of stucco from each of the 4 conditions was taken for screening before each layer to examine change in PSD over time

	Starting Mesh Size							
	20	30	40	50	70	100	140	pan
Old RD	0.00	0.38	25.13	47.98	25.18	0.99	0.16	0.19
Old FB	0.00	0.16	26.71	46.15	25.60	1.06	0.12	0.20
DD RD	0.00	9.56	41.16	43.67	5.15	0.19	0.13	0.15
DD FB	0.00	8.03	45.33	41.21	5.12	0.17	0.05	0.09

The DD stucco was significantly coarser with much higher amounts of +30 mesh particles

DD also had much less -50 mesh material

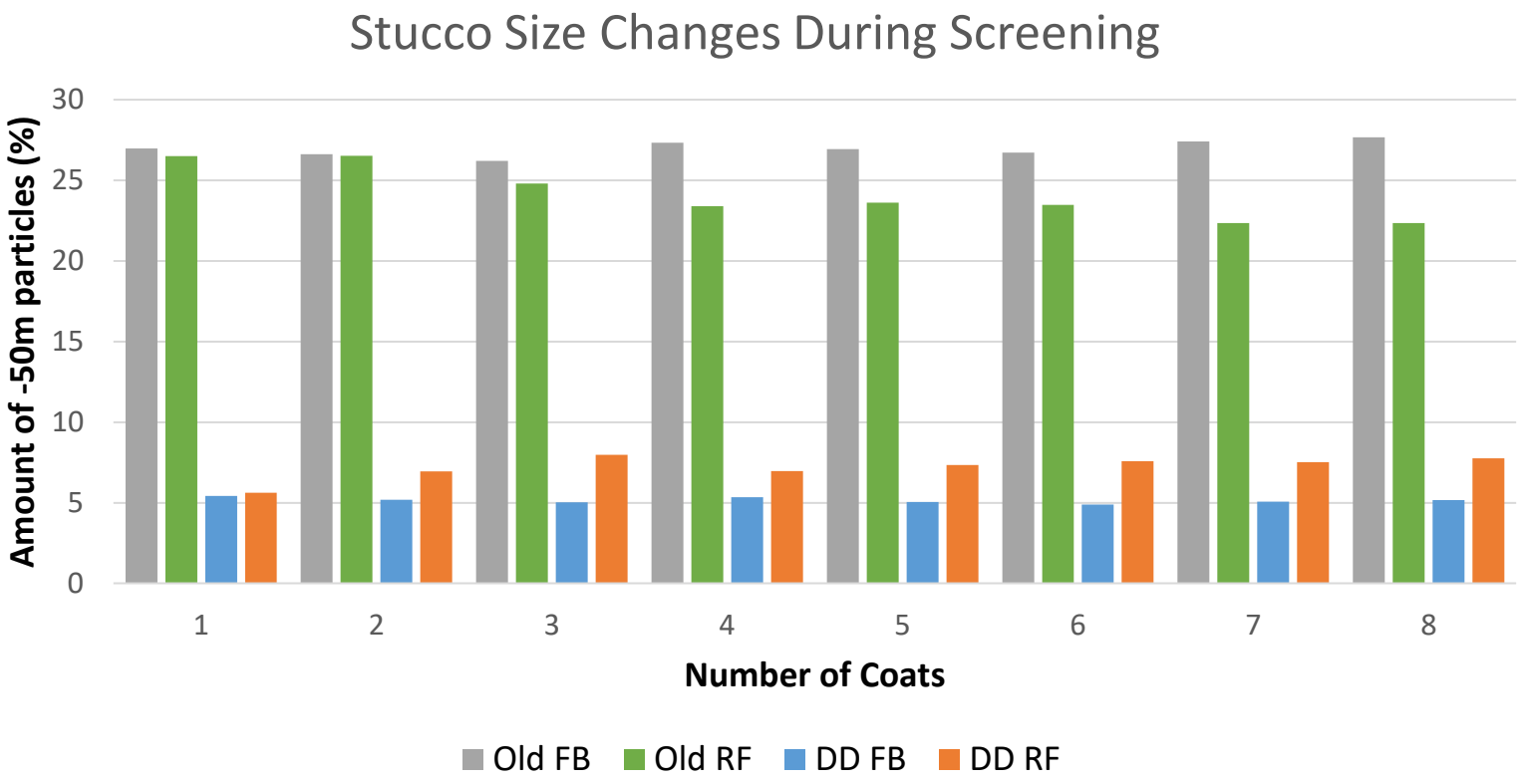
Results and Discussion-Screening



Amount of fines in both FB samples did not change much over the course of the testing

