Crushing
Principles of Mechanical Crushing

QUARRY ACADEMY

Improving Processes. Instilling Expertise.

DYNO
Dyno Nobel

SANDVIK

QUARRY ACADEMY

Objective

Explain the interaction between

rock material

and

crusher

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Take home messages

The Take Home Messages will address:

- Trouble Shooting
- Improve Yield
- Improve Performance

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Agenda

- Crusher Application
- Cone Crusher Operating Principle
- Crusher Capacity
- Crusher Operation
- Crushing Chamber Design and Selection
- Conclusions

NCC, Borås, Sweden

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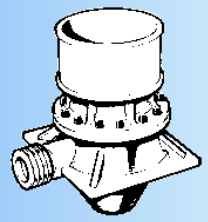
Crusher Selection

Feed size

5” 15” 20” 40” 60”



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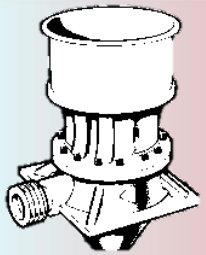

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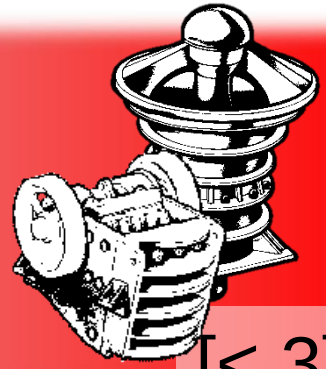

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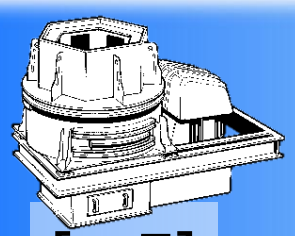

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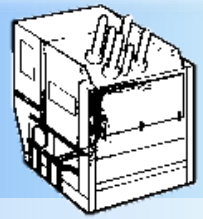

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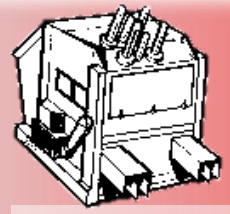

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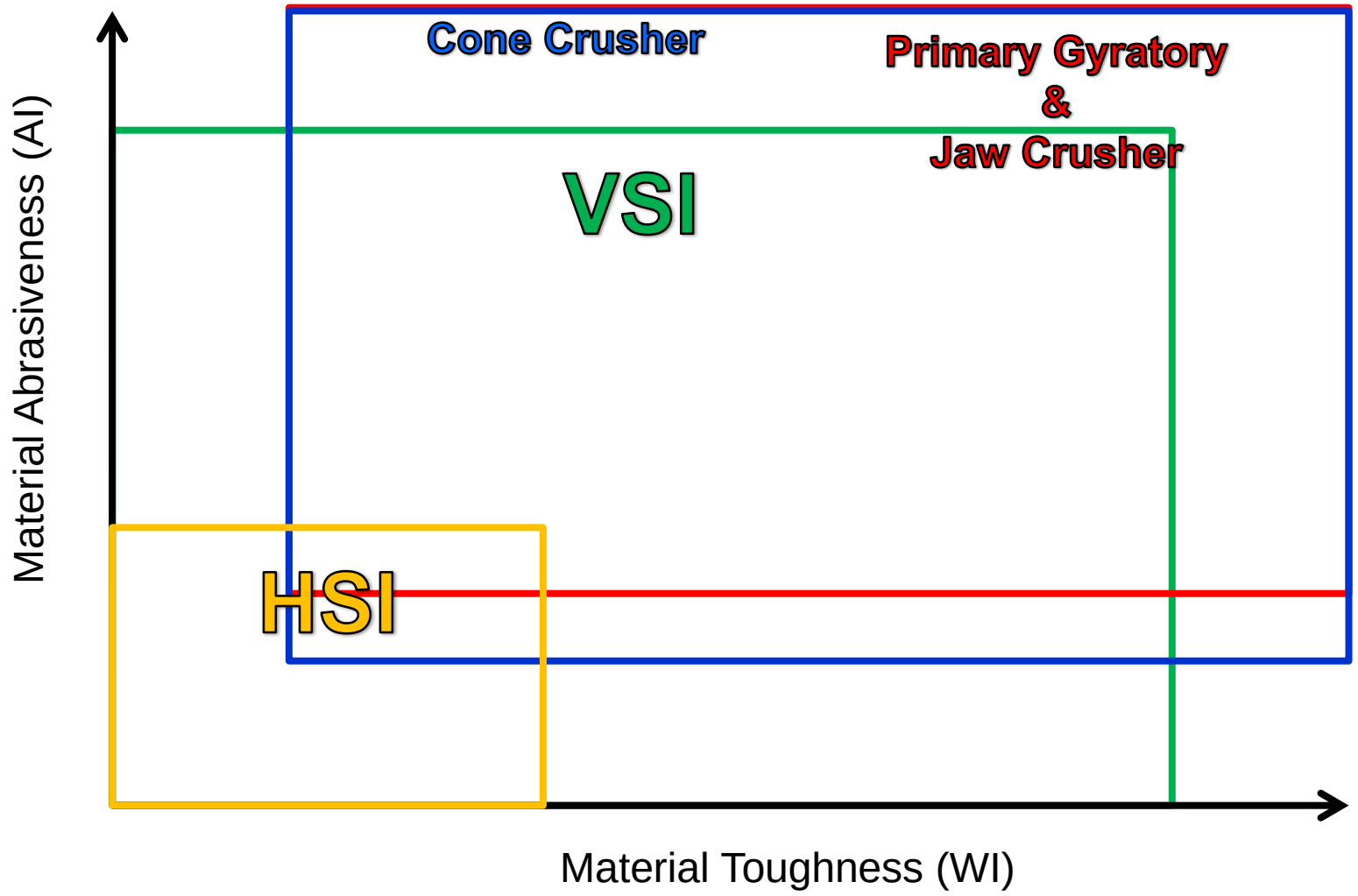
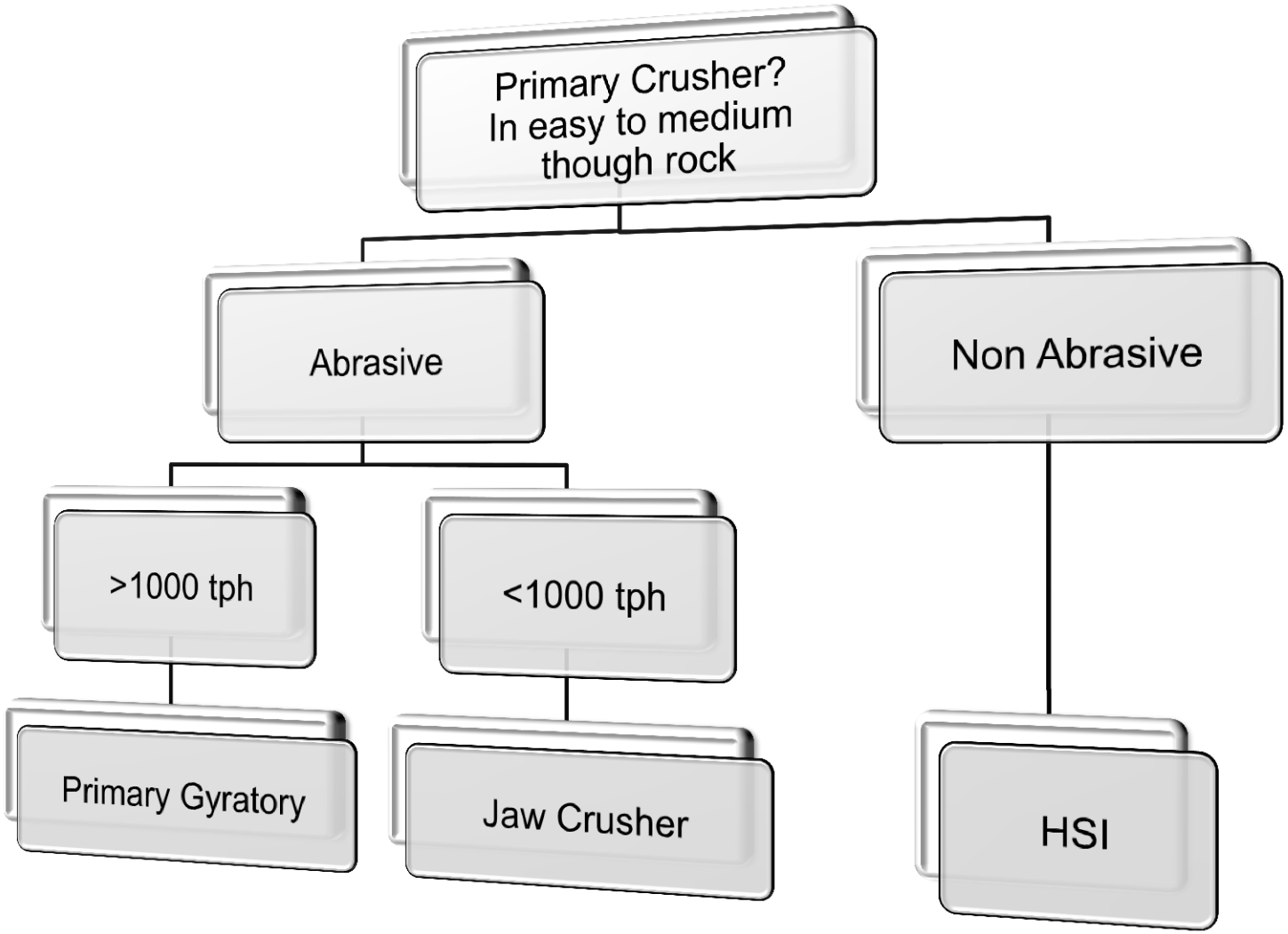
Crusher Selection



QUARRY ACADEMY

Crusher Selection



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Cone Crusher

- Why Cone Crusher?
- The cone crusher design concept is an effective and smart way of realizing compressive crushing
- Aggregate Production
- Mechanical Liberation of Valuable Minerals

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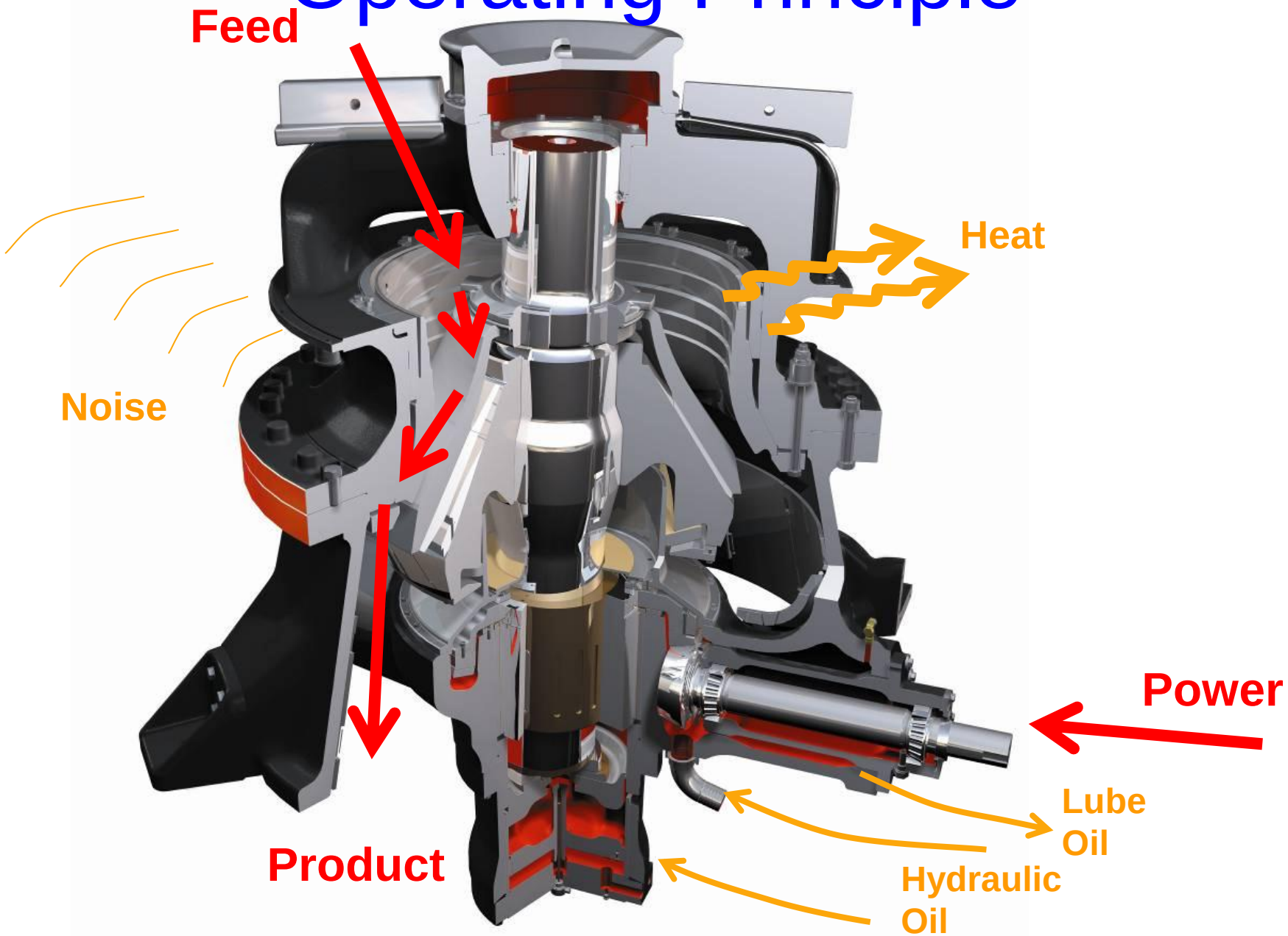
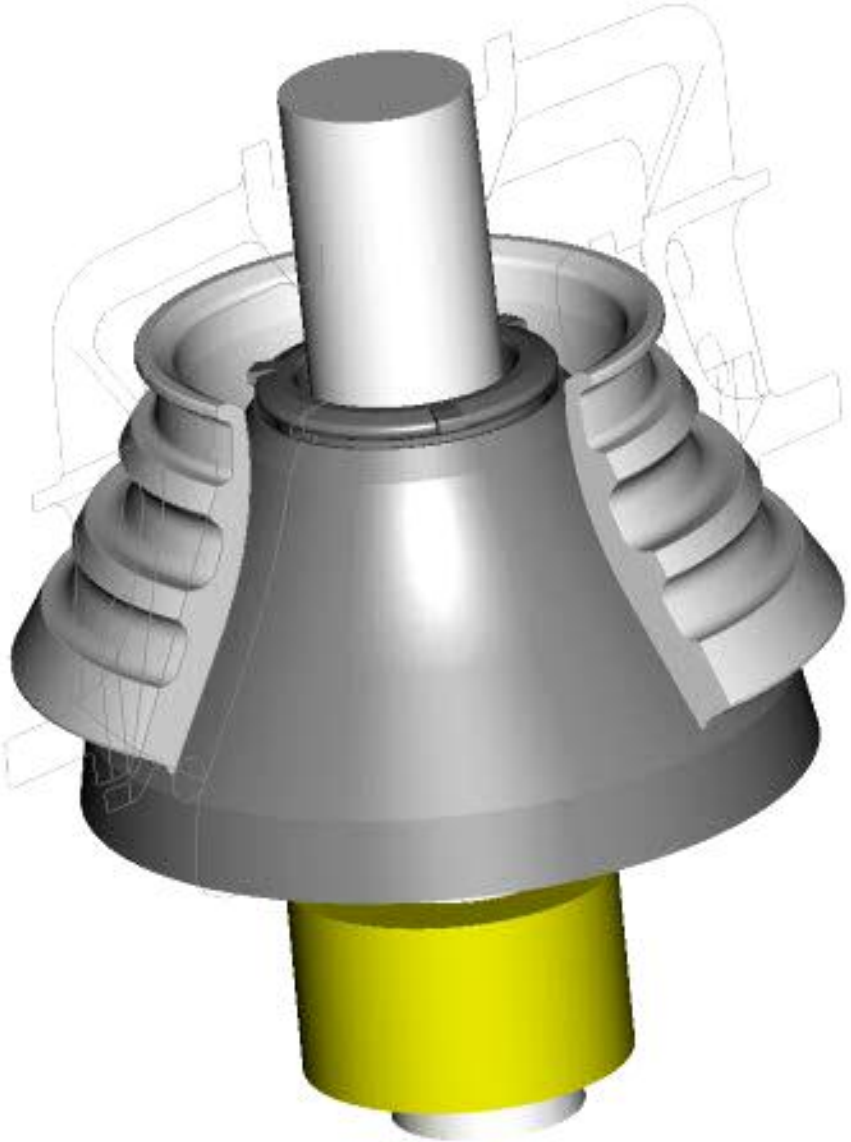
Operating Principle



