Practical considerations on improved feeding arrangements for cone crushers

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Improving Processes. Instilling Expertise.

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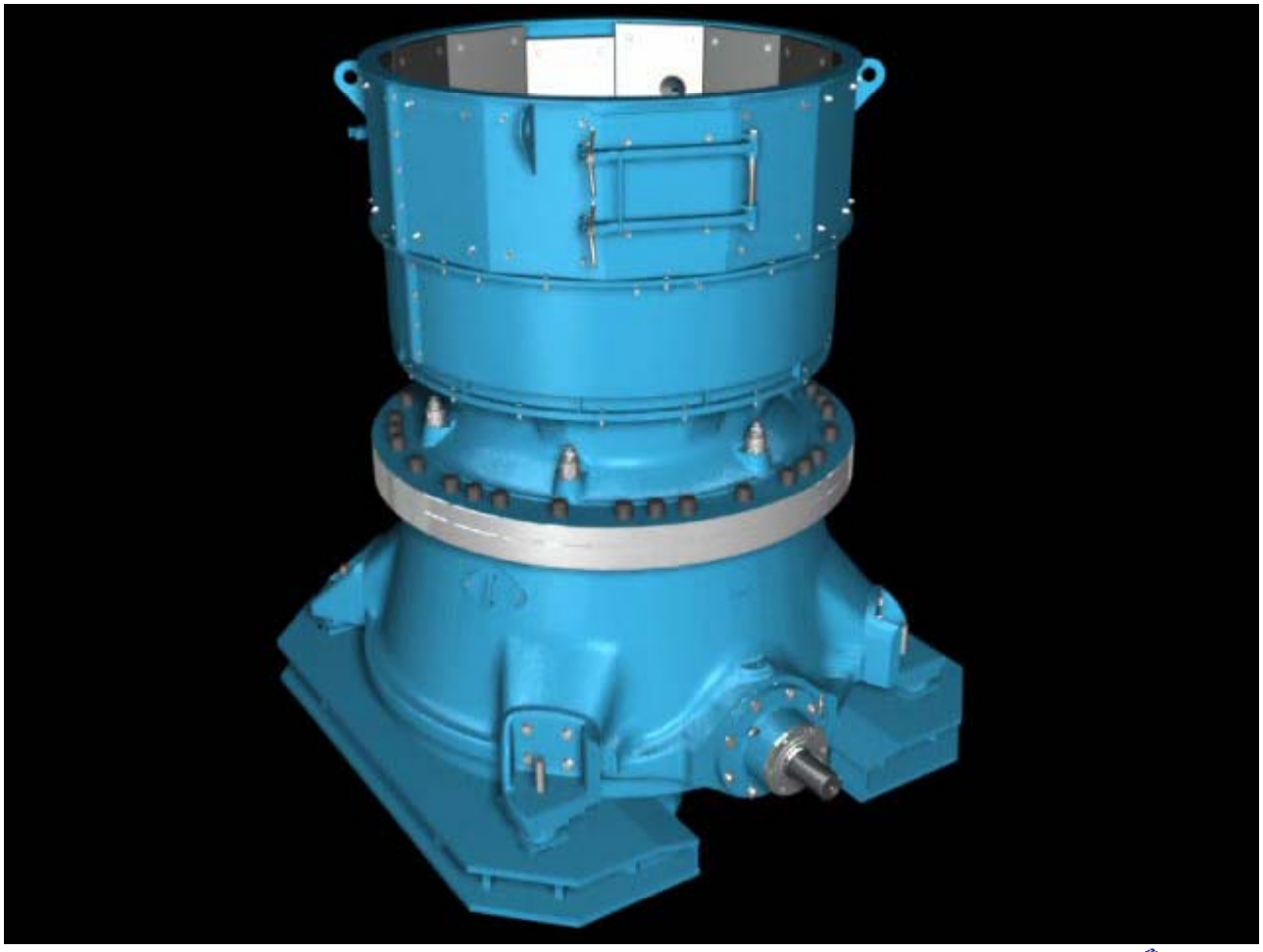
Cone Crusher Function

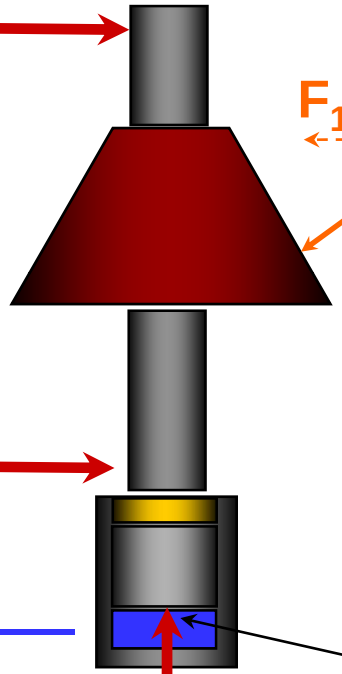
- A cone crusher has an annular crushing chamber.
- The CSS runs around the chamber so the action is basically rotational.
- Raw material enters the chamber on the OSS and is crushed one half revolution later by the CSS.
- This cycle takes place in most cone crushers 5 to 6 times per second

