MARCH 2018 ISSUE

ROC'N

REMco Operators Council Newsletter

Cone Crusher vs. Vertical Shaft Impact Crushers for Tertiary Crushing

Some view this debate like a prize fight, VSI in one corner, cone in the other, just waiting for the bell to ring and the bloodbath to ensue. That is not the point of this article, what we are going to do here is lay out the case and let you, the reader, decide. For this discussion, we are going to define tertiary crushing (the third stage) as having a feed size of 3" or less, with finished product size typically below ¾."

The Cone Crusher

Cone crushers are formidable machines that have a proven track record of reliability in the secondary and tertiary stages of crushing. These machines boast excellent production capability of crushed rock products from 1 ½" to ½," with a relatively long service life of the wear parts and reasonable wear cost when crushing hard abrasive materials. These admissions of fact automatically mean a cone crusher is best for tertiary crushing? Maybe yes, maybe no, let's continue.

The advent of the cone crusher was a giant leap forward in rock crushing technology, no question. Before E.B. Symons patented his cone crusher for fine crushing in 1925 our only realistic options for crushing hard abrasive rock were jaw crushers or gyratory crushers. Both good machines in their own right but, both limited in the production of rock products below ¾" even before we consider modern specifications for the finished products of today.

Cone crushers use a bell-shaped movable crushing member called a head that is typically wider than it is tall. Like the gyratory crusher, the shaft of the cone crusher is held in an off-center eccentric, ring and pinion system which causes the head to move in a similar 360-degree fashion. A fixed crushing member surrounds the head called a bowl. In a major departure from the gyratory, the head and bowl of the Symons cone crusher utilize an area where a significant portion of these crushing members are even with or parallel to one another which was aptly named "The Parallel Zone". Due to the significantly increased contact area of the parallel zone, three important weaknesses of the gyratory were eliminated; low production because rock could experience compression multiple times as it traveled through the parallel zone; poor wear metal utilization due to the increased contact area; and the ability to produce finer materials which made the cone a true tertiary crushing alternative to the machines of the day. For the next 50 years or so cone crushers reigned supreme at the tertiary position before changing finished product requirements would force the invention of a complimentary machine and a competitor, the VSI.

The VSI Crusher

VSI is an acronym for Vertical Shaft Impactor, and there are three types or modes of operation for VSI crushers: autogenous, hard parts, and semi-autogenous. Understanding how the three modes of operation of VSIs work provides insight as to why the three exist in the first place.

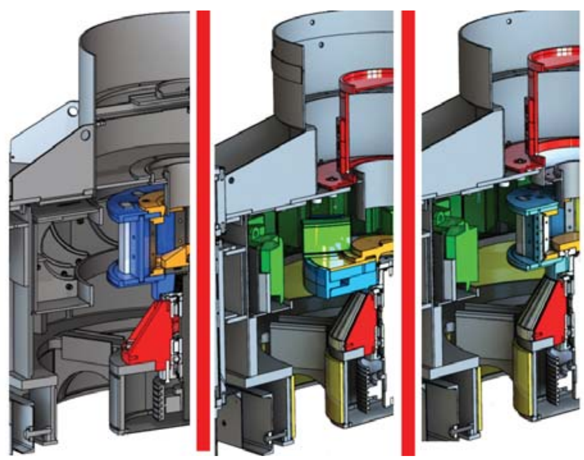

Figure 1: *The three modes of operations (left) autogenous (middle) hard parts (right) semi-autogenous.*

Autogenous (rock-on-rock) VSI crushers utilize an enclosed impeller called a rotor that is designed to trap rock within the rotor providing the main wear surface. Rock delivered to the rotor by the feed tube lands on the distributor plate where centrifugal force caused by the rotation of the rotor moves the rock outward where it impacts the rock trapped between the tip and trail plate and reduction begins. Rock is then accelerated along the trapped material where it experiences attrition due to the impinging forces of multi-layers of rock sliding over the uneven surface of the rock build-up within the rotor. Rock is then ejected from the rotor with great speed to travel across the gap between the rotor and rock-lined crushing chamber. Rock held within the crushing chamber forms a concave shape that forces the high energy rock ejected from the rotor to impact the rock-lined chamber folding back toward the rotor in a dense particle cloud. However, high speed, high energy rock is still being pumped from the rotor ports impacting the particle cloud held in the crushing chamber by the rotor exhaust. This crushing and shaping action is a continuous chain of events 360-degrees around the crushing chamber until the volume of the chamber becomes full and crushed rock begins to fall away and out of the crusher base.