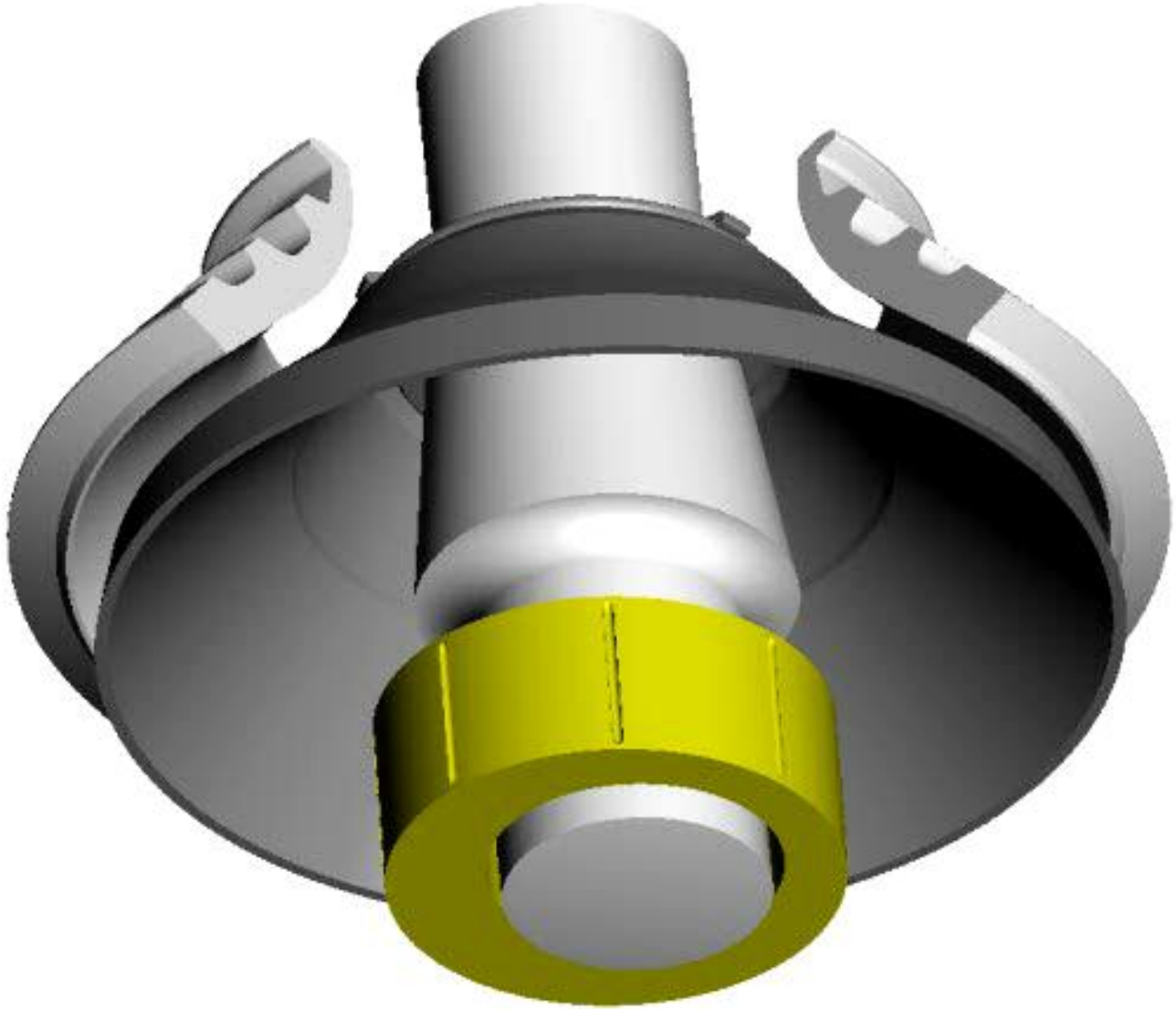
QUARRY ACADEMY

Operating Principle



QUARRY ACADEMY

Operating Principle



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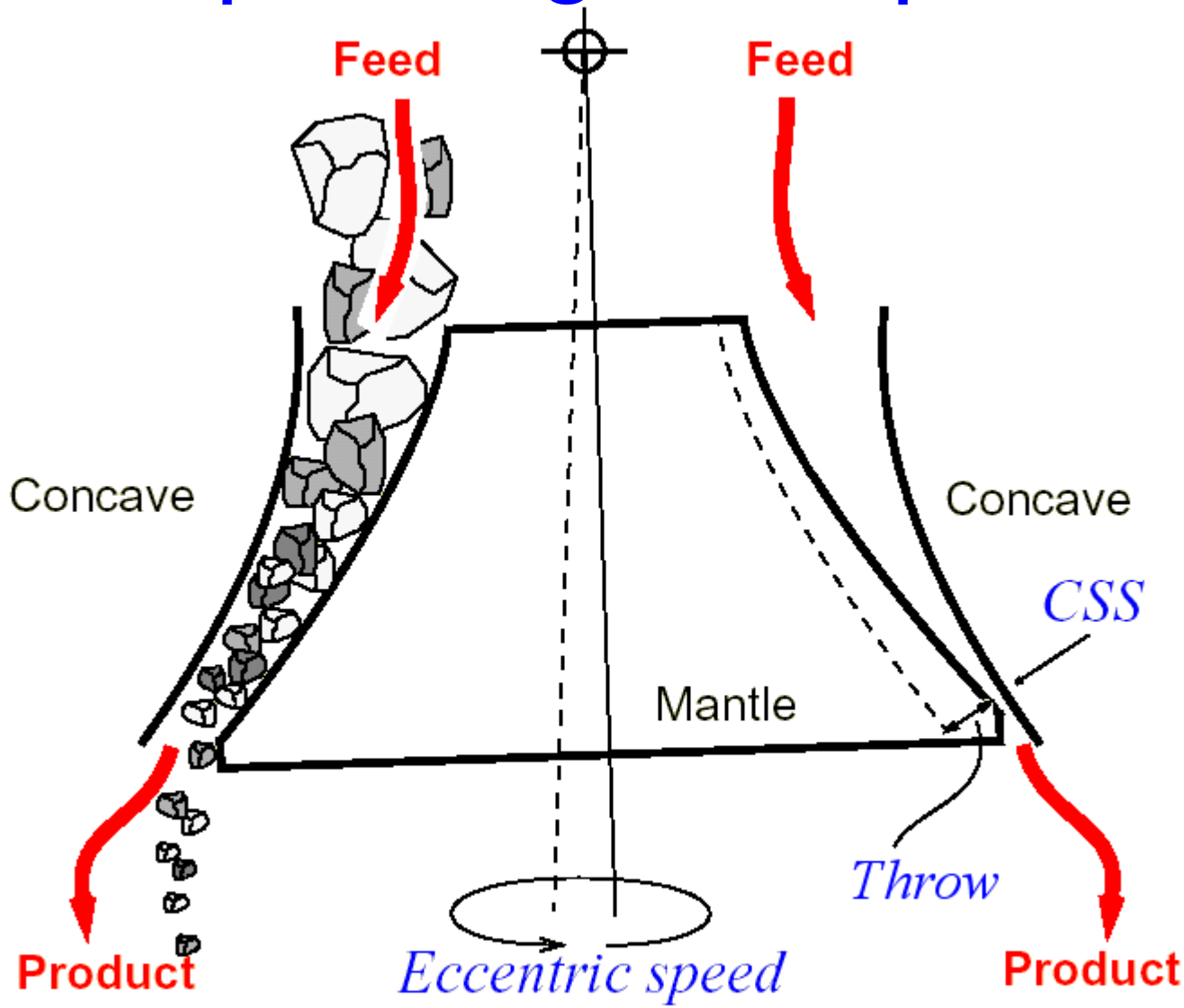
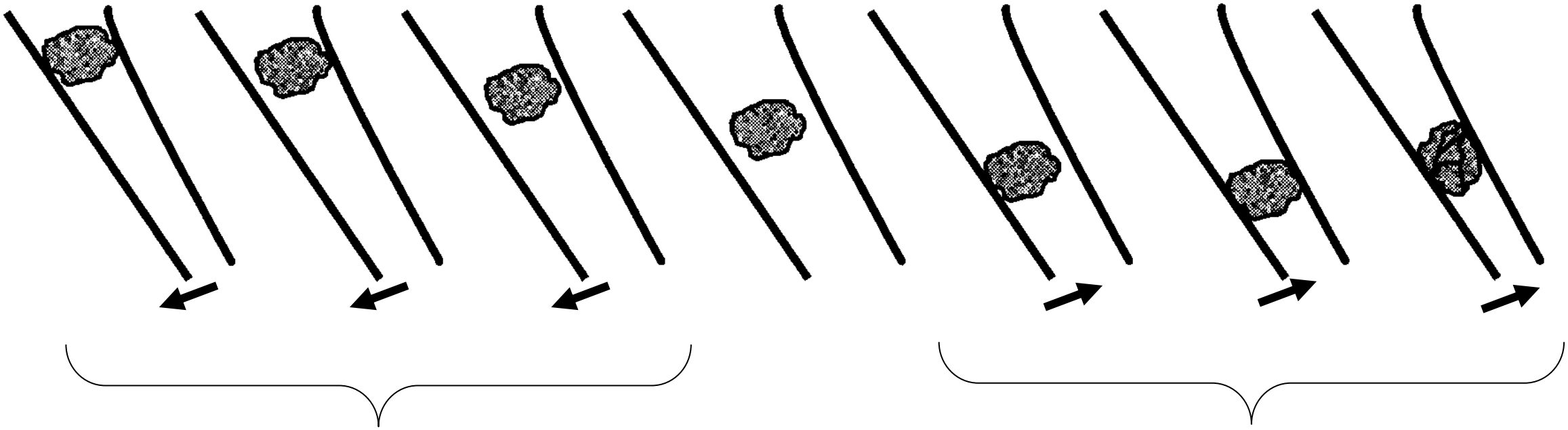
Operating Principle