Function



Reaction to well distributed, unsegregated feed

A similar crushing force will be seen throughout each and every revolution



Reaction Force F_1

Crushing Force F

F_1+F_2

α

F_3

Reaction forces seen as

Power, hp (kW)---- F_1+F_2

Pressure, psi (mPa)--- F_3

Crushing force affected by

- Toughness of rock
- CSS, throw and chamber profile

Reaction Force F_2

Area of Piston: A

Reaction Force F_3

Hydroset pressure

i.e. proportional to F

$$p=\frac{F_3}{A}=\frac{F\cdot\cos a}{A}$$

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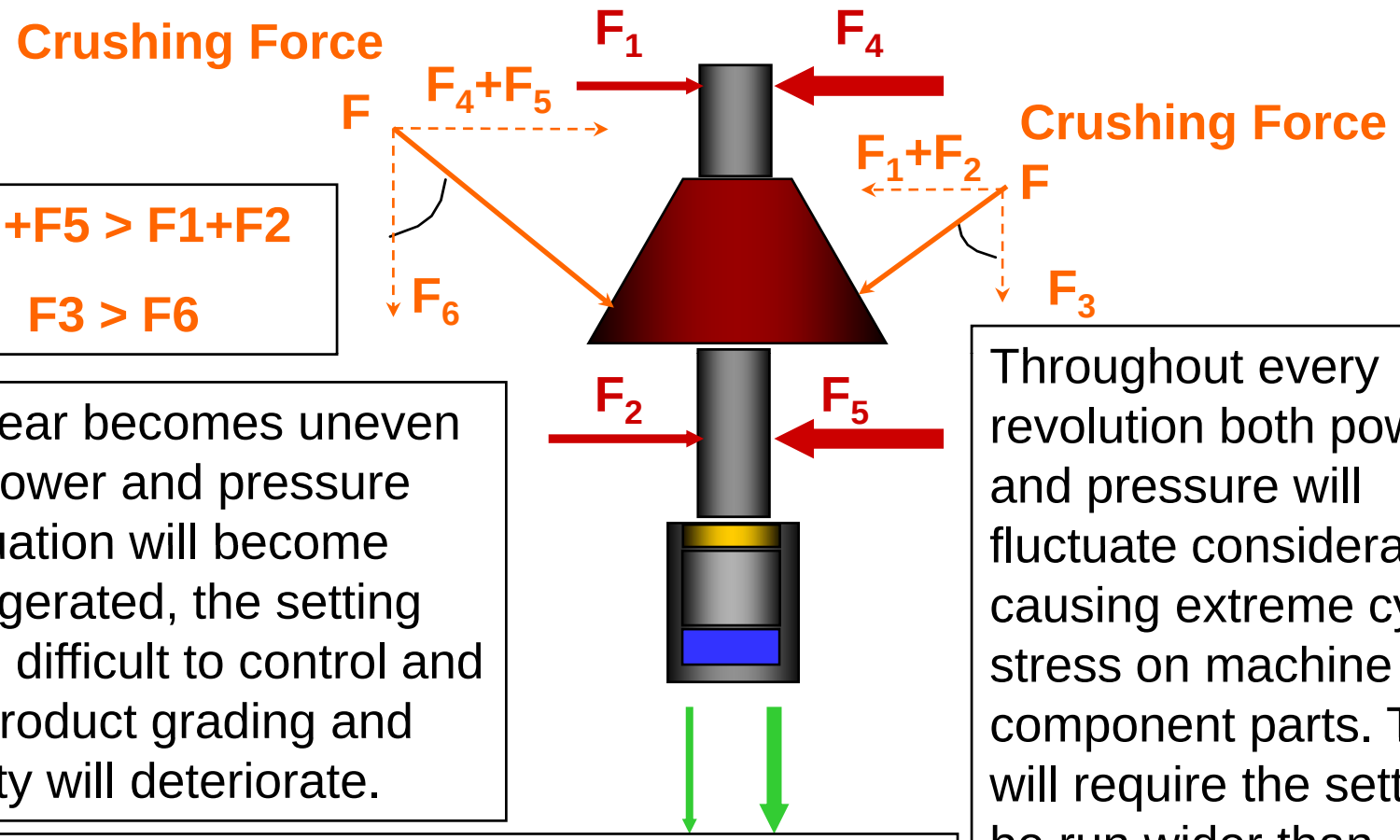
Reaction to uneven,segregated feed



F4 +F5 > F1+F2

F3 > F6

As wear becomes uneven the power and pressure fluctuation will become exaggerated, the setting more difficult to control and the product grading and quality will deteriorate.