Figure 2: *(above) Uses a fully rock-lined rotor and a rock-lined autogenous chamber.* ***Figure 3:*** *(below) uses a cast iron anvil, and a rotating impeller with cast iron shoes.*

Hard Parts (shoe table and anvil) VSI crushers utilize an open shoe table impeller which in its simplest form is a flat disc with paddles called shoes affixed to it. Rock entering the impeller from the feed tube hits a distribution plate where it changes direction from vertical to horizontal, centrifugal force generated by the rotation of the impeller moves the material outward where it is impacted against the shoes and size reduction begins. The rock is accelerated along the shoe until it is expelled from the impeller. Once ejected from the impeller, rock travels a short distance where it impacts the face of the anvil and typically shatters due to the rapid transfer of energy. With its energy expended crushed rock falls from the anvil face by gravity and out of the base of the crusher.

Figure 4: *Is a hybrid combination that uses a rock-lined rotor with anvil chamber.*

Semi-autogenous (hybrid, rock-on-rock and rock-on-steel) VSI crusher uses components from its two cousins. Most often semi-autogenous VSI crushers are configured with a rock-lined rotor and anvil crushing chamber. While the possibility exists to use a shoe table and autogenous crushing chamber, there is little to no benefit in doing so. Generally speaking, the rotor has an advantage over a shoe table because rotor velocity can be much higher than that of an open shoe table imparting greater force to the rock and eliminating the shoe as a wear item. Anvil crushing surfaces have increased crushing efficiency over the autogenous chamber until the anvil face deteriorates due to wear reducing the ability of rock ejected from the impeller to impact a flat surface and glances off the worn edge of the anvil.

Which VSI mode is the best?

Determining which one has the best overall performance for a given crushing task is done by tallying a variety of factors which include; type of rock, abrasion characteristics, crushing characteristics, power requirement, finished product size and shape as well as operating circumstances to develop an overall cost per ton. It is the finished cost per ton that determines which mode of operation is best for a given application.

VSI history

As an alternative to the flat and elongated crushed rock particles produced by the typical cone crusher, hard parts VSI crushers produced cubical shaped aggregate and could even make sand if needed. The concept of an autogenous VSI crusher was not new, some of the earliest designs date back to the 1930s with an American named A. L. Runyan but, the manufacturing materials and technology of the day were not sufficient to make the machine commercially viable. By the 1970s however, the right combination of need, metallurgy, inexpensive rolling element bearings and sheer determination led by George Jim MacDonald and Brian Bartley to develop an autogenous VSI that used few wear parts and produced cubical shaped rock products, the Barmac.

The autogenous VSI was conceived as a shaper to fix the flat and elongated rock particles that would not meet shape specifications. Producers would run finished sized product through a Barmac to break off the flaky portions of the rock, leaving a cubical particle. With the added benefit of less oil usage in asphalt, better pumpability of concrete, better strength for both and the ability to produce sand economically.

Once the market learned of the advantages of this cubical material, specifications changed quickly. Many plants went to four stages of crushing typically using a jaw crusher primary, cone crusher secondary, cone crusher tertiary and a VSI as a quaternary crusher. This was sufficient with cone crusher manufacturers as they still got to sell a cone crusher tertiary.

Being the former majority partner of Barmac America from 1985 - 1990 and the leading distributor of the product from 1985-1993, REMco began building its version of the VSI in late 1993 to expand the technology to a wider application envelope. In REMco's view, since the cone crusher made the poorly shaped product in the first place, why not crush and shape at the same time. All that had to be done was develop a high-performance rotor that could take the larger feed, with a chamber that could take the beating.