OSS=CSS+Throw

QUARRY ACADEMY

Operating Principle

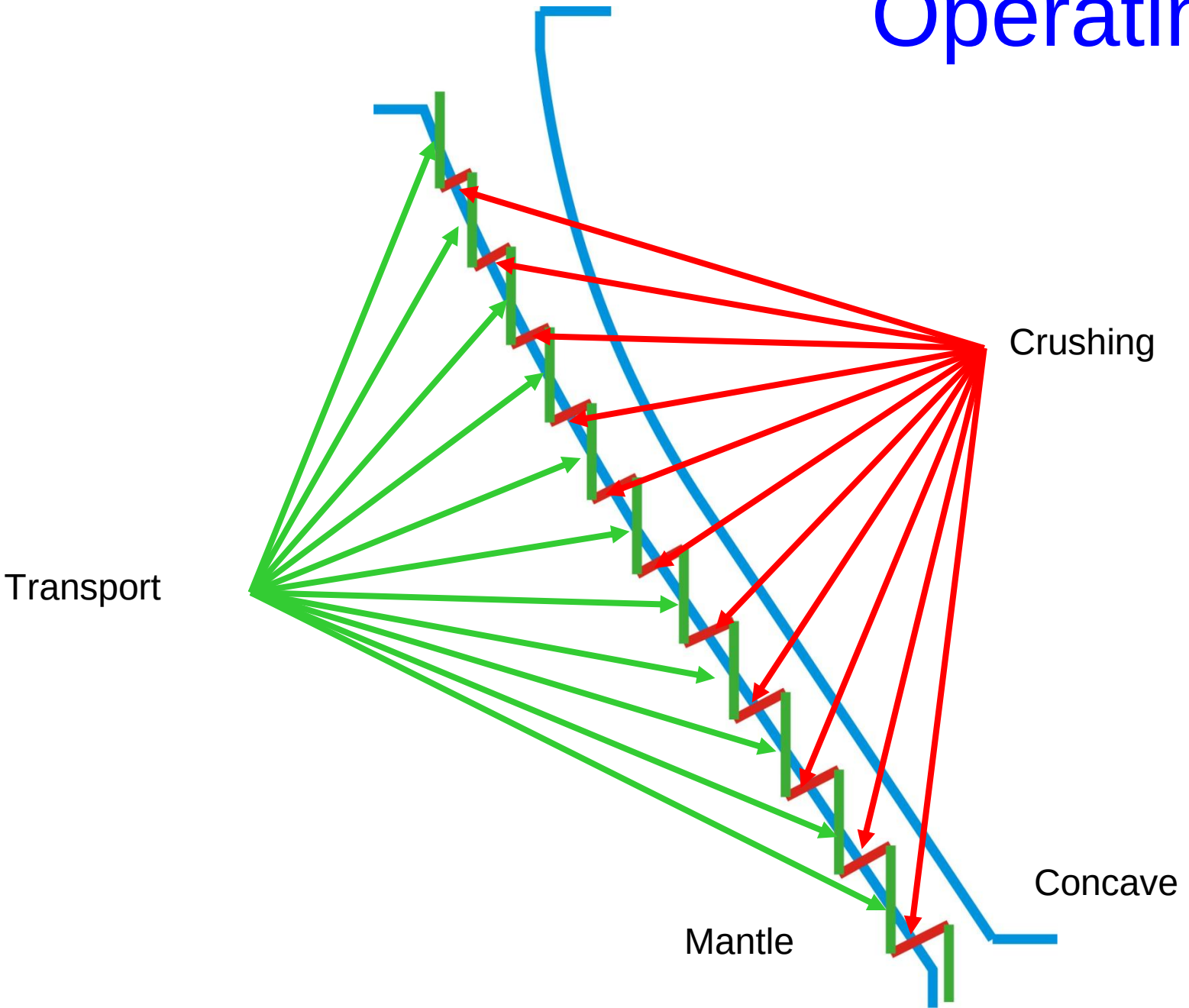


Opening Phase = Transport

Closing Phase = Crushing

QUARRY ACADEMY

Operating Principle



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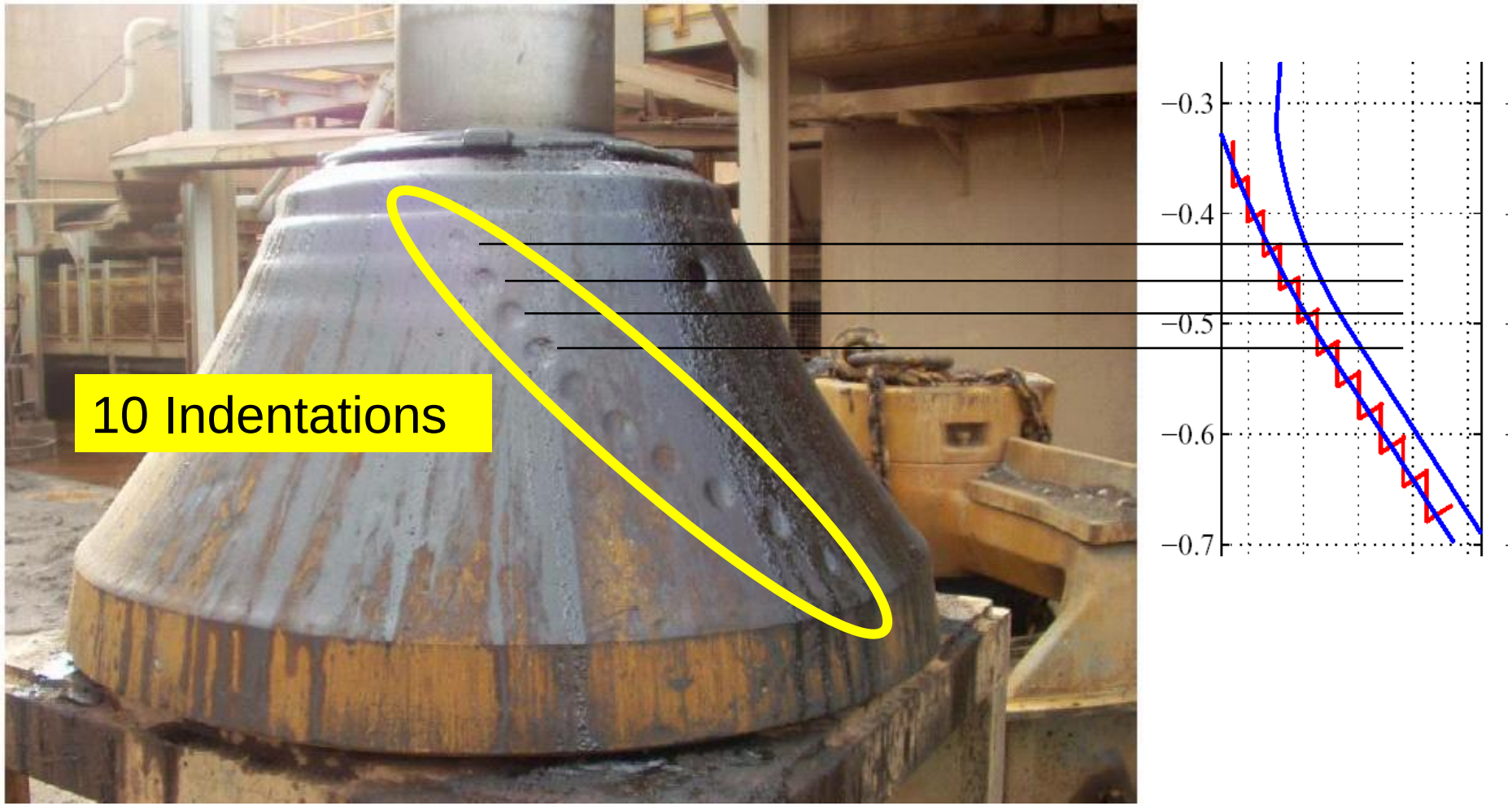
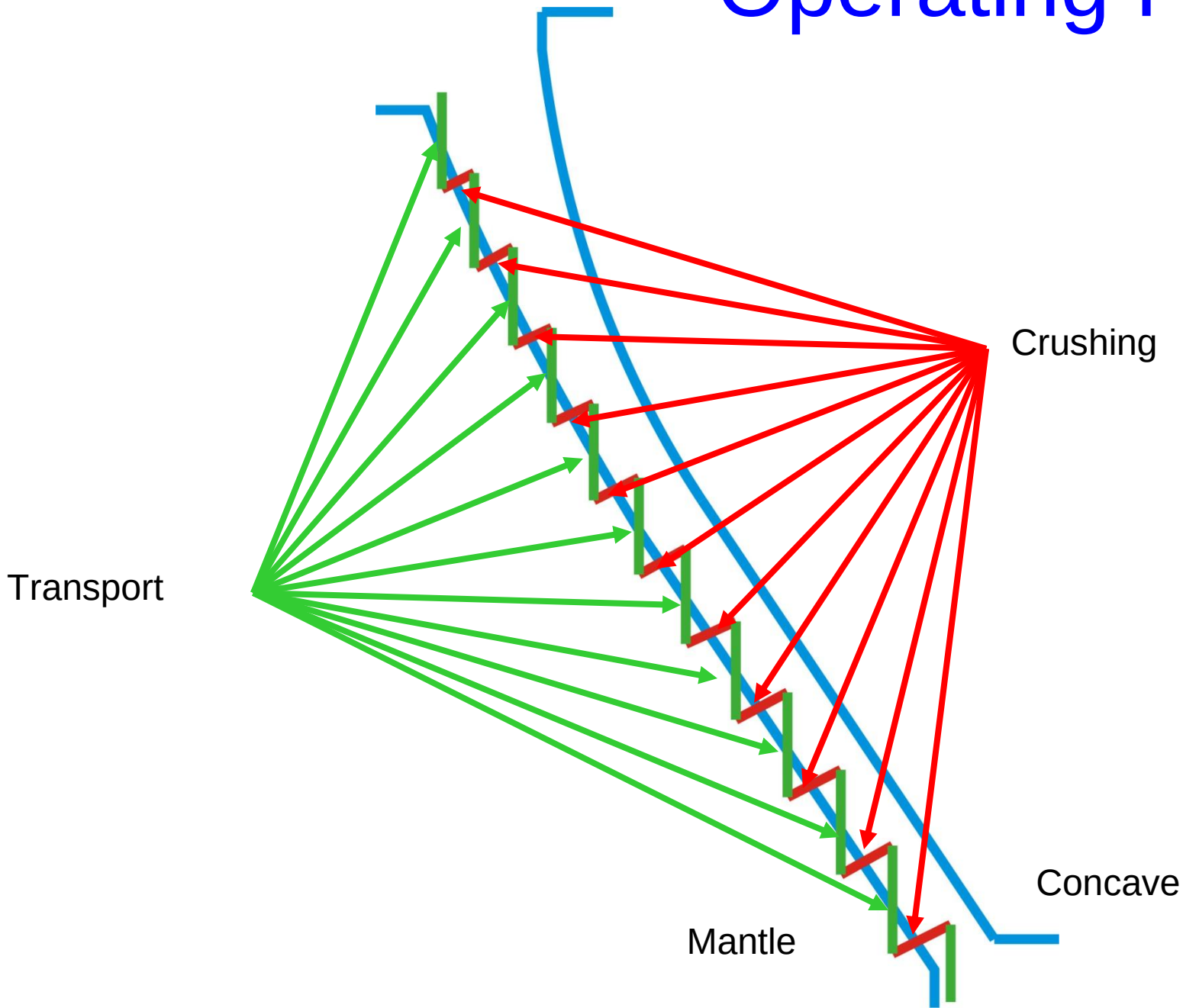
Operating Principle



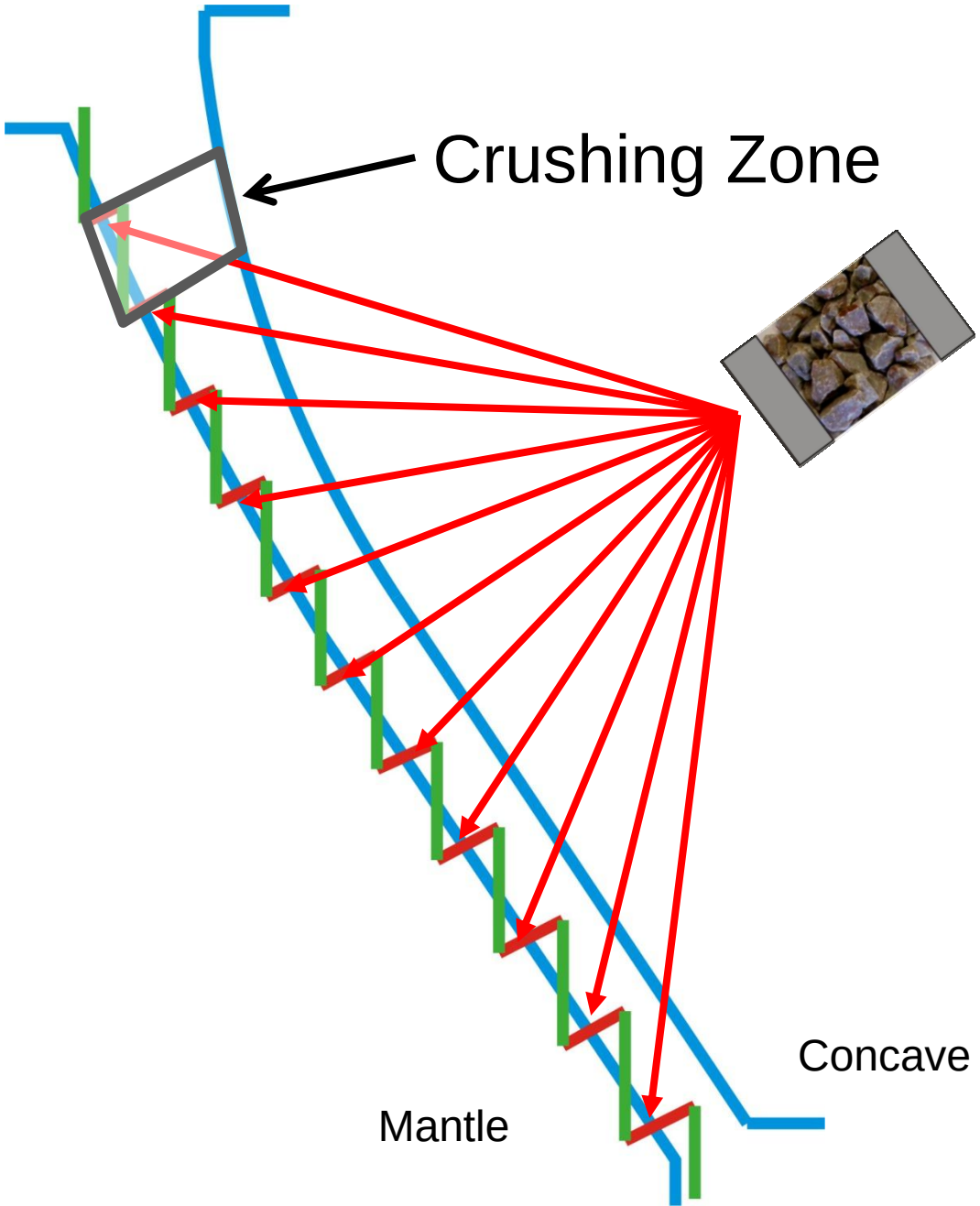
QUARRY ACADEMY

Operating Principle



QUARRY ACADEMY

Operating Principle



Single Particle Breakage SPB

Inter Particle Breakage IPB

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Operating Principal

- In a cone crusher the stones are crushed with both SPB and IPB as the material moves down through the chamber.
- The relative amounts of IPB and SPB depends on factors like chamber design, crusher geometry, speed, css, eccentric throw, and others.