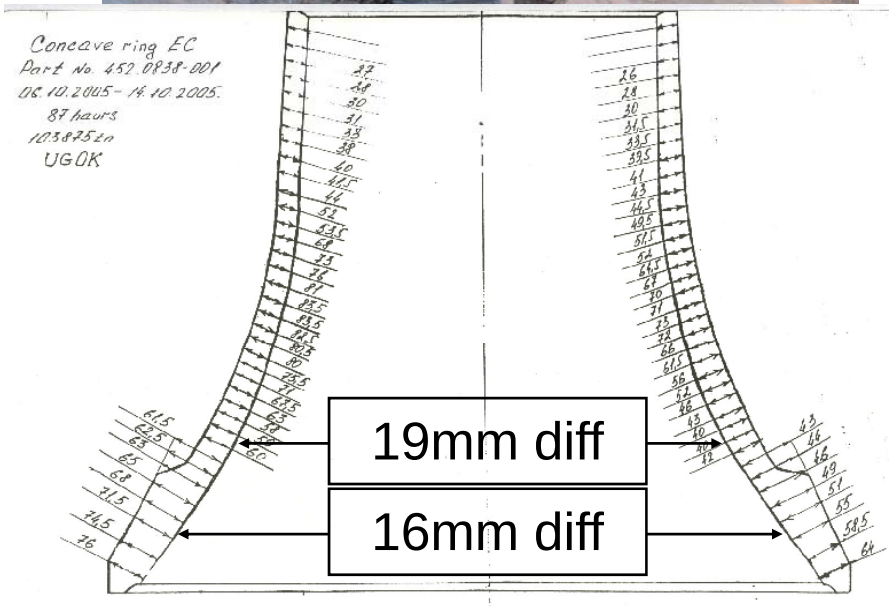
Throughout every revolution both power and pressure will fluctuate considerably, causing extreme cyclic stress on machine component parts. This will require the setting to be run wider than necessary

Zero reaction at any point during the revolution will suggest a portion of the chamber is empty

What are the negatives?

- High power and pressure will cause the crusher to be run at wider than necessary settings resulting in coarser product therefore higher recirculating loads with increased conveying,wear and crushing costs.
- Occasionally the necessity for increased crushing will demand increased capital investment.
- Segregated and poorly distributed feeds will cause the crusher liners to wear unevenly, again with deteriorating performance and associated costs.
- Product will become coarser and cubicity, often in critical products, will deteriorate. Costs??
- Both situations will cause reduction in liner life.
- Both situations will cause reduction in mechanical component life, often leading to traumatic failure and the costs of unplanned stoppages.
- **ALL IN ALL CONSIDERABLE COST TO THE OPERATION.**

Another negative effect



Demands much higher scrap weight----increased operating costs

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Prevention

- During the design stage, whether a new plant or plant extension or replacement crusher is being planned, careful consideration is required to the design of the feeding arrangement.
- Material normally arrives in a stream, from a conveyor, feeder or chute—the need is for even full width distribution with no segregation.
- Height can be an ally when available and employed to constrain material, change flow direction, combat segregation and remove impact, but a deadly enemy when working against us.
- Flexibility in design---e.g.the opportunity to alter the position and speed of the material trajectory.
- Each feed arrangement design is unique, can be complex and may require several compromises
- **THE OPERATIONAL SUCCESS AND OVERALL OPERATING COST OF THE INSTALLATION WILL DEPEND ON A SATISFACTORY DESIGN.**

Material characteristics

- **Abrasive materials not only cause wear on the crusher liners but will cause wear on chute work and distributors**

H7800EF crushing iron ore in Ukraine showing centralised feed from conveyor, and attempt to de-segregate using finger splitter.

Distributor showing signs of wear. Eventually through lack of maintenance distributor became ineffective

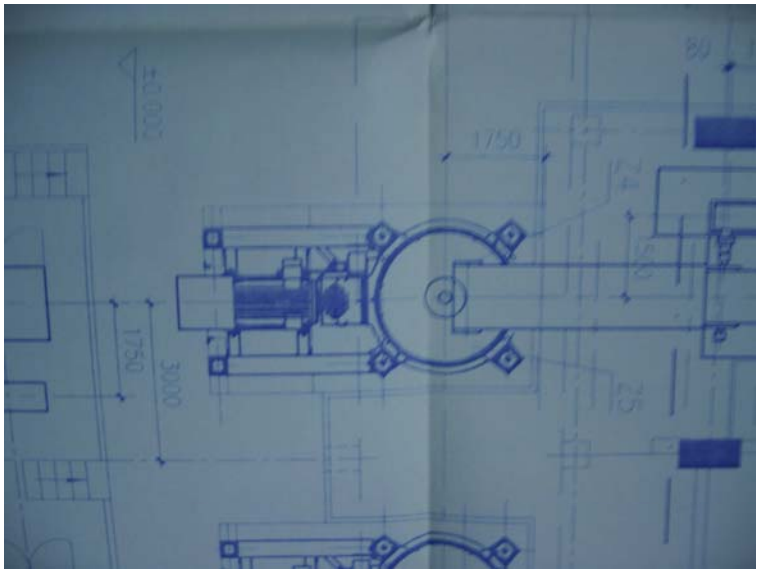
Variable feeds

- Cone crushers work at their best when the chamber is full and there is a constant feed of material.
- In many cases this is not the case. Feeds vary for many reasons such as, poor recovery from stockpiles, process fluctuations, poor feed control.
- Fluctuation in rate will affect material trajectory and distribution into the chamber.
- Variations in flow rate are easily controlled by surge bins with feeders—either vibrating or belt. Level monitors will ensure both bin and crusher feed hopper always have material present.
- However bins and feeders don't necessarily ensure a well distributed , homogenised feed. The process of discharging from a conveyor to a bin causes segregation