- Some inconsistency in the middle coats for Old FB but overall less than 1% change from 1st to last coat
- Could indicate improper dust collection over the fluid bed

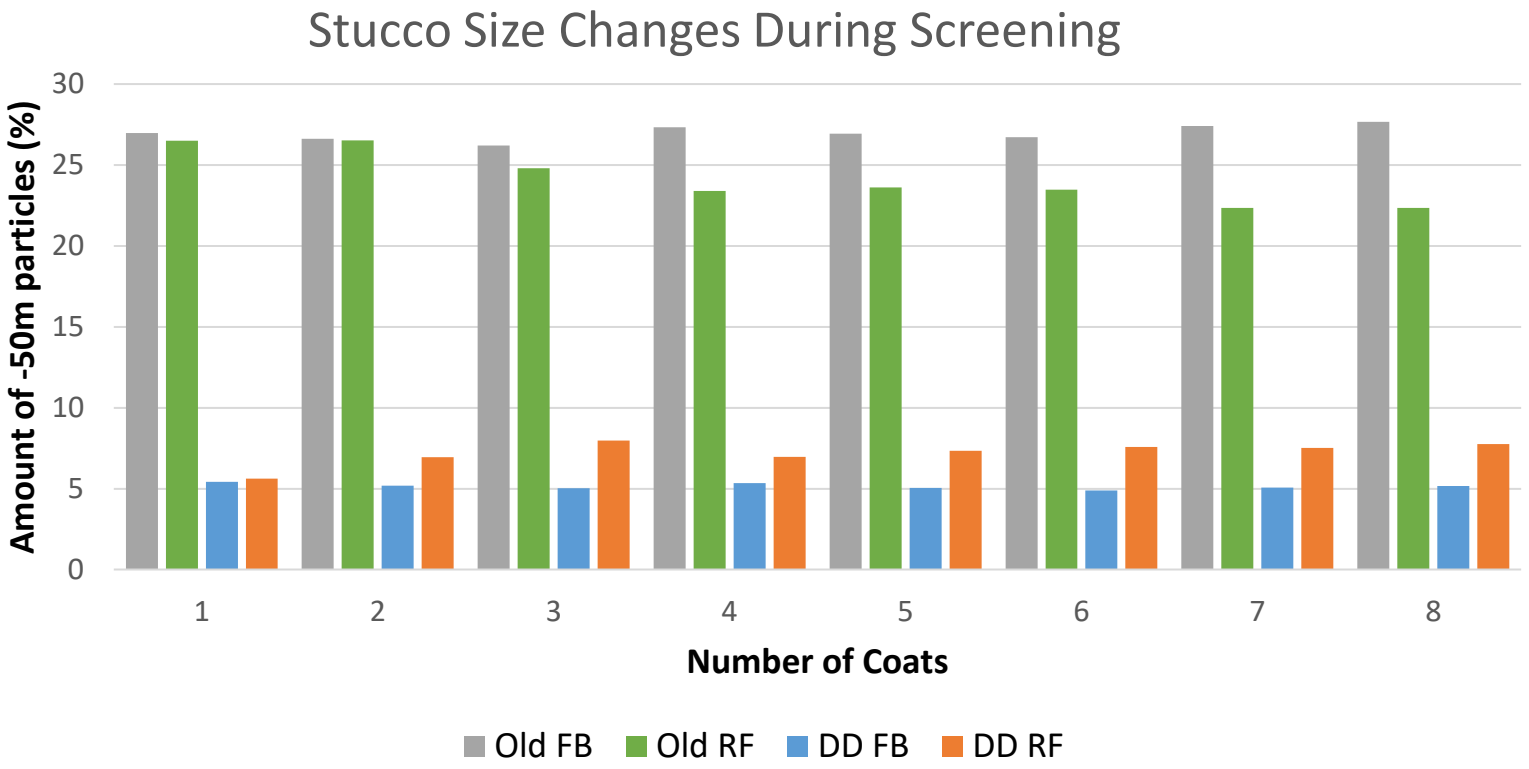
Results and Discussion-Screening



Old RD lost ~4% between 1st and last application

- Likely lost as nuisance dust to the environment

Results and Discussion-Screening



DD RD gained 2% between 1st and last application

- Fines reached a high point on 3rd coat then remained consistent throughout the test
- Friable nature of mullite
  - Sharp corners break off and weak crystals break
- By the 3rd coat, all the weaker particles have broken