A tertiary VSI could be purchased and installed for 30% to 40% of the price of a cone crusher with comparable capacity. Cubical shape with a VSI is a given. However, cone manufacturers were not going just to give up a market that was traditionally theirs without a fight.

Figure 5 *A REMco VSI does its best work when operating in conjunction with a cone crusher in a typical third stage circuit*

Shaped aggregate with a cone crusher

Depending on your state, shape specification fall into two basic camps for limiting the ratio of flat and elongated particles; 5:1 or 3:1. Most state specifications limit the percentage of poorly shaped rock to be 10% @ 5:1 or not more than 20% @ 3:1.

In a public forum, a large cone crusher manufacturer presented their ideas of how to producer acceptable shape from a cone crusher. If a customer's objective was to produce ½" aggregate with reasonable particle shape, the cone crusher must be operated as follows; feed size not larger than 1" to keep the reduction ratio @ 2:1 with the close side setting of the cone @ ⅝" for a circulating load of at least 50%.

If all worked as planned, the percentage of poorly shaped particles would be 9.6% or just below the 10% maximum. Now, let's look at what this does to the crusher and the crushing circuit;

- increases the amount of pre-crushing required to keep a short reduction ratio
- Increases the circulating load which increases the amount of screening area required
- Increases the amount of wear on the liners due to increased rock throughput
- Increases the horsepower per ton required by the cone to operate due to increased pressure
- Increased the amount of minus $^{3}/_{16}$" screenings

New REMco Series 1530 VSI Crusher:

- Feed sizes up to 3”
- Oil lubrication system
- Field convertibility
- 300 HP electric motor and V-belt drive
- Easy access with “H.O.T” system & drop-in style tips

New 6 x 16 TD Inclined REMco PROscreen:

- HD side plates
- Integral feed box & discharge lips with bolt in liners
- Clamp rails with quick remove/install wedge locks
- Coil spring trunnion suspension
- 20 HP motor with pivoted motor base and V-belt drive
- Grease lubricated vibrator mechanism with adjustable throw

Available with any REMco VSI / PROscreen or PROcone / PROscreen

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WORLDWIDE PRODUCTS OF REMco - AN AMERICAN COMPANY

All the items listed are the very same things cone crusher manufacturers used to say were bad about autogenous VSI crusher; high circulating load, high horsepower, requiring big screen and produce more minus $^{3}/_{16}$" screenings. Only when you do the job with a cone, the shape is not as good, the wear cost is higher than a VSI and you get to pay two to three times the capital cost for the privilege of using a cone for the work.

The shape from a VSI is always better than that of a compression machine. A REMco VSI will also allow a customer to balance plant production with market demand as excess products that are stockpiled as under-utilized inventory can be crushed again in a VSI to products that sell like sand and chips.

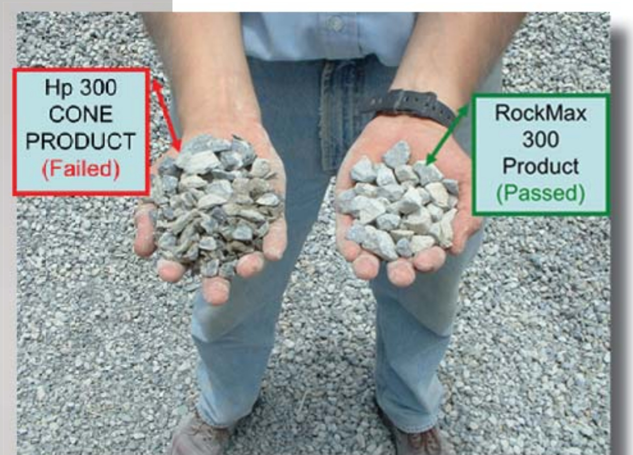

Figure 5: *The pile on the left hand is from a HP 300 cone, while the pile on the right is from a RockMax 300.*

The production of sand with a cone crusher is not easy. Remember in order for the compression crusher to work it must squeeze the rock. Therefore if the rock is smaller than the close side setting of the head, that rock does not see compression. This problem gets worse when the cone liners deform from wear. What the producer is left with is; low production of sand that is barely in spec with unacceptably high FM, making the sand coarse and difficult to sell. Should you find the depiction of sand production from a cone crusher less than convincing, think about this: have you ever seen a cone crusher operating in closed circuit screening over an #8 mesh opening producing concrete sand with low FM and cubical particle shape without the aid of blend sand? Me neither, however, it is not difficult to find a REMco VSI doing it.