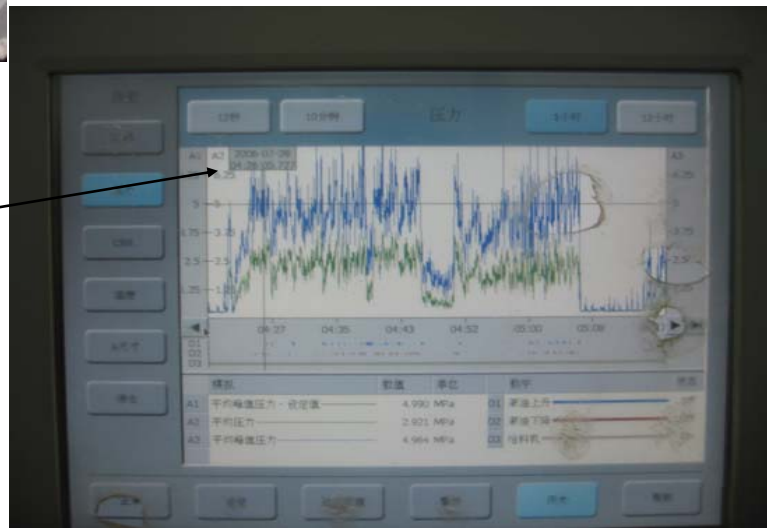
Variable feed conditions

H7800 EC handling molybdenum ore

Variable feed conditions



There is no choke.
There is segregation.
There is extremely poor distribution.
There is oversize product causing more work for the tertiary.
There is a high risk of component failure.
There is uneven wear on liners.



Possible solutions

A hopper should have been included at design stage.
A pre-screen should have been considered.
Reduce crusher capacity if the facility is available.

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Segregation in crusher hopper

Segregation is the enemy of optimum crusher performance and operating costs

Remember: crushers operating under conditions as indicated above, suffer from cyclic pressure peaks and cannot safely be operated at settings reasonable with a non-segregated feed.

Larger settings mean less reduction with subsequent increased costs as oversize is returned to the crusher, reducing net capacity, or to another unit—possibly a new investment

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Segregation in bins

2 x CH440 fed from same bin

Solution: Distribution OK but improve segregation with splitter in hopper of top crusher

2 x CH660 with EC chambers fed from same bin.

Solution: Allow continued segregation but divide surge bin and change to finer chamber in left hand crusher

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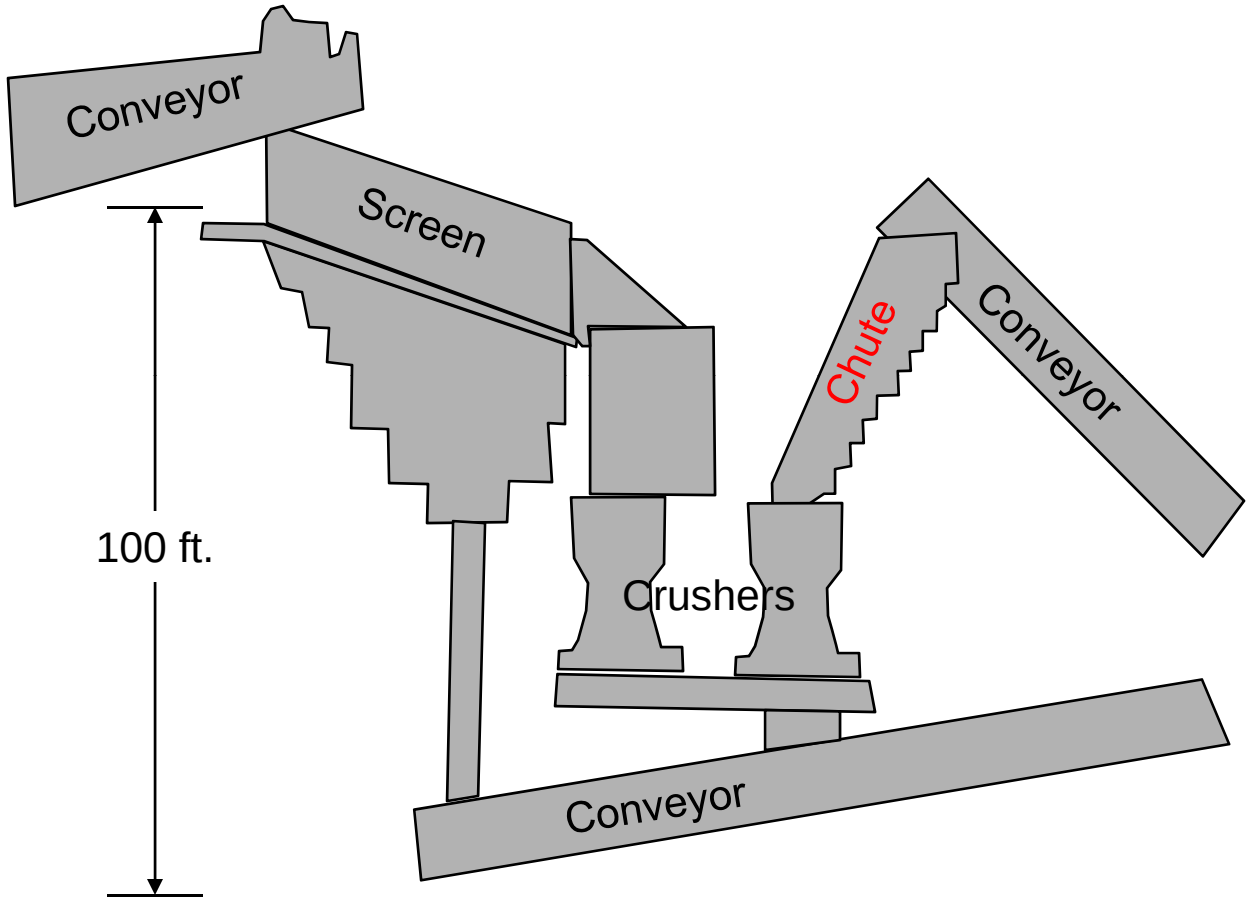
Types of Feeding Arrangements