Results and Discussion-Screening

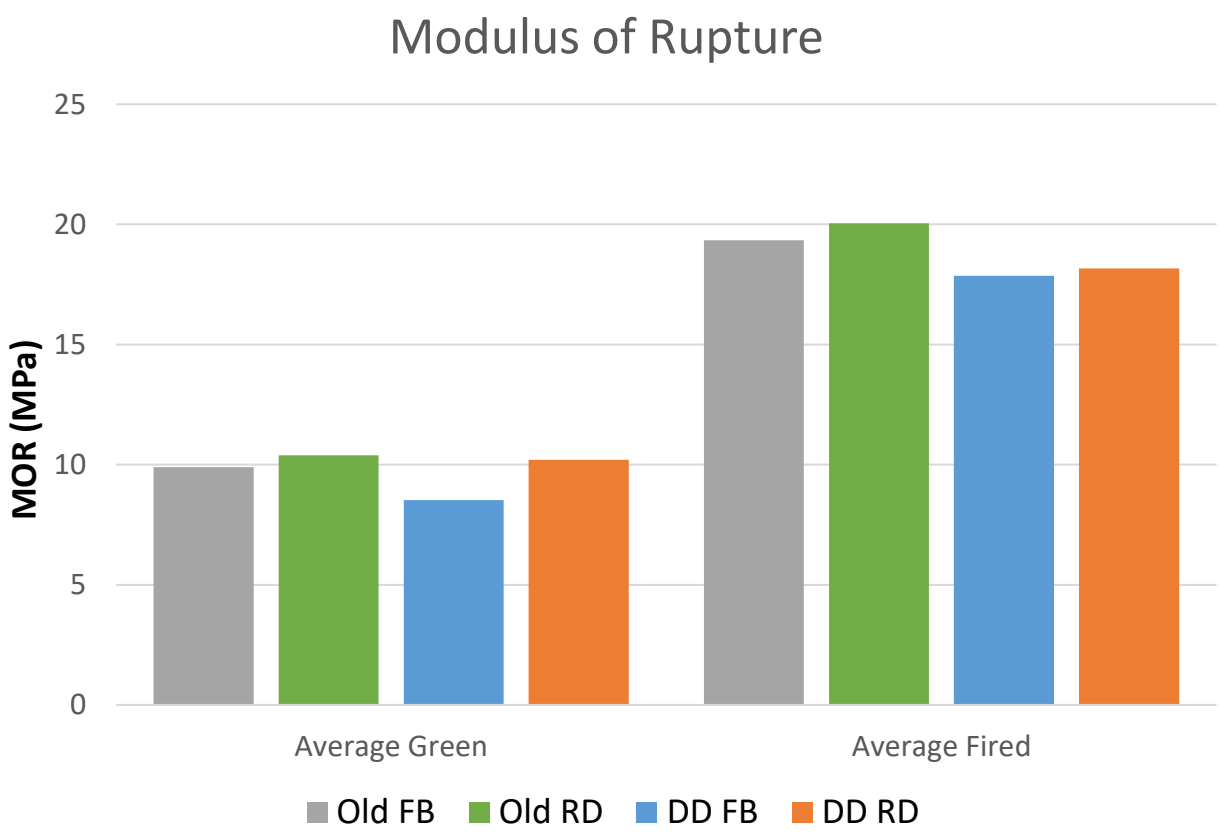
The results of the screening test indicate the DD stucco will not cause a lot of issues with nuisance dust, accomplishing the goal set forth by the customer

- Cleaner work environment
- Less bag house maintenance

Dust loss data also suggests that dustier stuccos should be run for a while before use each time new material is introduced to the sander to limit operator exposure

But how does this effect shell properties?