The common misconceptions of VSIs

VSI crushers use lots of wear parts?

Wear parts and their usage are a function of applying the right VSI crusher to the task. If you apply a hard parts or semi-autogenous machine to an abrasive high silica material your wear cost will be high. That is a misapplication of the device. But for the moment lets assume the VSI is properly applied. Wear steel in a cone crusher represents several tons of metal, of which about 50% at best is usable, which means a lot of those tons are thrown away as scrap.

Autogenous VSI crushers, on the other hand, with their autogenous rotor use parts that are handled by hand. Due to their weight and size relative to the work they do yes, they typically have shorter service life than the tons of a cone liner. However, these parts do not wear out at the same time and their replacement is measured in minutes not hours. Including labor, the VSI most often wins the wear cost battle against a cone crusher for the same work.

VSI crushers are too labor intensive, I'll have to go in every day for inspections.

That is true, most VSI manufacturers do recommend a visual inspection of the crusher, taking just a few minutes daily. But did you know that most cone crusher manufacturers also suggest a daily inspection of the machine (check the manual).

VSI crushers are not real crushers they are just shapers.

Due to the VSI's versatility, lower capital cost, ability to produce quality shaped aggregate and sand it continues to grow in market share. Further, every major cone crusher manufacturer also has a VSI in its product mix. The real question is which time were they misleading you? When they tell you the VSI will not work, or when they try to sell you one against the REMco? You decide.

We covered a lot of ground and ultimately, youwill decide the winner when you purchase your next machine.

But maybe it's worth looking at another possibility for tertiary crushing and maybe you should ask for a performance guarantee for wear cost and production from your supplier.

By: REMco (02/2018)

Tech Talk

Service and Maintenance tips for REMco crusher operators

Rotor Series: Quick Balancing Procedure

4,5 & 6 Port open side rotors

The REMco Rotor Balancing procedure has been developed to assist plant personnel when doing this work under field conditions. Because of the variety of models, there may be some slight mechanical difference between rotors.

Any damage to the rotor body should be repaired through weld touch-up or other means before balancing. Pre-assembly of the rotor with wear parts should be done prior to balancing.

You can use new wear rings or worn wear rings that still have more than 50% wear life remaining. Always use new bolts.

The Essential Check-list

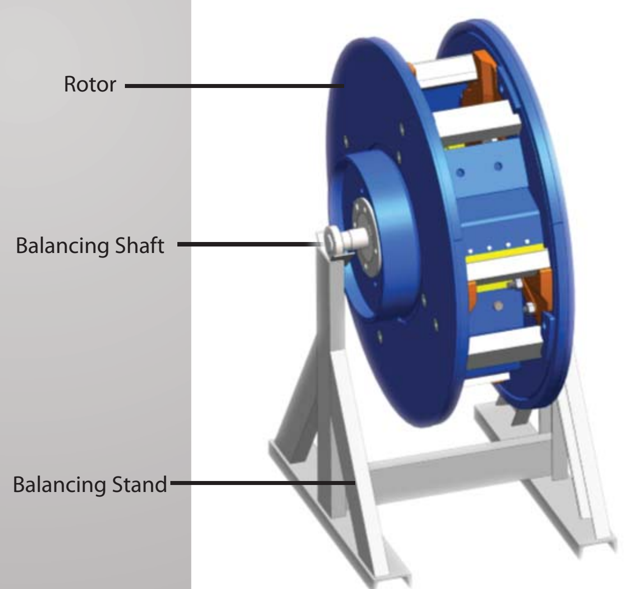

Figure 1*: Assembly of the rotor balancing machine.*

☐ Read all check-list points prior to balancing the rotor.