Segregation in the feed material is caused by

- **The fraction length-- long fractions i.e. 3”x $^{1}/_{2}$” segregate easily short fractions less so i.e. 3”x 2”,1”x $^{1}/_{2}$”.**
- **The type of machine or feed arrangement used to present material to the crusher.**
- **Process conditions such as intermittent feed**
- **Plant design and layout such as recirculation conveyors discharging at an angle.**
- **Different feed arrangements have different advantages and disadvantages.**
- **Here are a few points to consider for the different arrangements**

Inclined chute



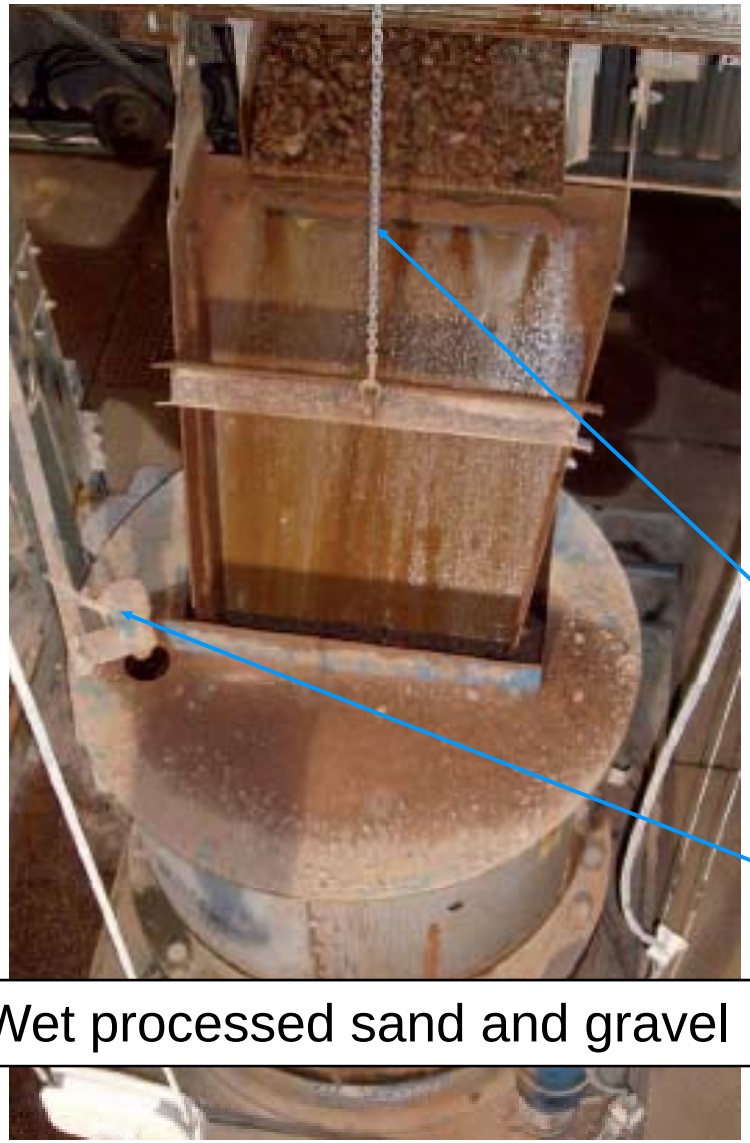
The chute is so long that the feed into the crusher is not really under control.