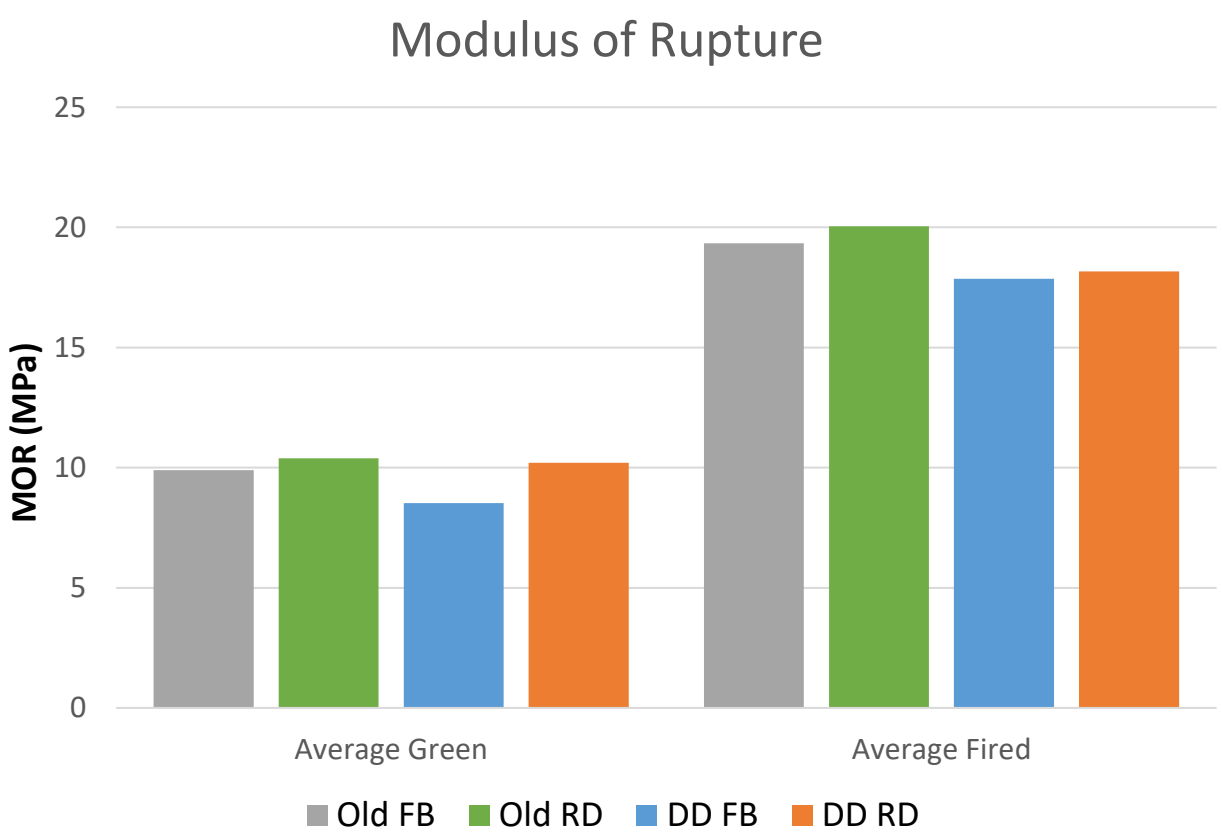
Results and Discussion-MOR



Green MOR was very similar in 3 of the 4 conditions

- The DD FB was 16% lower than Old FB
- Not entirely sure why this happened
- More testing will be done to confirm or deny this result