SPB

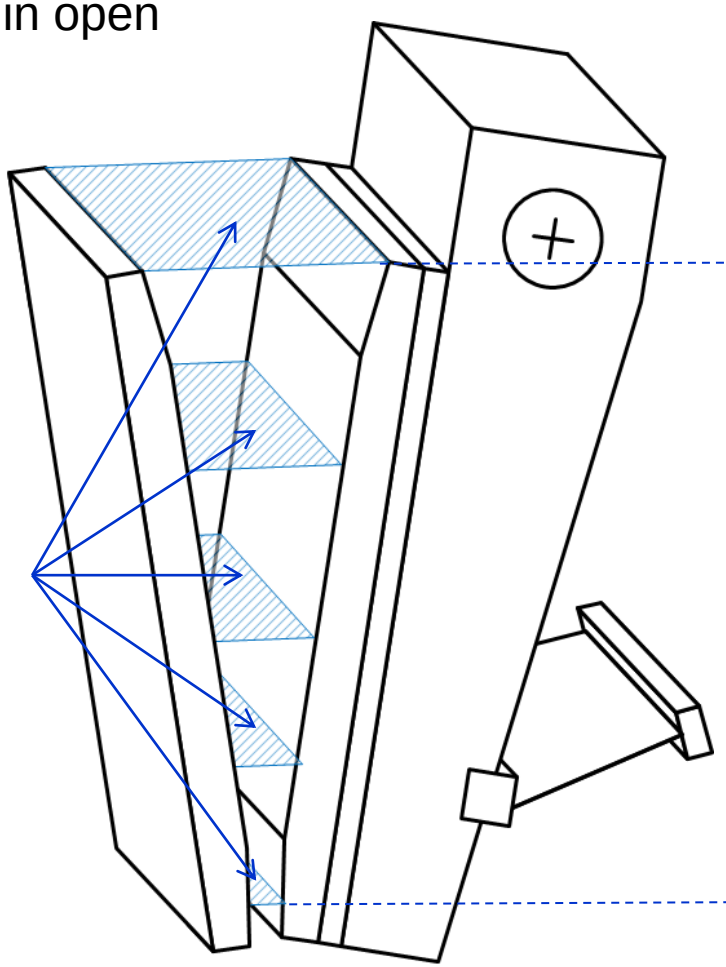
IPB

Fines	Less	More
Shape	Flaky	Cubic
Force	Low	High

QUARRY ACADEMY

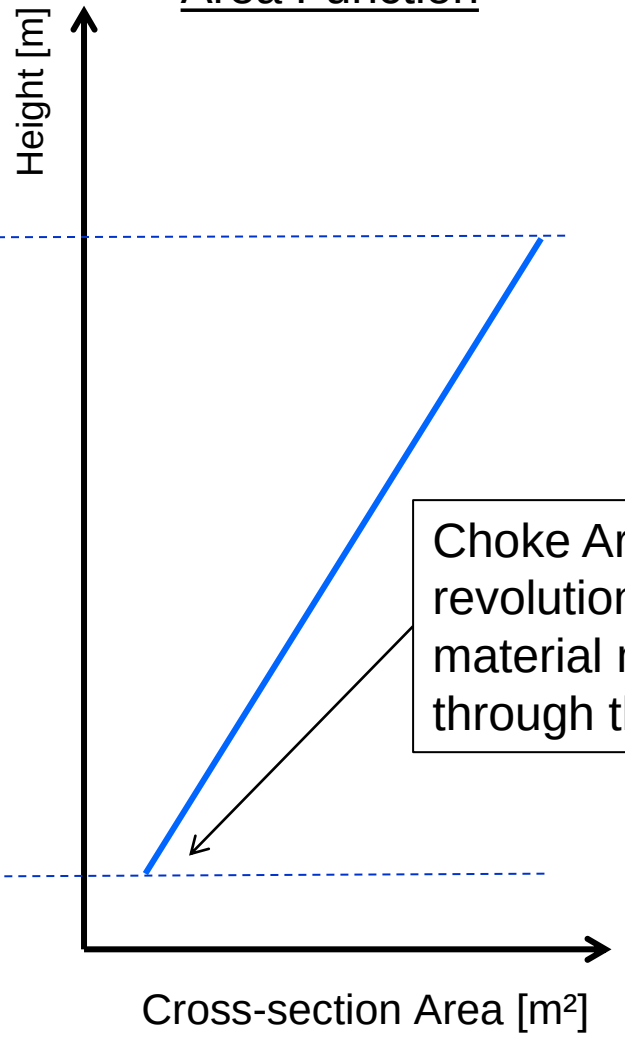
Crusher Capacity

Crusher in open position



Cross-section Area

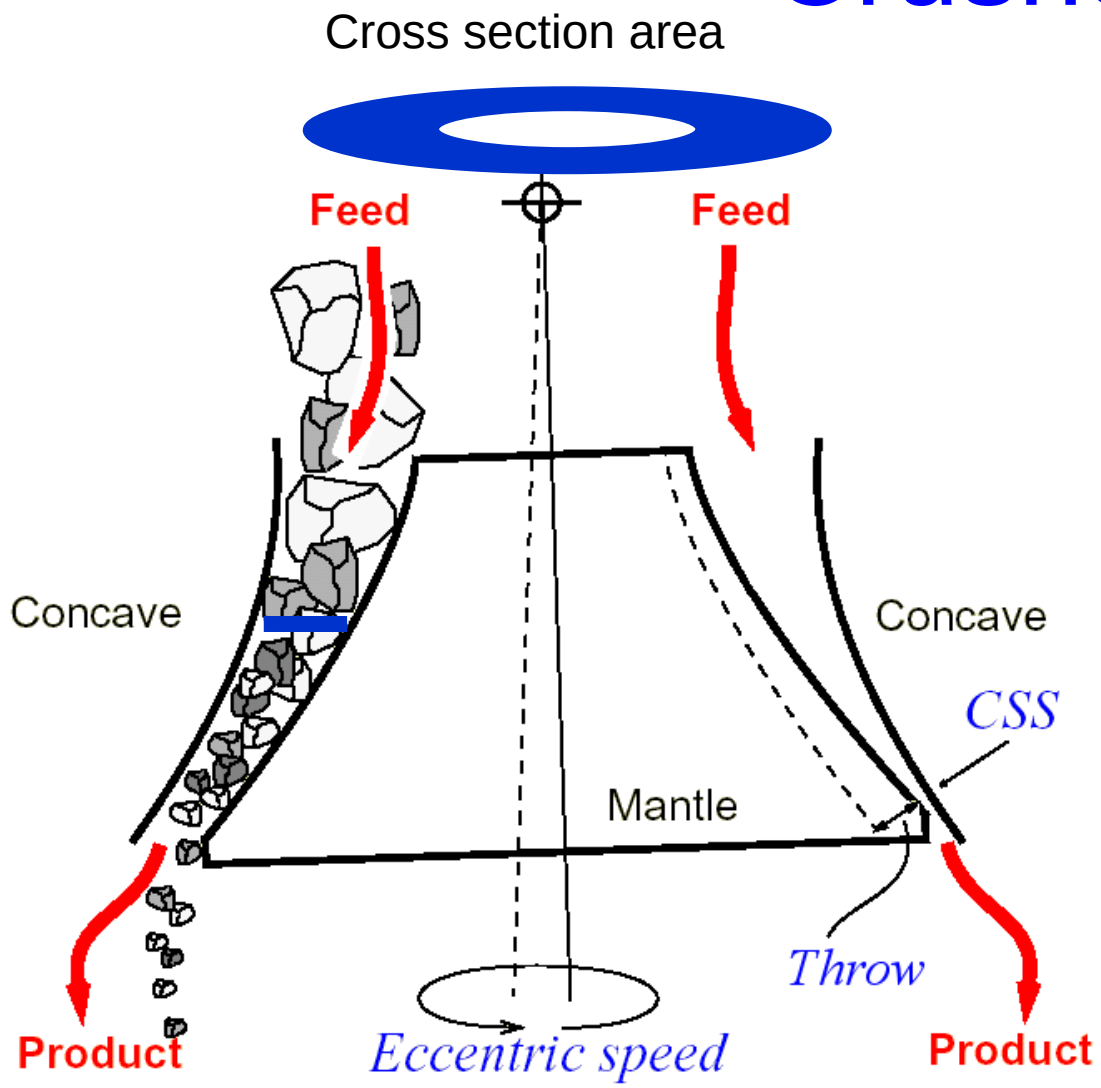
Area Function



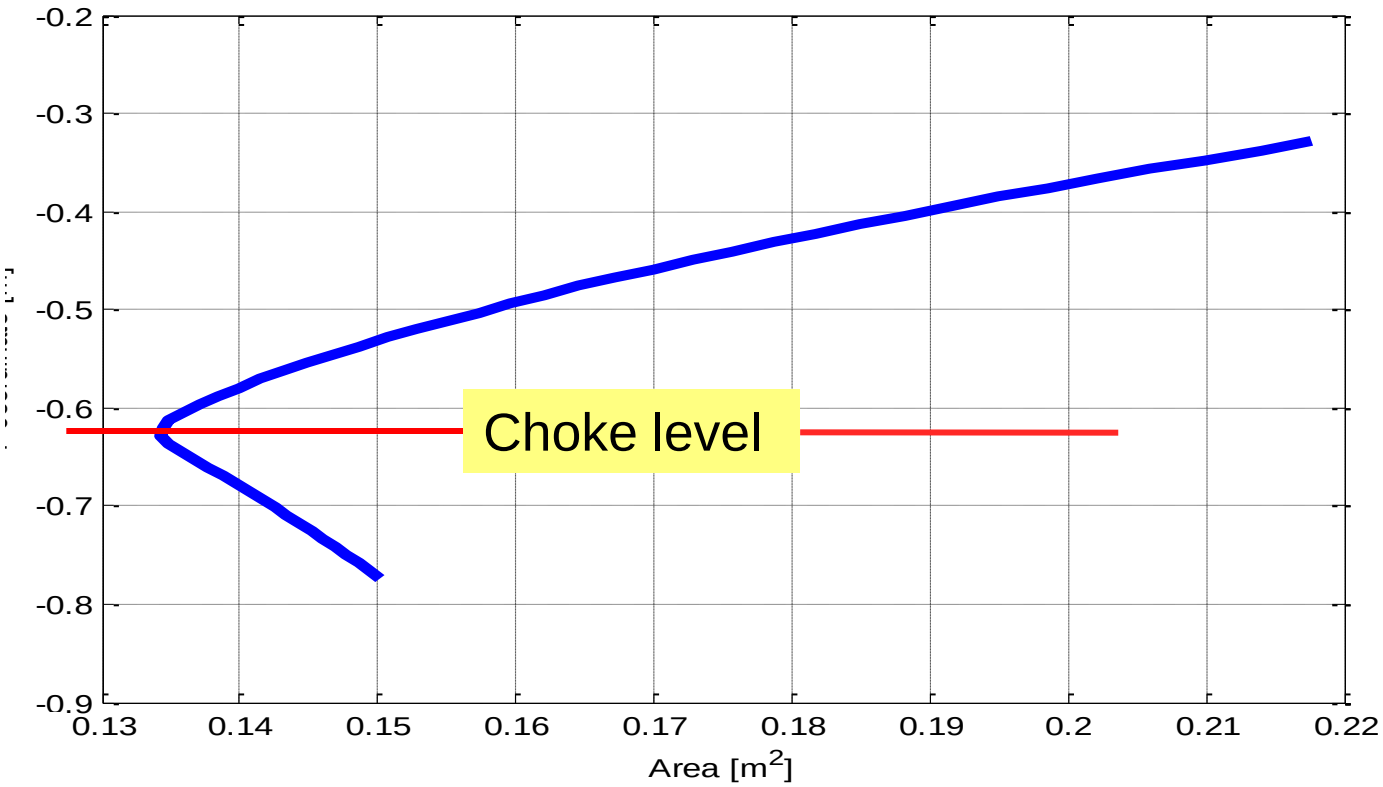
Choke Area: During one revolution of the crusher the material must pass (accelerate) through the choke area.

QUARRY ACADEMY

Crusher Capacity



Area function

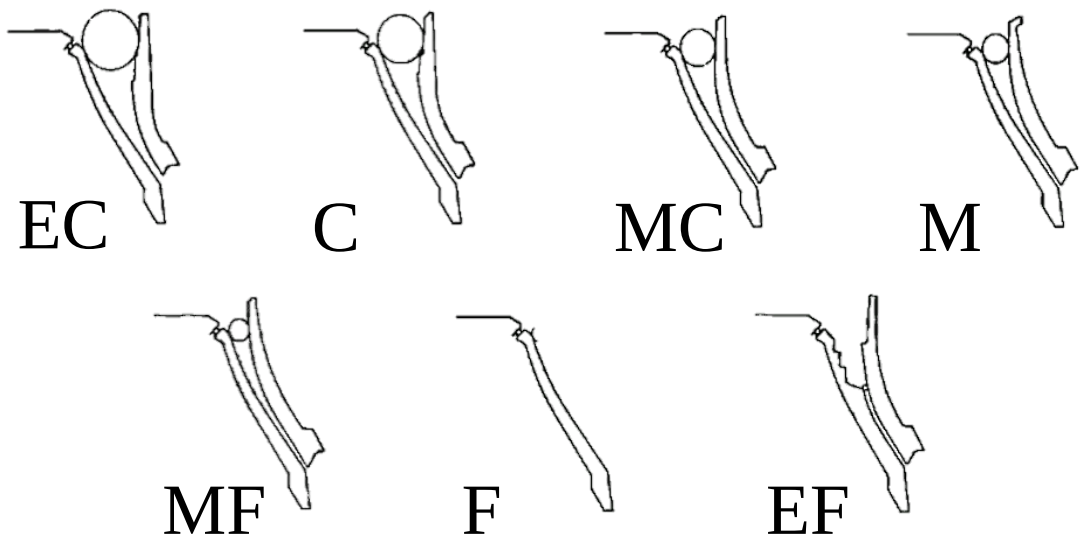


QUARRY ACADEMY

Crushing Chamber Selection

- Concaves EC-EF

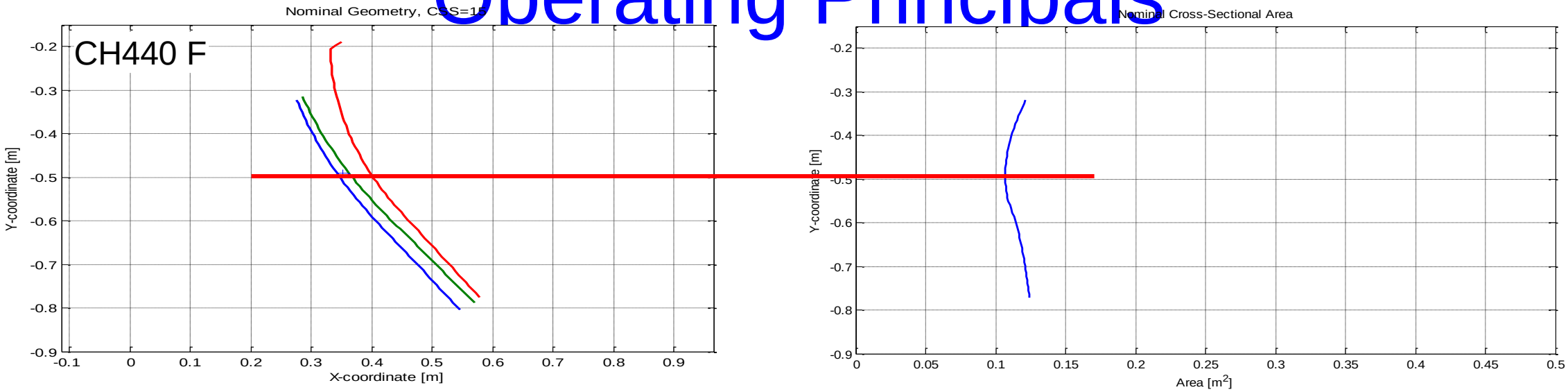
	EC	CX	C	MC	M	MF	F	EEF	EF	EFX
CH420										
CH430										
CH440										
CH660										
CH870										
CH880										
CH890										
CH895										