The large will roll and accelerate –the finer slow down.

Solution

Surge bin and feeder, possibly belt

Inclined chute



However, an inclined chute, perhaps with the advantage of a short fraction, can work well and assist distribution

If a static distribution box or splitter is used, a more than adequate feed can be presented to the crusher, especially if the inclination of the chute can be adjusted

Inclined chute

2 deck screen feeding to CS440

More height--might give the opportunity to remix?

Less height-- by removing screen to ground level, replacing chute with bin and connecting with conveyor?

A screen directly ahead of a crusher guarantees segregation. The chute only serves to aid the problem.

Screen is often employed where there is a need to remove fines but have a relief deck on top. This situation creates severe segregation.

Often an unavoidable necessity on mobile plant.

Belt conveyors

A common feed method, but unless considerable care is taken, possibly the most unsatisfactory method of feeding cone crushers.

There are a number of concerns

1. Material is segregated by the “tamping” action of the idler sets as material passes over.
2. Belt speed. Material leaving the end pulley follows a parabola. The path depends on the speed of the belt. Coarse material, with greater mass, will tend to travel further than finer material. This segregation will become more pronounced the greater the differential size and the higher the conveyor speed.
3. Belt width. Improvement in materials and restrictions on capital investment have possibly created a trend towards narrower but higher speed belts. These do not only segregate but lack the capability to distribute sufficiently.
4. Discharge height.

Belt width and speed

CS440 fed by narrow high speed belt

* Note segregation and extremely poor distribution

A simple and hopefully long term solution---a simple rubber lined deflector plate

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Belt width and speed

Belt feeders

Belt feeder before a CH870

A compact low design with lower speed should give improved vertical trajectory and an opportunity to spread material across the feed hopper width.

N.B. Still some segregation, perhaps caused as material is fed into the bin. Full width feed and vertical discharge stream allow for an effective de-segregation device in the crusher hopper.

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Vibrating feeders

Probably the most common feed device.

Has excellent control over the feed rate but due to it's vibration, like a screen, has the tendency to segregate.
The longer the feeder body the greater the tendency.
Discharges material in the form of a parabola which will alter dependant on feed rate.

Narrow, high angled vibrating feeders, cause poor distribution.

In cases where there are large lumps a simple vertical breaking curtain provides a good solution

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Gates

Moveable bin
CH440

Distributor support

Level monitor

One advantage is that it is easy to arrange a choke feed without spillage.

NB inclined chute can still segregate

Gate operation can be electrical, pneumatic or hydraulic.

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Design of feed arrangements

Man axcess to permit wear and blockage inspection

Static distribution boxes

The use of a static distributor for small and medium size F & MF cone crushers

A simple three section static splitter using the spider cap as the central compartment.

The material stream has to fall over the entire width.

The outer compartments can be moved inwards and outwards to fine tune.

Wear has to be maintained

Static splitter boxes

Note ceramic inserts to extended life

Larger number of compartments based on the riffle box sample divider.

Tailor made to receive feed from a vibrating feeder.

Effective in presenting a well distributed homogenised feed

Easily removed

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Horizontal segregation

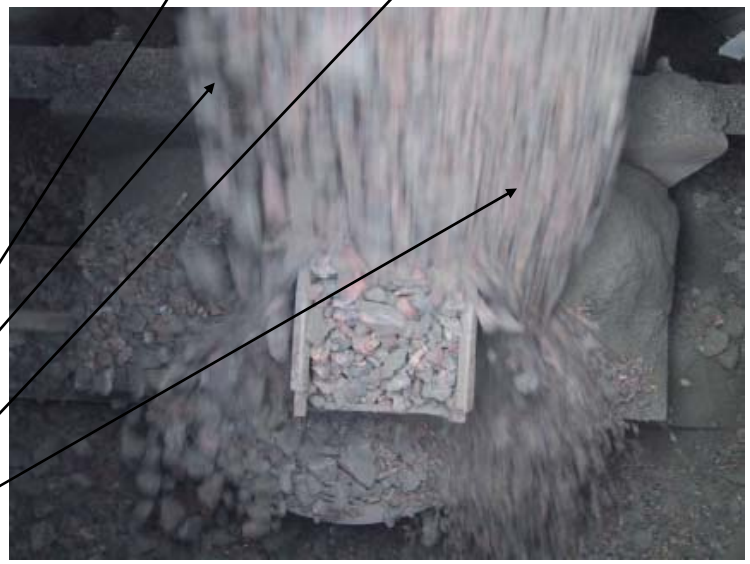
- Until now we have looked primarily at the most common problem of segregation in the vertical plane.

- However there are also severe problems caused with segregation in the horizontal plane. This is the most difficult to solve especially on larger crushers.