Results and Discussion-MOR

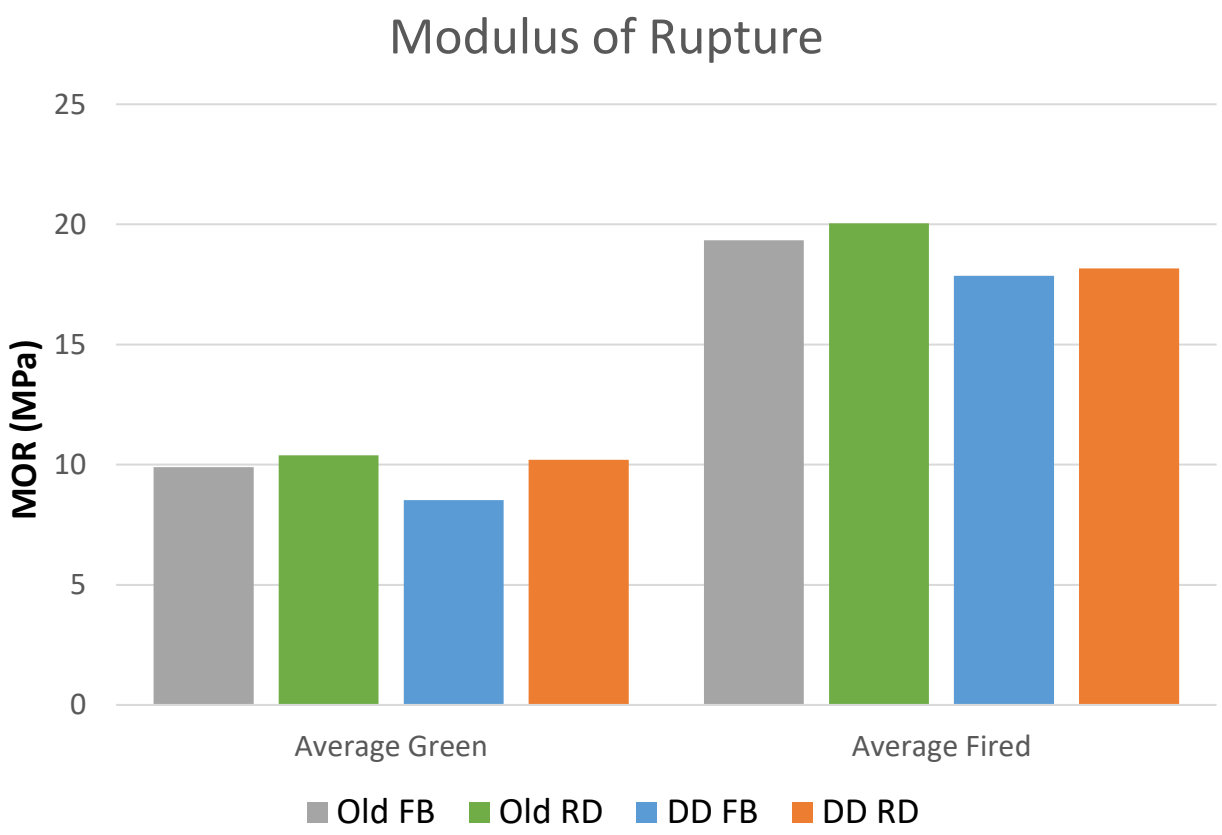


Both Old stuccos had a higher post-fired MOR than the DD stuccos

- 10.3% for RD and 8.3% for FB
- Wider PSD led to better sintering
- Agrees with the data in the literature search

A lower post-fired MOR may seem like a bad thing, but could lead to easier knockout of the shell

Results and Discussion-MOR



Fired MOR made via the FB had lower MOR values than those made with the RD

- Extra kinetic energy helped the stucco penetrate the slurry layer more deeply to create better bonding
- Agrees with data in the literature search

Shell Thickness

DD stucco created a thicker shell

- Expected as similar results were seen in the literature
- 6% thicker on average
- Presence of larger +30 mesh particles (where there we basically none in the Old stucco)
- Removal of dust also seemed to have an effect
  - Videos of the stucco application showed dust starting to coat the bars as soon as it was introduced to the sander, making it harder for larger particles to properly adhere to the surface
- This may help with shell build, but 6% is not a large increase and likely wouldn’t have an effect overall

Shell Thickness

Bars made with the FB were thicker than when using the RD sander

- Due to deeper penetration of the stucco into the slurry layer due as mentioned previously
- Also agrees with data from the literature search

Permeability

Samples made with DD had a higher permeability than the Old

- Reduced amount of fines less likely to settle between larger particles
- Allows for more open passages through the shell, creating higher permeability

Samples made with the FB had higher permeability than the RD

- Less stucco penetration into the slurry means less coverage of the particles
- Creates a shell with fewer void spaces, and thus higher permeability

Both findings conform to the data found in the literature

Conclusions

Screening results indicate that the DD stucco does not lose fines to the environment throughout the stuccoing process

- Indicates that nuisance dust will be less of an issue for the operators

Removing these fines created a shell with:

- Slightly lower MOR-better for knockout
- Thicker shell-due to coarser particles overall and less fines coating the slurry layer
- Increased permeability

Conclusions

Applying stucco via a rotary drum sander vs a rainfall sander created a:

- Shell with a higher post-fired MOR
- Thinner shell
- Less permeable shell

These characteristics can be explained by the effects of increased kinetic energy when using a rainfall style sander

- More penetration into the slurry layer, creating a more monolithic shell

Conclusions

KMC feels the goal of a less dusty product was achieved and is ready for another trial with the customer

- While the change did slightly alter the properties of the shell, removing the fines did not have a significant negative impact

KMC has already begun the same process of making a tighter closed screen PSD on its 50x100 stucco and hopes to see similar results

Thank you for your time and attention!

Questions?