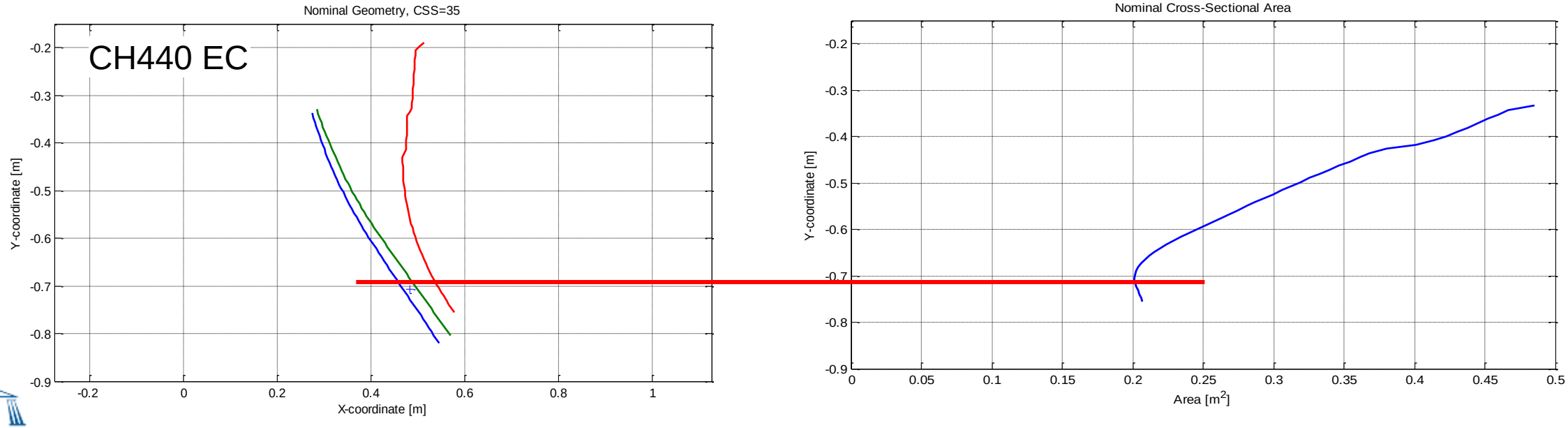
QUARRY ACADEMY

Operating Principals

CH440 F

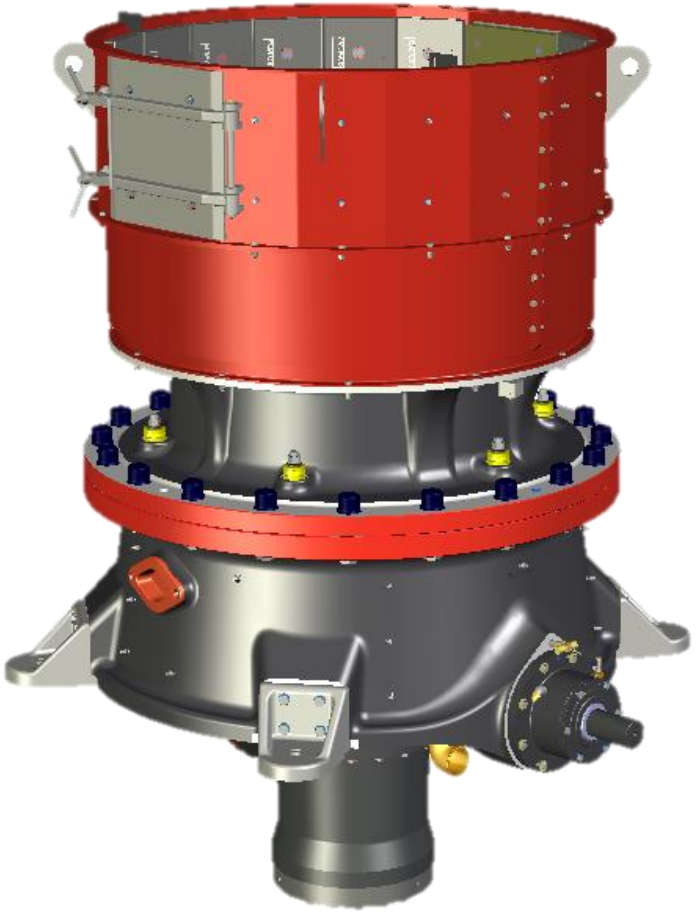


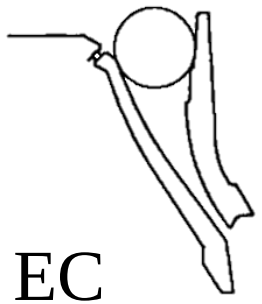
CH440 EC



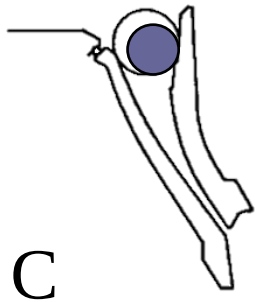
QUARRY ACADEMY

Chamber Selection

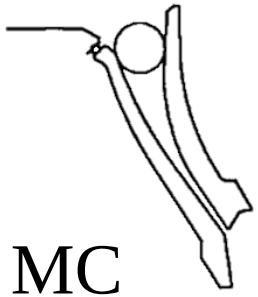




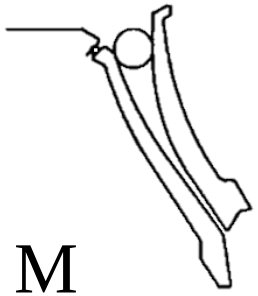
EC



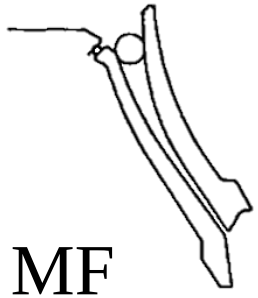
C



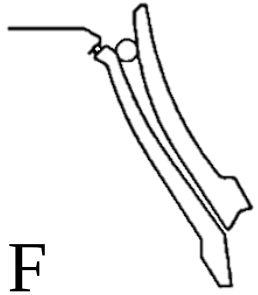
MC



M



MF



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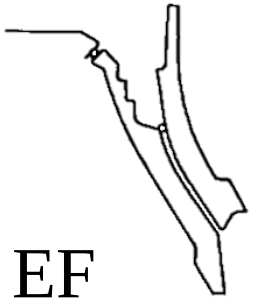
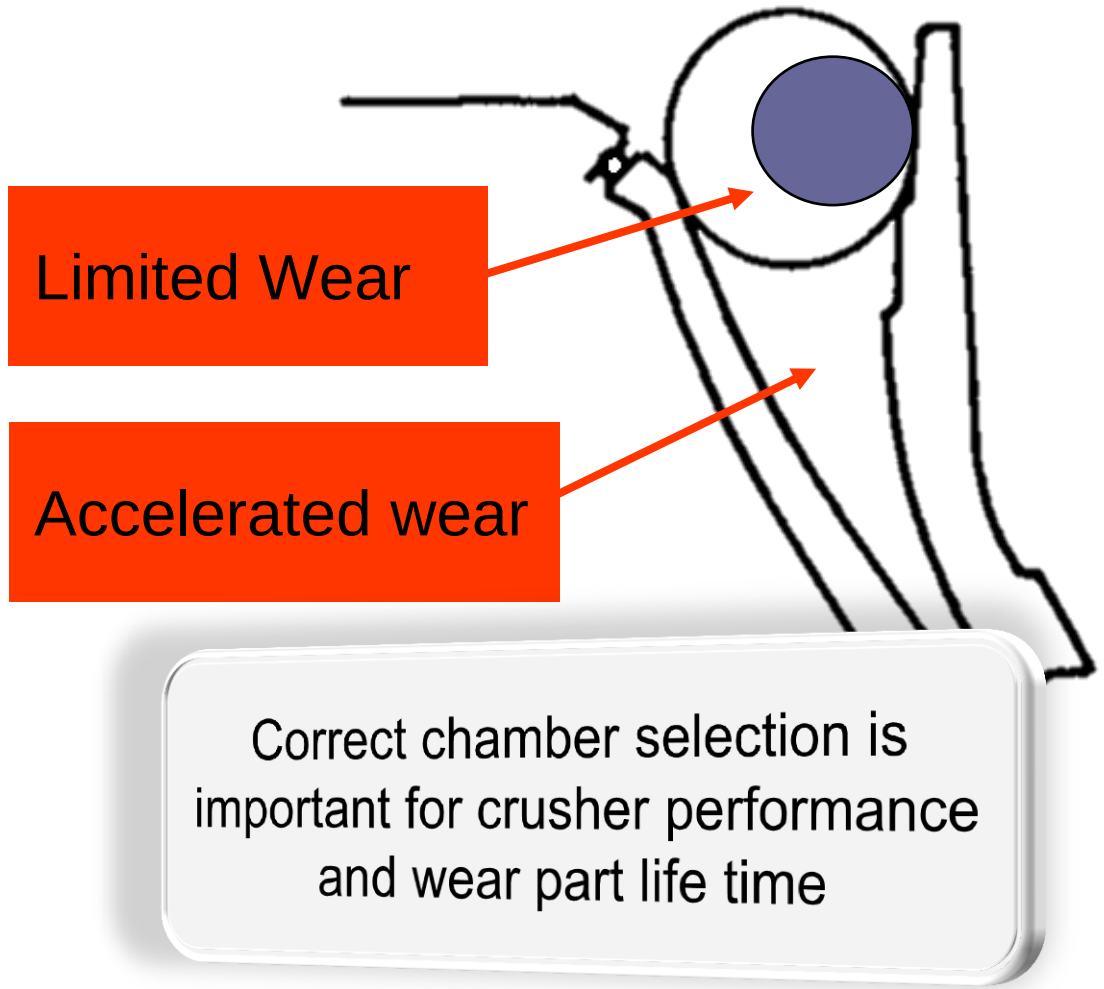


EF

QUARRY ACADEMY

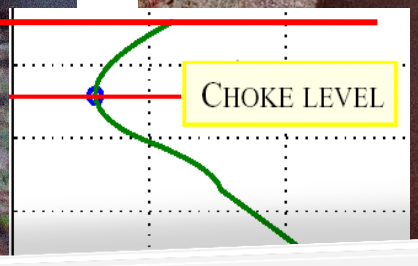
Wrong Selection

- To course
  - Limited wear in the upper part of the chamber, shorter life time
  - Problems running the crusher on smaller settings
  - Concave not designed to run at small setting
- To fine
  - Material will not be able enter the chamber



QUARRY ACADEMY

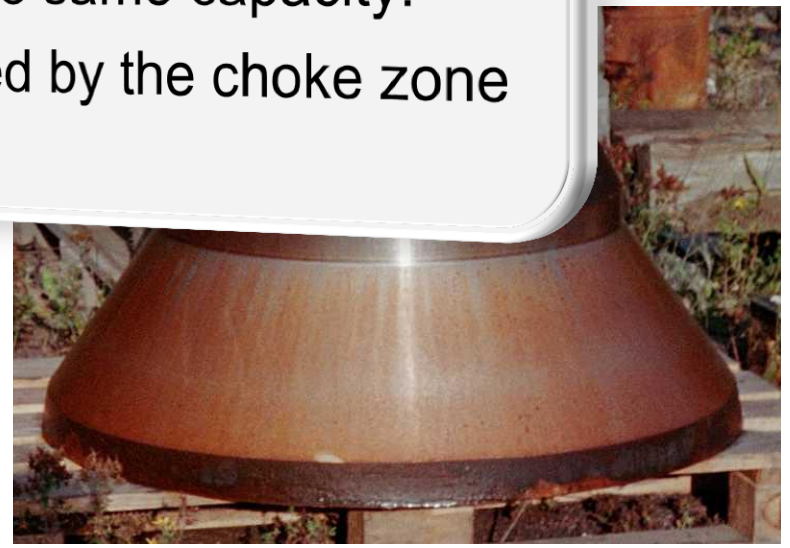
Crusher Capacity



Do you believe it?

All chambers have same capacity.

Capacity is determined by the choke zone



QUARRY ACADEMY

Crusher Operation

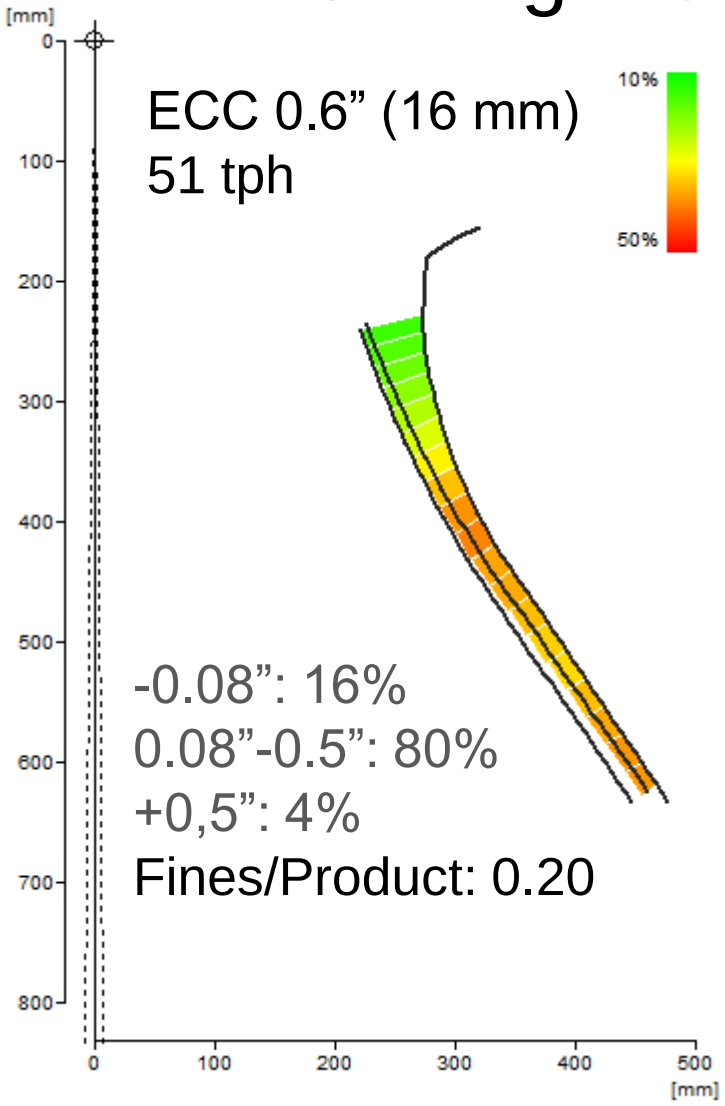
- As the market demand shifts can the crusher operation be modified?
- The crusher is likely to be installed for maximum production. Can it be changed to maximum efficiency?

- Understanding how breakage and capacity is effected by
  - Eccentric Throw
  - Speed
  - Closed Side Setting

QUARRY ACADEMY

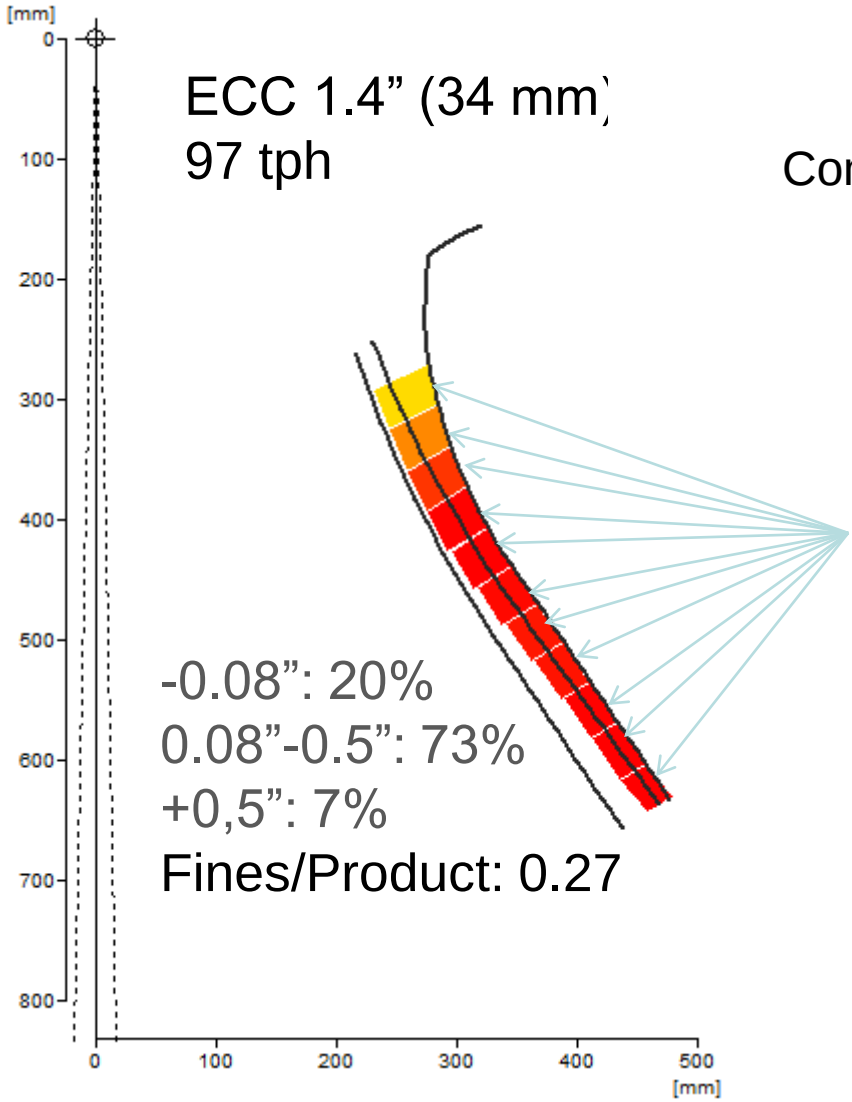
Crusher Operation

Running the crusher at different eccentric throws



ECC 0.6” (16 mm)
51 tph

-0.08”: 16%
0.08”-0.5”: 80%
+0,5”: 4%
Fines/Product: 0.20



ECC 1.4” (34 mm)
97 tph

Compression Ratio

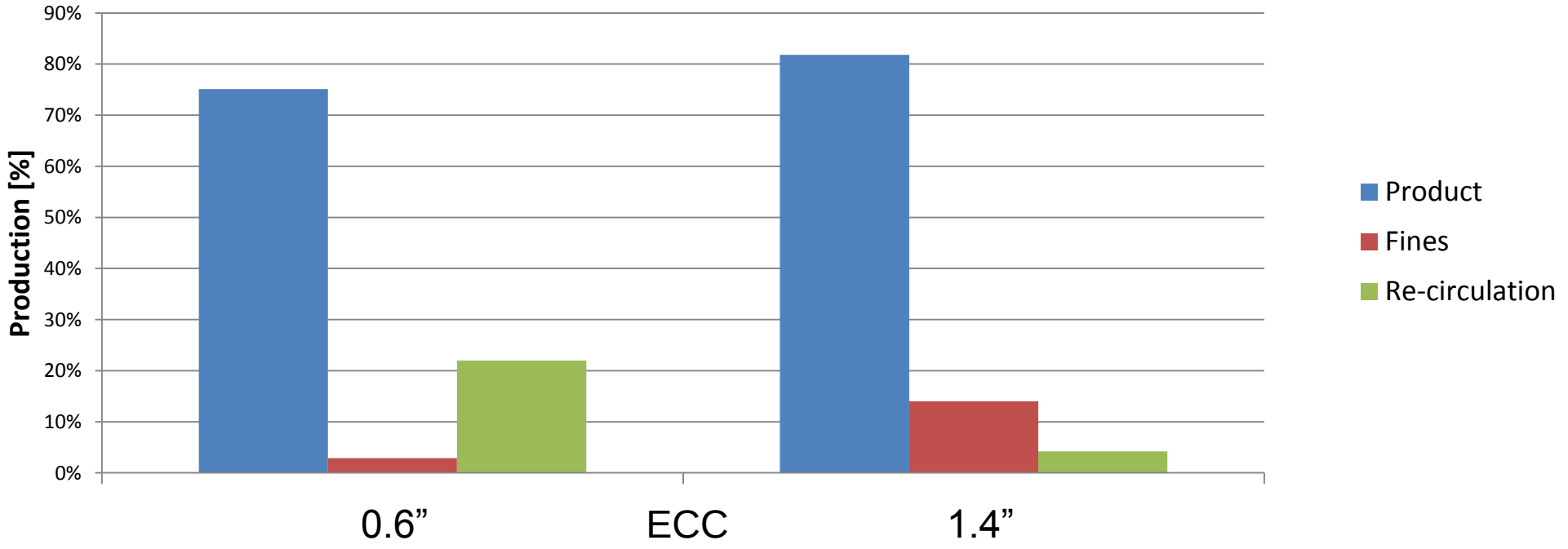
Crushing Zones

-0.08”: 20%
0.08”-0.5”: 73%
+0,5”: 7%
Fines/Product: 0.27

QUARRY ACADEMY

Crusher Operation

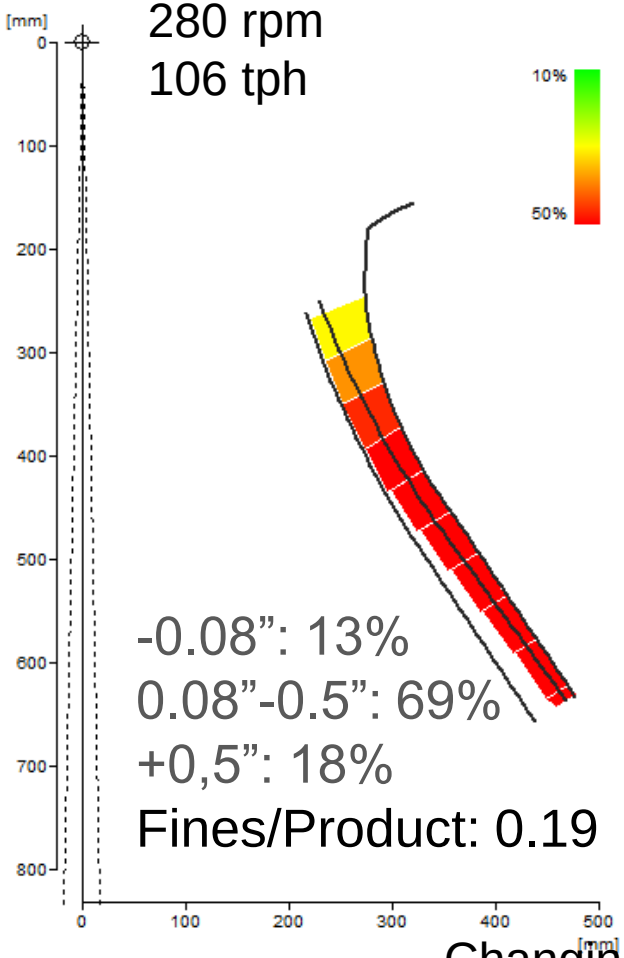
- Running the crusher at different eccentric throws, CSS optimized