- Horizontal segregation is often made more difficult as it is often accompanied by a significant differential in volume.

- A CH880 (H8800) has a feed hopper diameter of 2750mm or approx 9ft.

Horizontal segregation



Reclaim feeders from storage bins distribute different fractions unevenly across width of the belt.
Distribution box fitted to crusher cannot de-segregate nor adjust uneven volume

Coarser lower volume

Finer higher volume

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Rotating feed distributors

Perhaps the only solution to horizontal segregation

Material must be concentrated and fall vertically onto the centre of the rotating plate.

There must be no horizontal component of velocity to cause a flow-rate variation.

The RFD must be sufficiently large to accomodate the largest pieces.

Prototype fitted to CH870 in Ukraine

Typical examples of RFDs

Generally hydraulically or electrically driven

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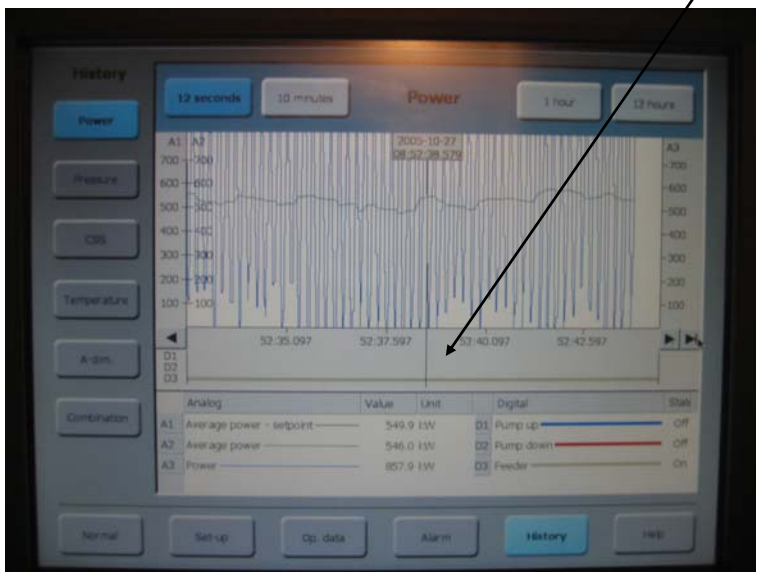
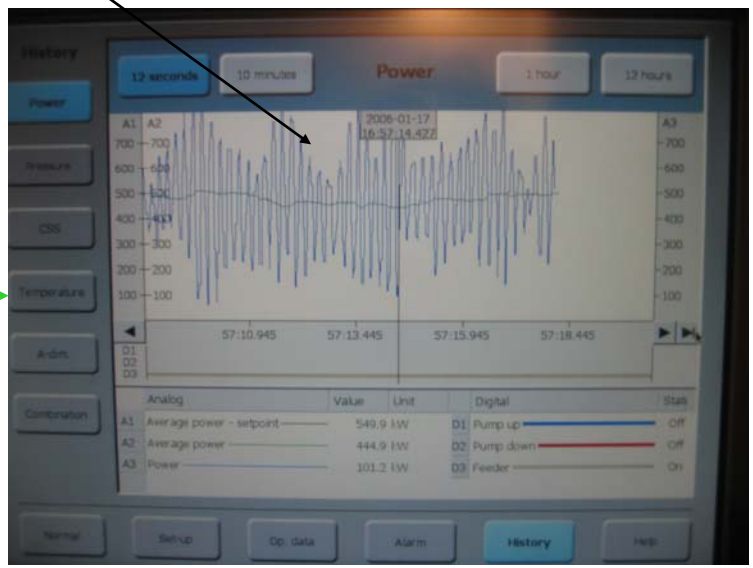
Improvements after fitting an RFD

1 cycle





Pre RFD

27. 10. 05

Extreme peaks

Extreme fluctuation

0 kW suggests that at one side of the chamber there is no resistance-no material.

10. 01. 06

Post RFD

17. 01. 06

Extreme peaks reduced in magnitude and numbers.

Extreme fluctuations significantly reduced

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Wear life improvement after fitting RFD