☐ Inspect the rotor, check for holes, cracks or severely worn areas in the inner and outer walls of the rotor.

☐ Locate rotor balancing shaft and the shaft bearings.

☐ Be sure that the shaft bearings are clean and turn freely. Do not use bearings that are sealed for this purpose as they will restrict free turning of the rotor.

☐ Remove rotor taper lock from the crusher shaft and mount onto balancing shaft. Check taper lock for damage.

☐ Place the balancing stand on a flat surface.

☐ Slip shaft into rotor and be sure taper fits snugly on both sides of bore.

☐ Check to be sure shaft fits tight.

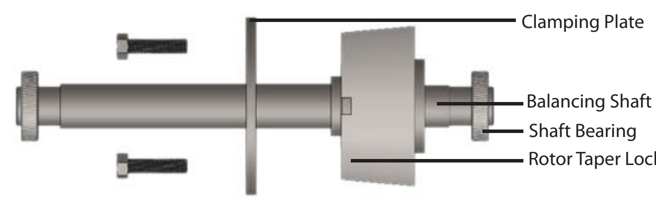

Figure 2*: The typical shaft bearing with the rotor taper lock.*

☐ Tighten 4 hole plate bolts to hold a tight fit between rotor boss and balancing shaft. Ensure that the bolts are tightened in place.

☐ Place bearings on rotor balancing shaft ends and place the entire rotor / balance shaft assembly on the balancing stand.

The 10 Guidelines to Balancing a Rotor

1. Facing from the feed opening side of the rotor, mark the balance weights on the ports alphabetically: A, B, C, D, E and F respectively.

2. Spin rotor by hand and allow it to come to its own stop. Heavy side of rotor will be located at 6:00 position. Light side of rotor will be at 12:00 position. Mark the 6:00 position with chalk and spin in both directions several times to confirm that the heavy side is at the chalk mark.

3. Port closest to 12:00 or top-dead center is the B port, port to the left is the A port and port to the right is the C port. Port D, E and F are clock-wise from the C port.

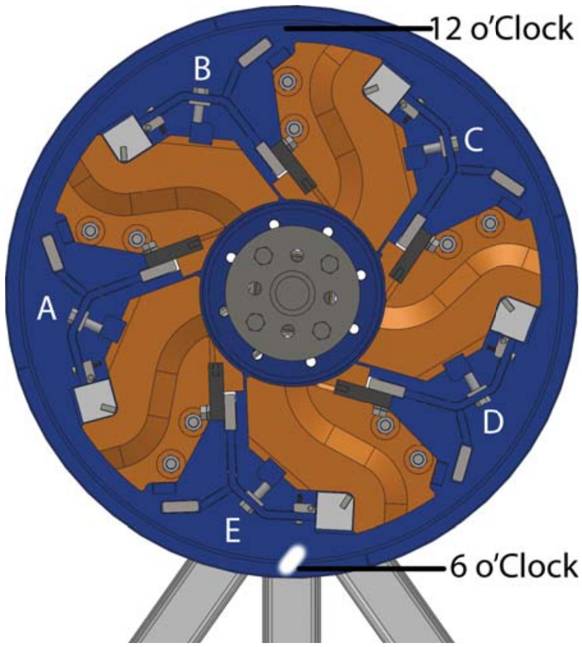

***Figure 3**: The typical rotor position with the balance weight clearly identified A, B, C, D, E and F respectively.*

4. Manually position the B port to the 3:00 position (90 degrees from top-dead center). If the rotor turns to the right, add weights to the left side (port A) to return the B port to the 12:00 position. If the rotor turns to the left, add weights to the right side (port C) to return the B port to the 12:00 position.