QUARRY ACADEMY

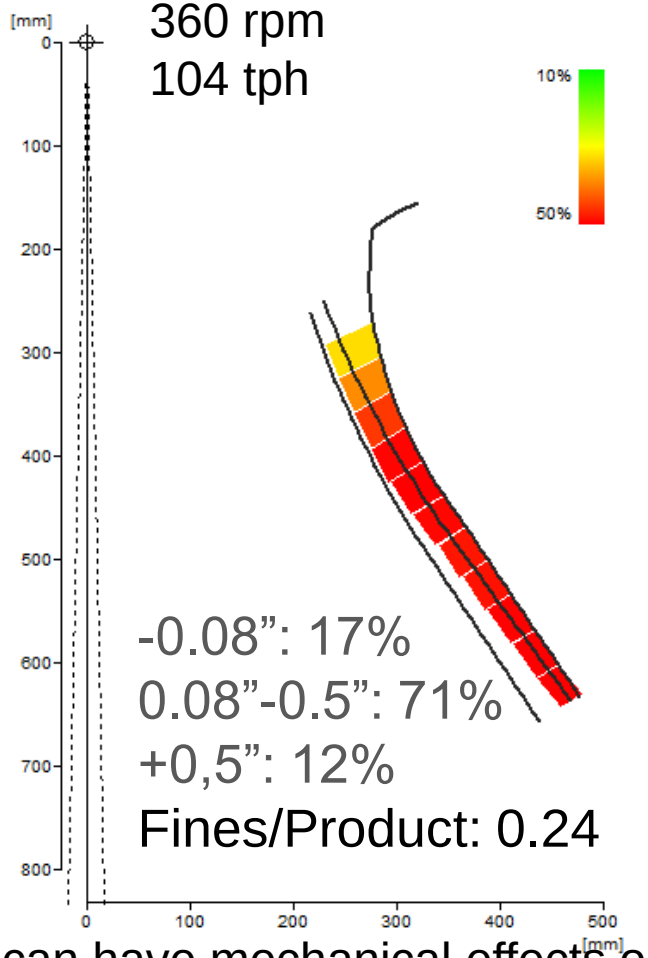
Crusher Operation

- Running the crusher at different speeds



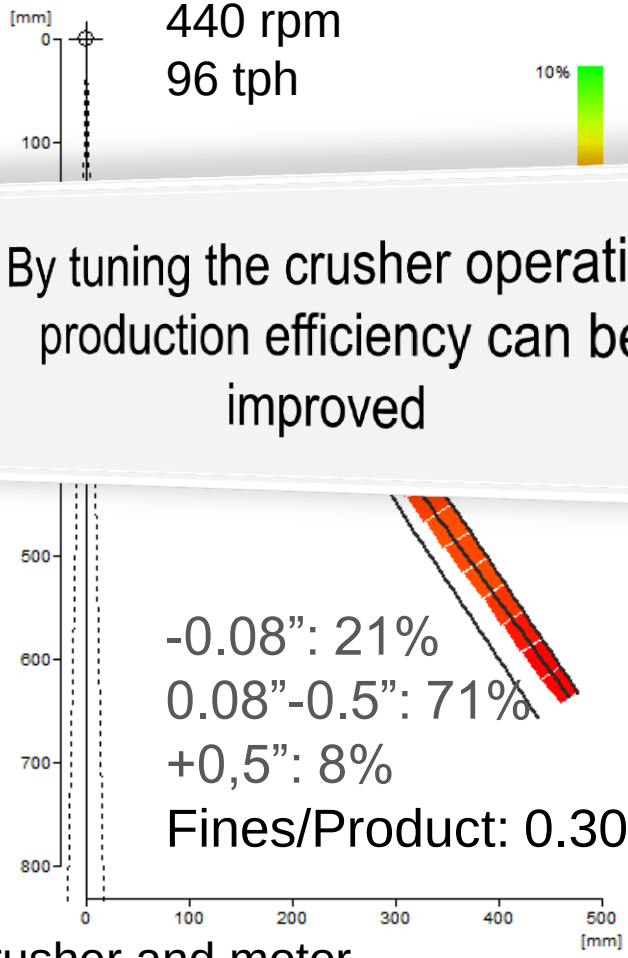
280 rpm
106 tph

-0.08”: 13%
0.08”-0.5”: 69%
+0,5”: 18%
Fines/Product: 0.19



360 rpm
104 tph

-0.08”: 17%
0.08”-0.5”: 71%
+0,5”: 12%
Fines/Product: 0.24



440 rpm
96 tph

-0.08”: 21%
0.08”-0.5”: 71%
+0,5”: 8%
Fines/Product: 0.30

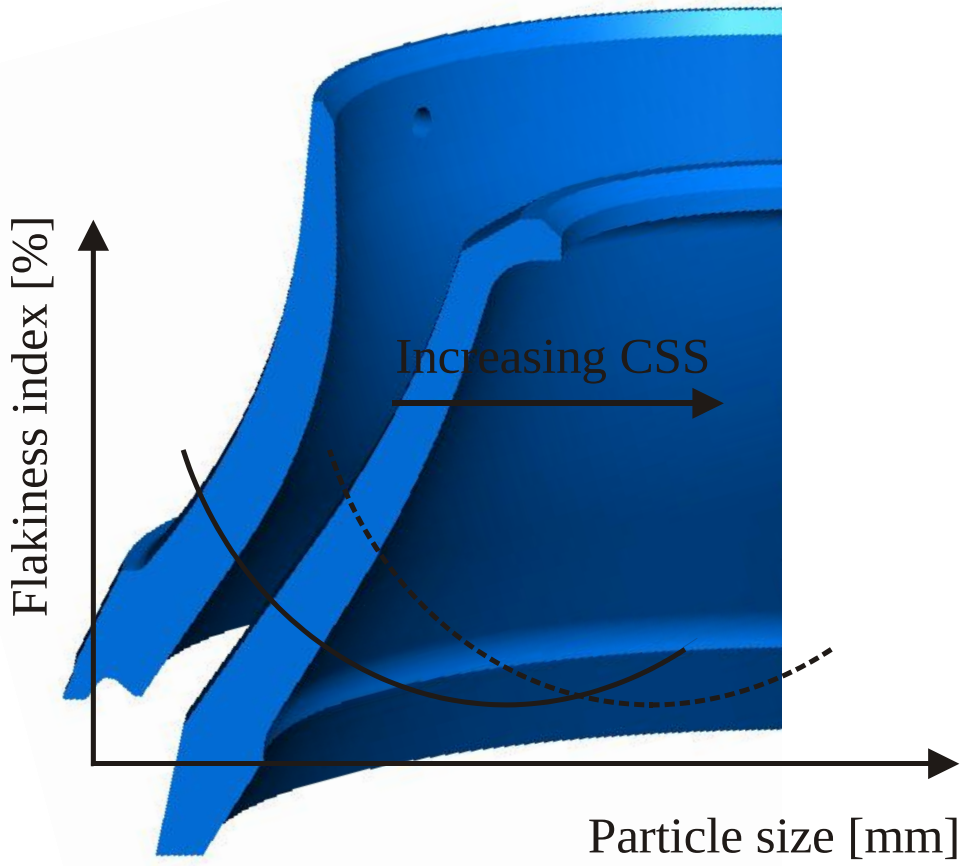
By tuning the crusher operation production efficiency can be improved

Changing speed can have mechanical effects on the crusher and motor

QUARRY ACADEMY

Crusher Operation

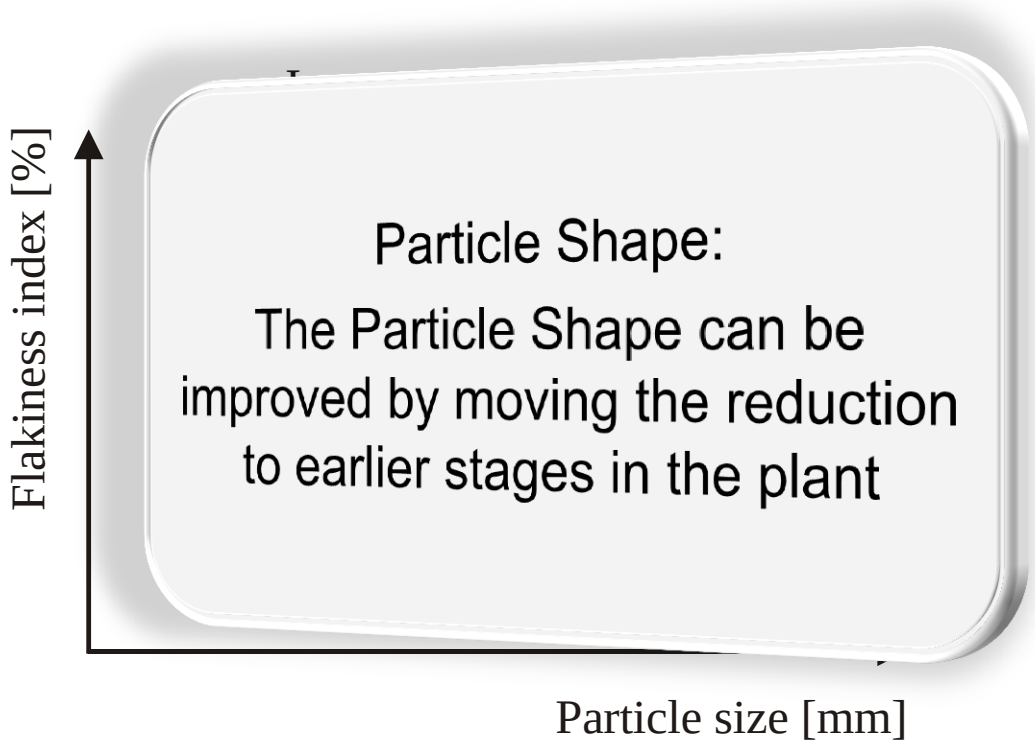
- Relation between CSS and Shape
  - The size where the best shape can be found is at CSS
  - It is very difficult for cubical stones larger then CSS to pass the chamber
  - Breakage of stones creates flaky particles. Smaller flaky stones will more easily find its way through the chamber



QUARRY ACADEMY

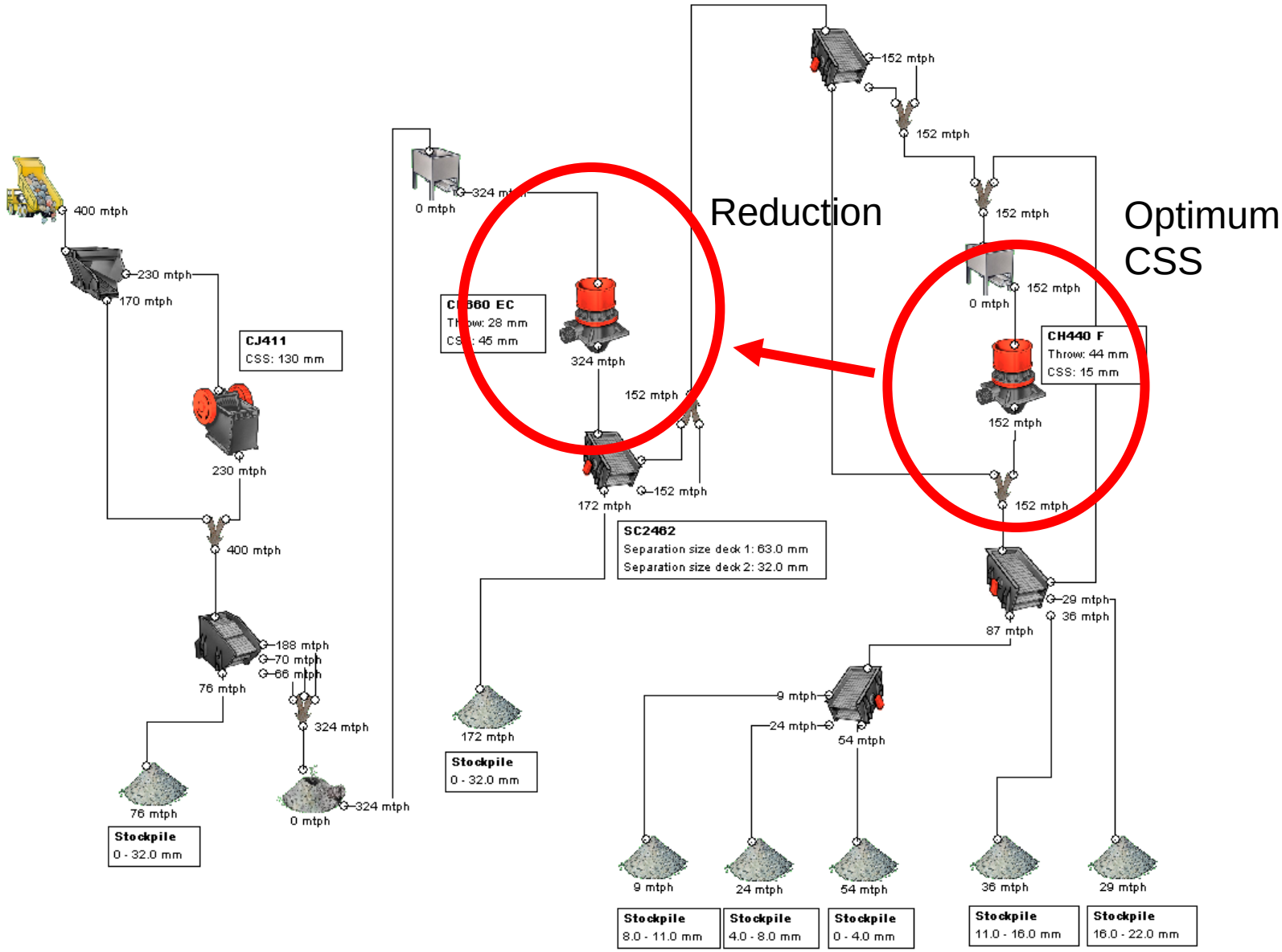
Crusher Operation

- Relation between Feed size and Shape
  - The greater reduction ratio the worse particle shape.
  - Inter particle breakage improves shape. When crushing a bed of material weaker particles will break first. Flaky or elongated particles are weaker then round.
  - Breaking round particles gives flaky material.



QUARRY ACADEMY

Crusher Operation



QUARRY ACADEMY

Does Chamber Design affect Crusher Performance?

- Crushing chamber performance. Can the output of the crusher be tweaked in order to reach better productivity?

QUARRY ACADEMY

Operating Principal

- In a cone crusher the stones are crushed with both SPB and IPB as the material moves down through the chamber.
- The relative amounts of IPB and SPB depends on factors like chamber design, crusher geometry, speed, css, eccentric throw, and others.