87 hours

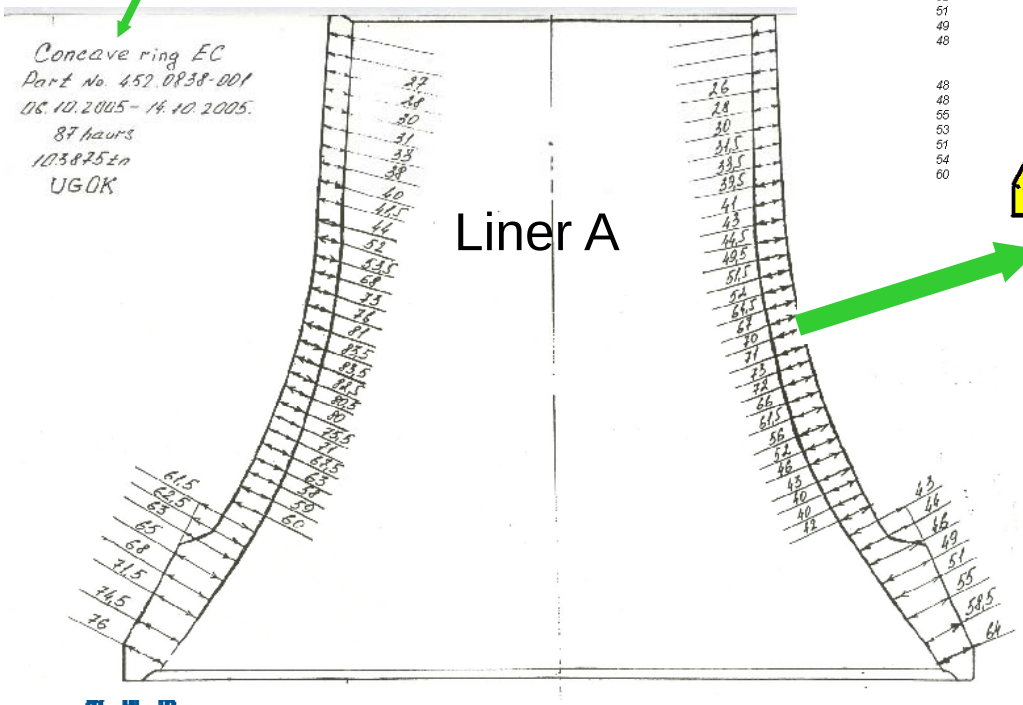
103875 tonnes

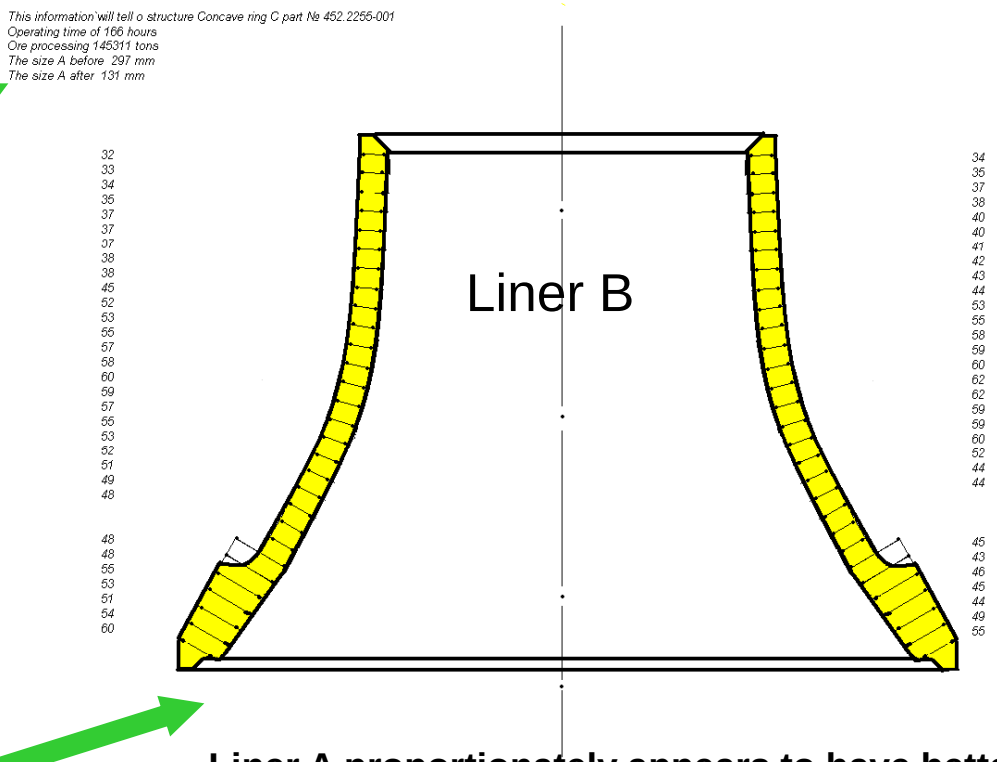
1194tph

166hours

145311tonnes

875tph





Liner A proportionately appears to have better performance but at start CSS was 55mm but by change-out was 65mm on non worn side and 84mm on worn side.

Liner B started at 55, maintained this setting until change-out and was 55mm and 60mm respectively

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Summary

- Poorly designed cone crusher feeds leading to segregation or uneven distribution are extremely costly and often remain so for the life of the operation.These costs result from

1. Re-crushing oversize through running crushers wider than necessary.
2. In serious cases increased capital expenditure.
3. Conveying and wear costs as oversize is transported around the plant.
4. Poor utilisation of manganese liners through uneven wear.
5. Poor utilisation of component parts through extreme cyclic overloading.
6. In serious case traumatic unplanned mechanical failures.
7. Lost business opportunities.

- Segregation and /or poor distribution if they already exist should be and can be improved.We hope we have given an insight to some causes and possible solutions.

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