5. Continue to check the balance of the rotor and stopping at each port. Position port D to the

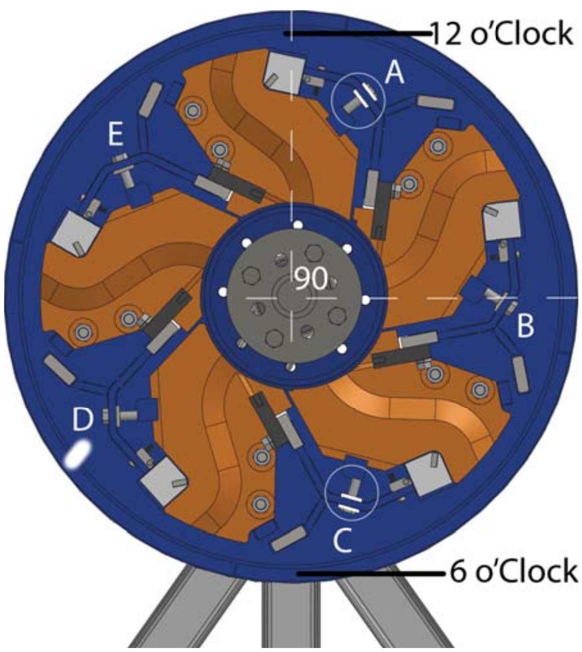

***Figure 4:** The B port is pulled to the 3:00 position, and weights are added to the A or C ports to bring the B port back to the 12:00 position.*

3:00 position and see if the rotor is balanced. ***NOTE: Add weights to the rising side to get the specific port back into the 12:00 position***.

6. If the rotor does not rotate from any position, it is balanced. If it rotates from any position, repeat Step 4 and 5 without removing any of the weights that have been installed. The second balancing procedure will give a finer level of balance. ***NOTE: No more than five two hole weights on any one port. Contact REMco Technical Service Department for guidance.***

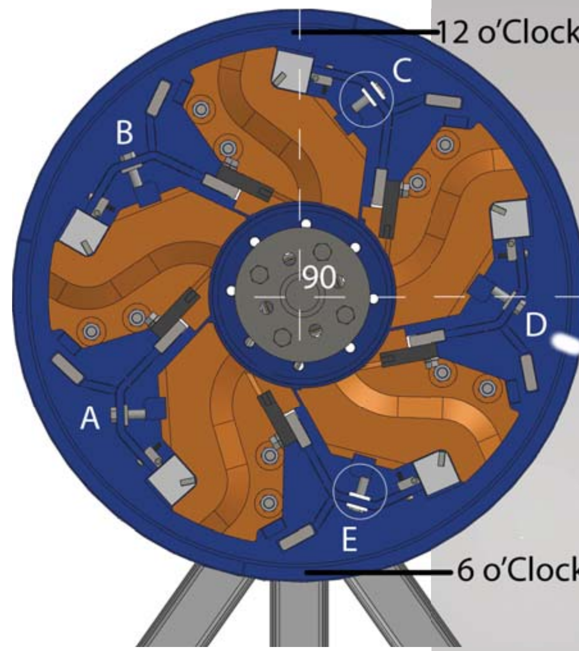

***Figure 5:** The D port is pulled to the 3:00 position, and weights are added to the E or C ports to bring the D port back to the 12:00 position.*

7. If after numerous attempts at balancing the rotor still turns, this is an indication that it is shifting on the shaft. Disassemble the rotor, taper lock and shaft and clean all surfaces to insure that the fits are correct. Be sure that the taper lock used in the crusher with the rotor you are balancing is used on the balancing shaft. ***NOTE: Different taper locks have different wear patterns and may cause shifting of the rotor in the balancing process.***

8. Be sure all trail plates are positioned on the OUTSIDE of the rotor wall adjacent to the boss.

9. Be sure all bolts are properly tightened.

10. Accuracy, care and patience with this procedure will pay dividends in smooth crusher operation and long bearing cartridge life.

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Announcements

Technical questions, featured job story, or crusher challenge?

The **REMco Operators Council Newsletter (ROC'N)** features stories, crushing techniques, and the latest news which we want to share with our most critical readers: **YOU THE CUSTOMER.**

Our success depends on your success. We want to hear what's been happening with the REMco VSI Crusher / PROcone or PROscreen at your plant site.

Send us your questions, comments, feedback or request to be featured in our next job story. If you don't use email, drop us a line by snail mail or give us a call. Who knows? Maybe you'll see your question or story in print.

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