SPB

IPB

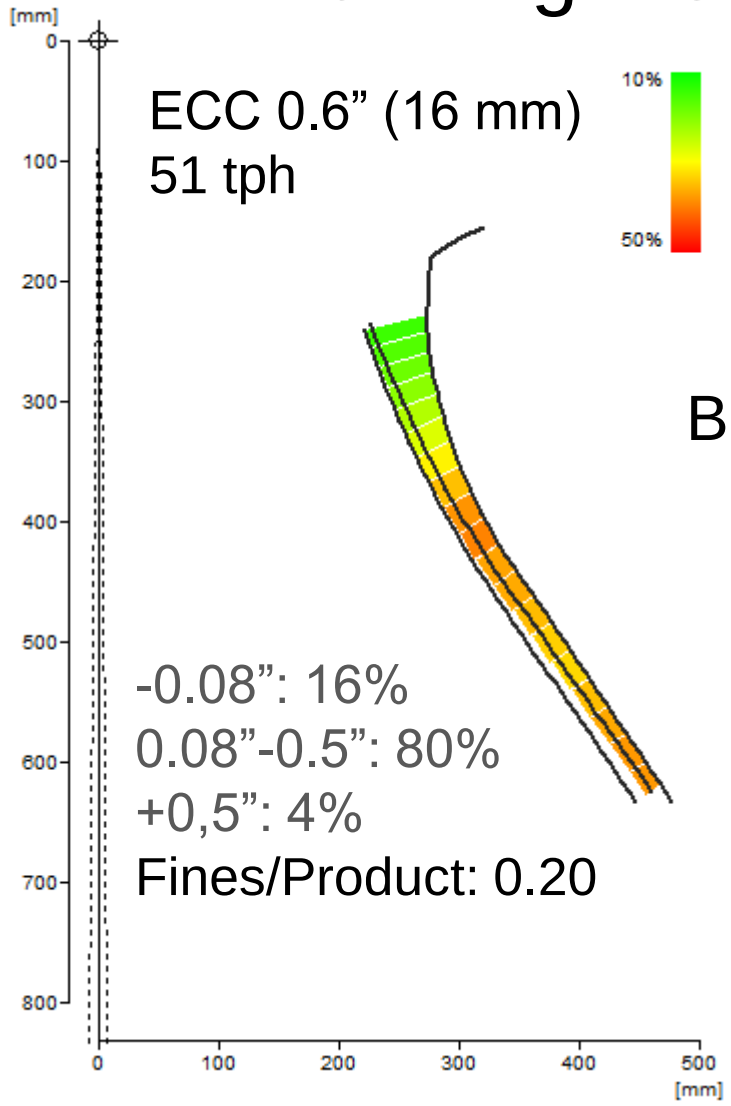
Fines	Less	More
Shape	Flaky	Cubic
Force	Low	High

QUARRY ACADEMY

Mantle Geometry

Running the crusher at different eccentric throws

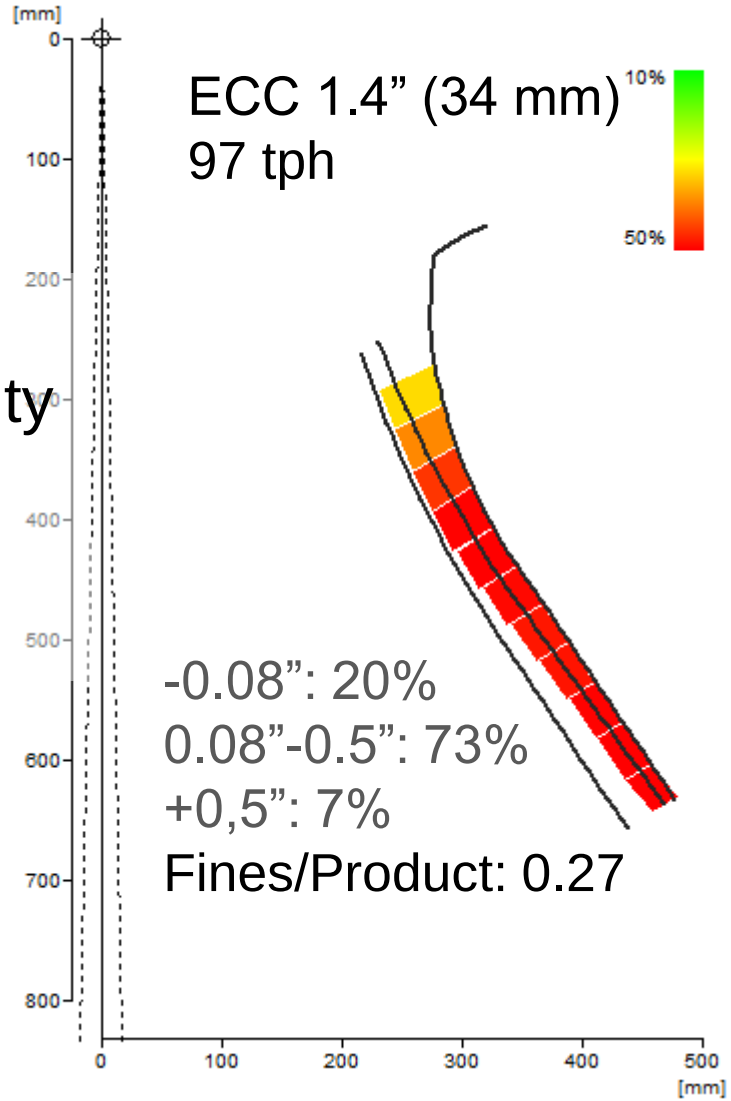
ECC 0.6” (16 mm)
51 tph



-0.08”: 16%
0.08”-0.5”: 80%
+0,5”: 4%
Fines/Product: 0.20

The trade off:
Big crushing zones for capacity
vs
Low pressure for better fines/product ratio

ECC 1.4” (34 mm)
97 tph

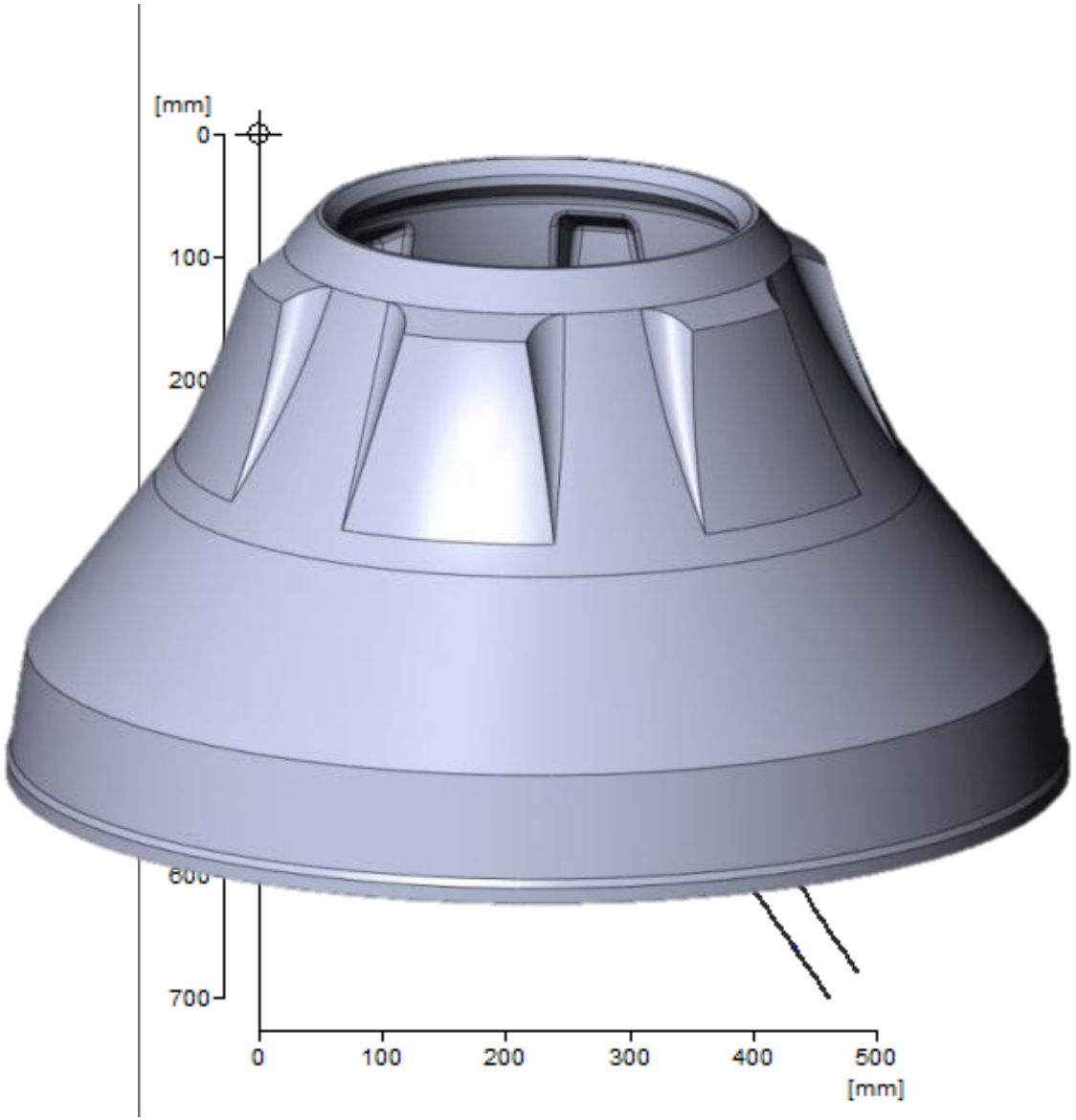


-0.08”: 20%
0.08”-0.5”: 73%
+0,5”: 7%
Fines/Product: 0.27

QUARRY ACADEMY

Mantle Geometry

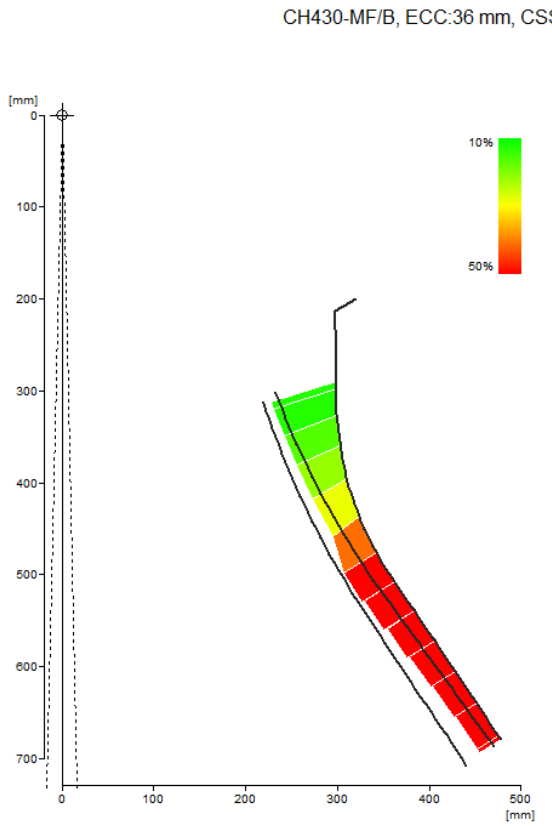
- Want to keep the big crushing zone for capacity while slightly decreasing the amount of material in the zone to reduce crushing pressure.

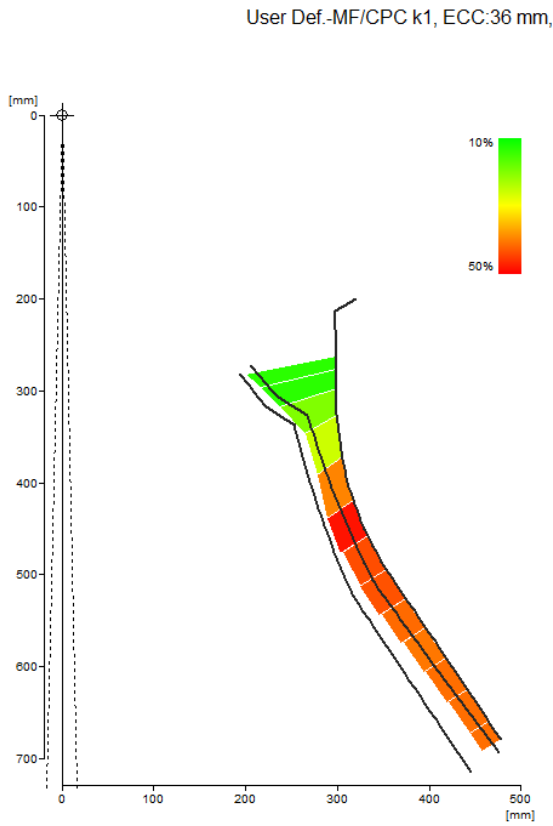


QUARRY ACADEMY

Mantle Geometry

- More crushing in the upper part of the chamber
- Less crushing pressure in the lower part of the crusher
- Lower forces in the crushing chamber
- Gentle crushing without increasing CSS





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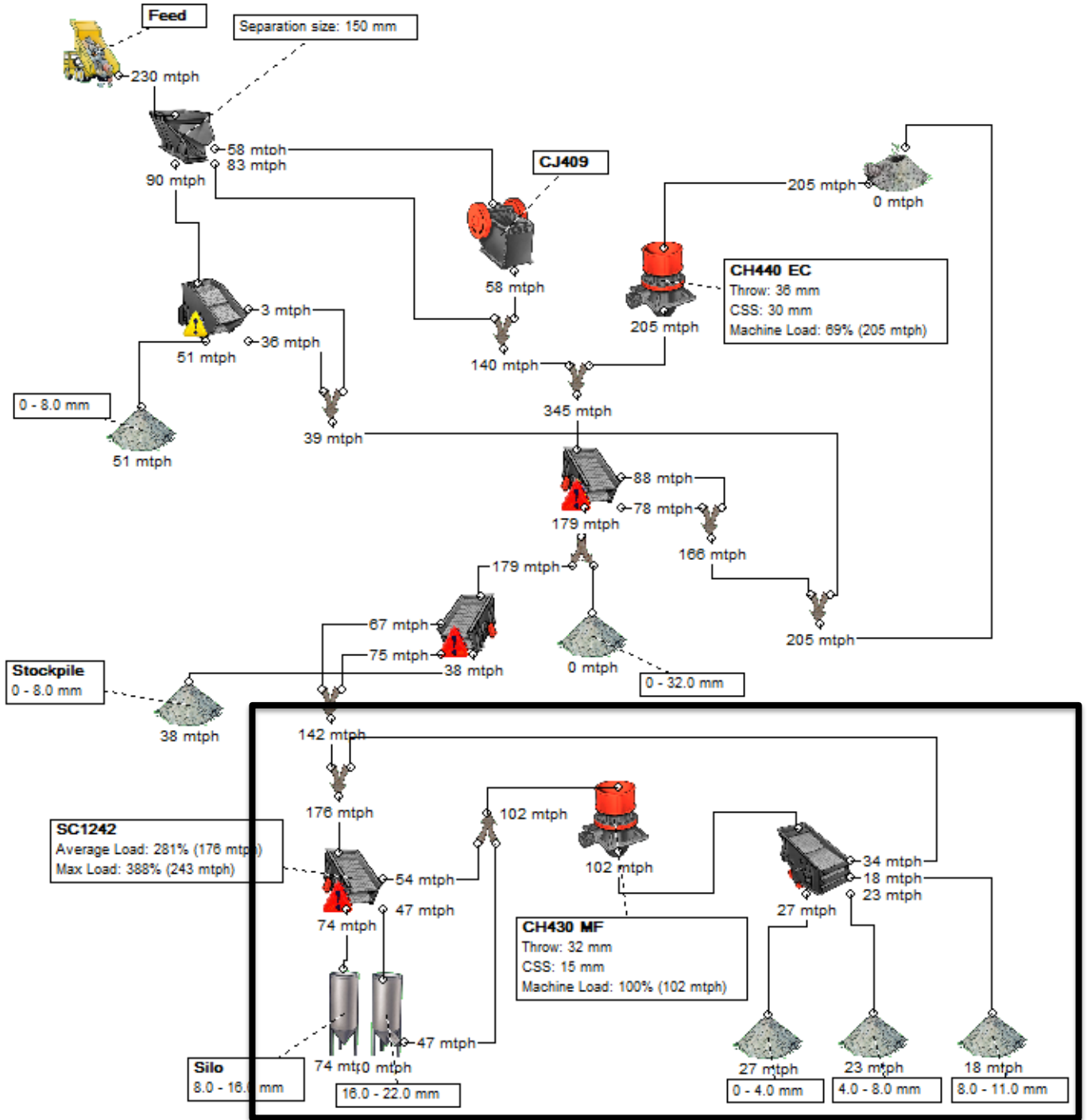
Field Test

Litra Grus, Norway

0.32”-0.43” (8-11 mm) Premium
0.16”-0.32” (4-8 mm) Low value
0-0.16” (0-4) mm Low value/Waste



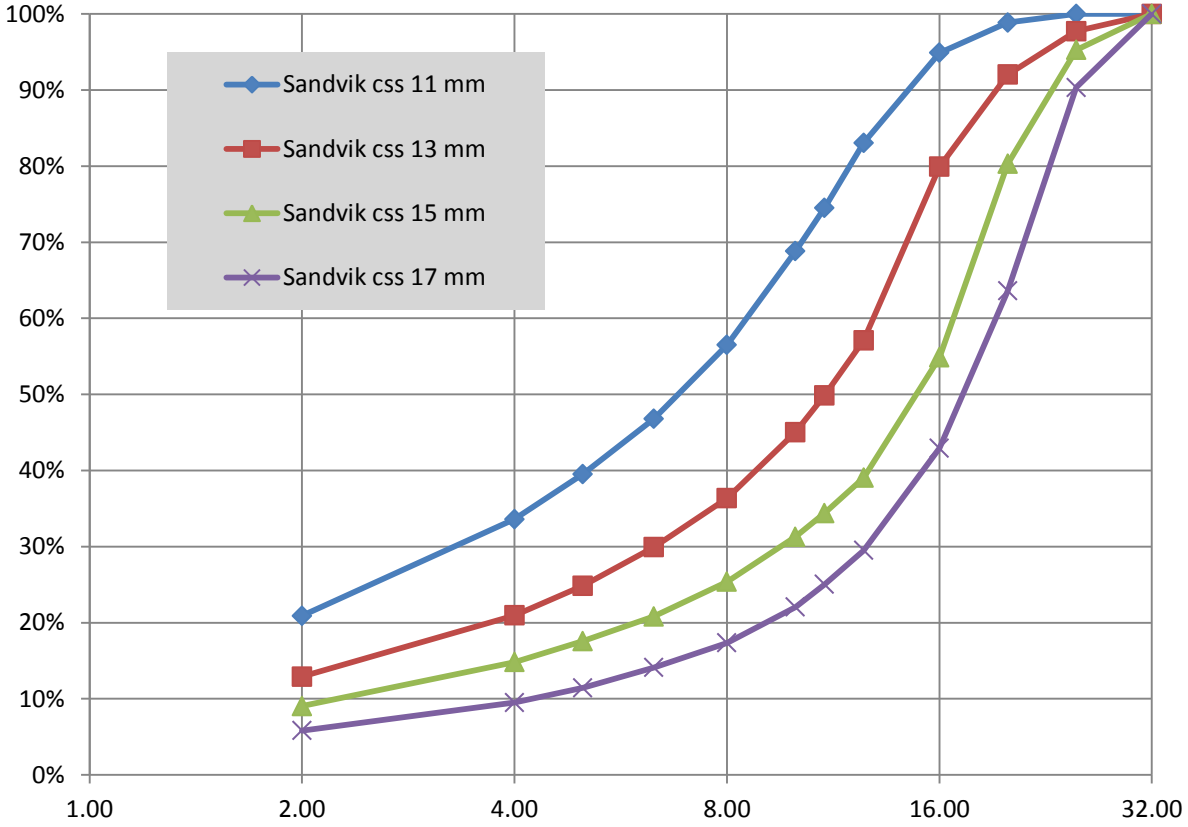
Field Test

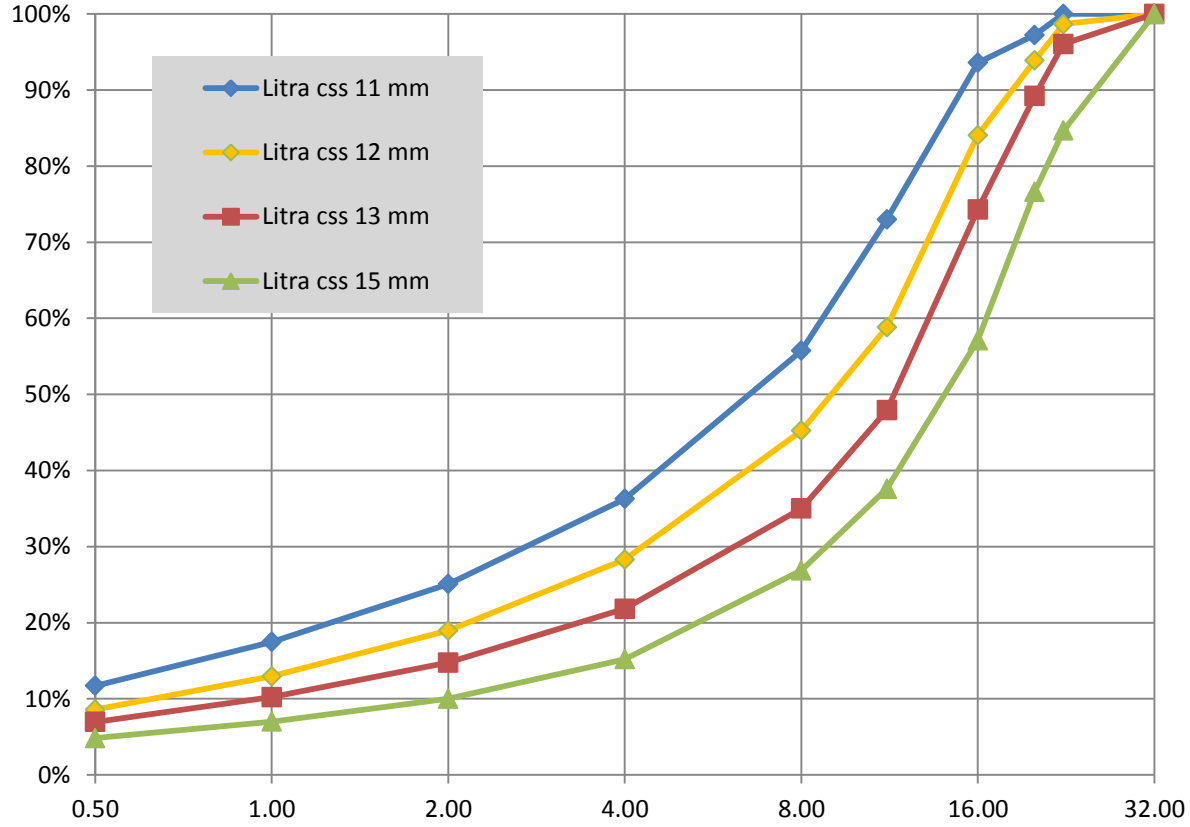
CH430 configuration

- Before:
  - MF B ECC 1.14’’ (29 mm)
  - Autoload ~0.6’’ (15 mm)
- After:
  - M combined with mantle
  - ECC 1.26’’ (32 mm)
  - CSS 0.51’’ (13 mm)

Field Test

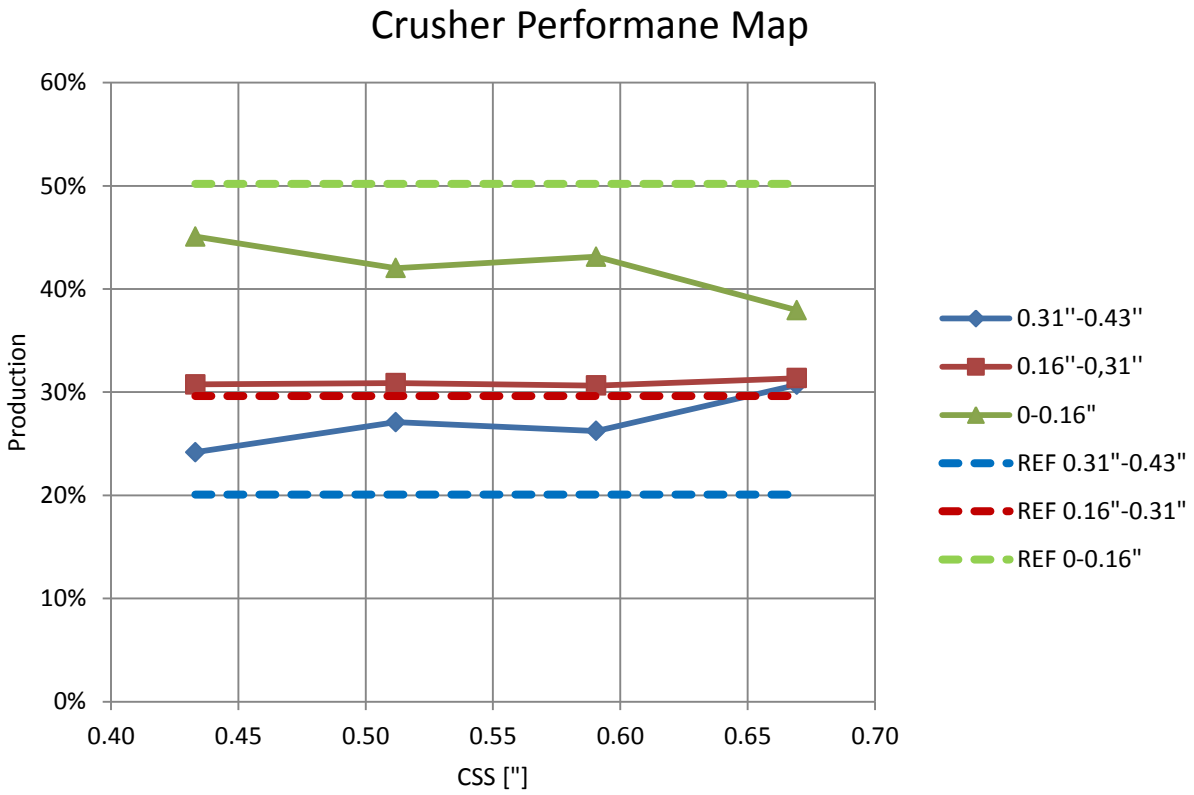
Test Results, Gradation Curves

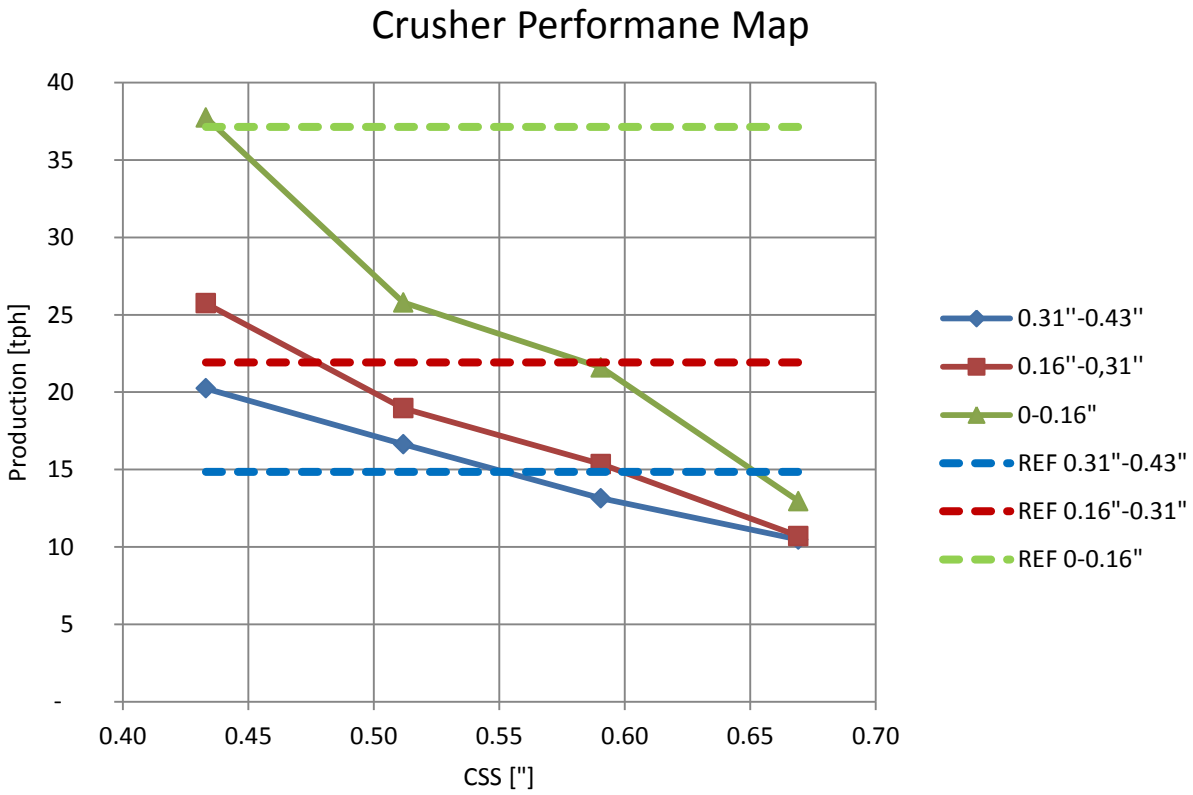




Field Test

Test Results, Crusher Performance Maps





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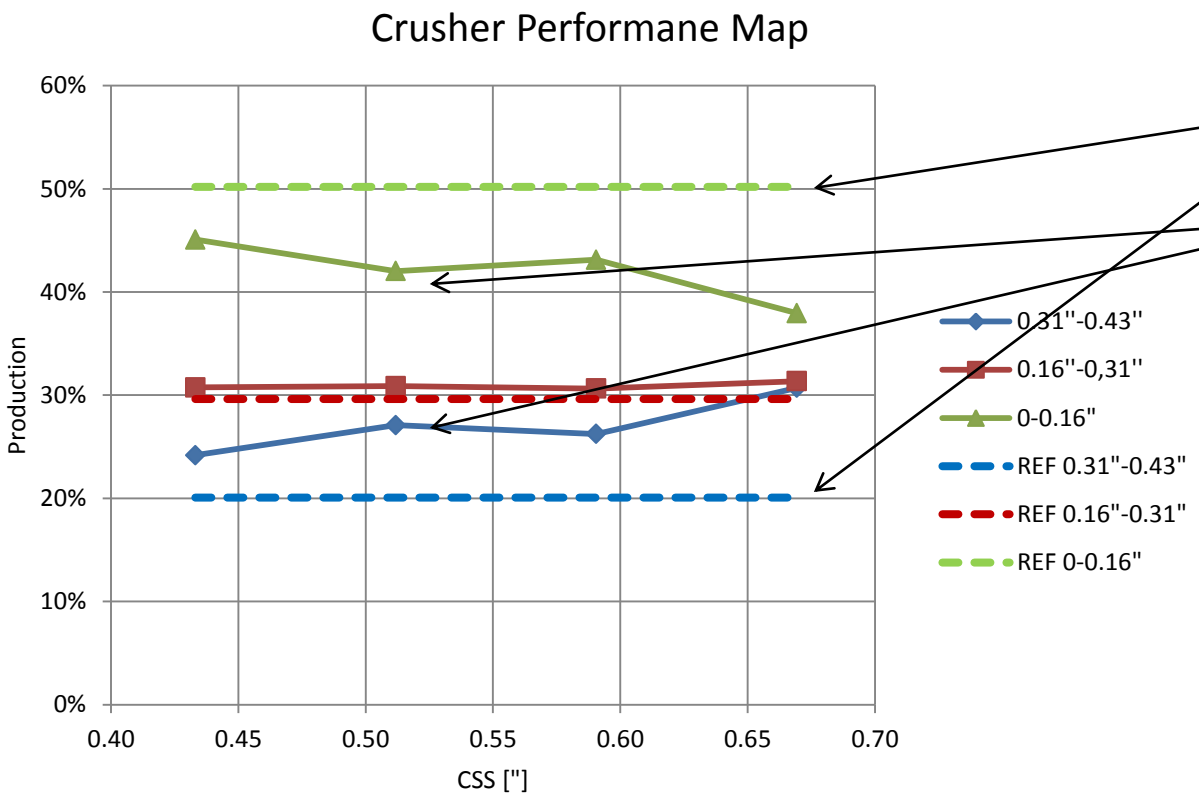
Field Test

Test Results, Crusher Performance Maps



- Waste/Product Ratio:
  - Previous: 2.5
  - New: 1.7
- By altering the compression and amount of material in the crushing zones the crusher performance changed

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Conclusions

Capacity is determined by the choke zone

Inter Particle Breakage and Single Particle Breakage affects crusher output

By tuning the crusher operation production efficiency can be improved. Throw, Speed and Chamber Selection

The Particle Shape can be improved by moving the reduction to earlier stages in the plant and selecting correct CSS

Chamber design and selection has a direct effect on crusher output

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