Crushing

Reducing the size of the ore particles prior to mineral separation is called comminution; this normally takes place in stages. The first stage is primary crushing; this may be followed by secondary crushing and so on. The last stage of comminution is grinding; this might also be done in several stages to optimise the conditions for mineral recovery. In practice the distinction between crushing and grinding is not precise. Thus stamps were often described as machines for crushing or grinding the ore.

As alluvial tin deposits were depleted underground mining for copper, tin and other metals commenced and by the mid 18th century there were many established mines. The run of mine ore needed to be crushed to pieces of around five to eight centimetres in size prior to grinding. From the earliest times until the latter part of the 19th century this work was done by hand.

The method for preparing the ore by hand, particularly in 18th and early 19th century copper mines, was as follows. The ore was hand sorted and the largest pieces broken or “ragged” using sledgehammers. Next the ore was “spalled” (broken finer) using a smaller hammer, and then “cobbed” with a special long-headed hammer to break off waste rock from the ore fragments. Finally, if stamps were not available, the ore was ground by hand on iron plates using a flat-faced “bucking” hammer. Many mines employed women and girls (bal maidens) to do this work.

As early as 1796 John Taylor improvised a machine from iron pipes to crush ore at Wheal Friendship mine in Devon. This early crusher was improved into an efficient machine consisting of two iron rolls each about 60 cm in diameter. The rolls were pressed together by a weighted crank and lever mechanism and turned by a water wheel. Ore was fed to the rolls to be crushed between them. If extra hard or large lumps of ore were encountered the rolls would spring apart and not be damaged. Roll crushers were favoured over stamps for treating some ores as they produced proportionally less fines and improved overall mineral recovery.

By the 1840’s copper mining in Cornwall was in decline but tin output was steadily increasing. On most mines the tin ore was brought to the surface and piled into heaps on the “spalling floors” where it was broken with sledgehammers into pieces small enough for the stamps.

In the mid 1800’s mechanical rock breakers or jaw crushers were invented. These squeezed the rock between heavy ridged steel plates or jaws, set in an upright position at an acute angle to each other, and held within a substantial steel frame. One jaw was fixed whilst the other was pivoted and free to swing. Rock fed into the crusher was systematically squeezed and broken between the jaw plates until the pieces were small enough to pass out through the narrow gap at the bottom.

The most commonly used rock breaker was the Blake-crusher (this was patented by W E Blake in 1858 and later improved by Marsden). This had the moving plate
pivoted at the top. As this moved back and forth against the fixed plate the variation in the gap size was greatest at the lower discharge point. Thus the ore being discharged varied slightly in size but passed through the crusher easily and with less chance of blockage. The Dodge crusher developed at about the same time had the swinging jaw pivoted at the bottom; this produced a more uniform sized product but had a smaller throughput rate and was prone to blocking.

In both types of crusher a heavy flywheel, driven by a steam engine (or from the end of the 19th century an electric motor), turned an eccentric mechanism linked to the swinging jaw plate to move it back and forth.

Jaw crushers are ideally suited for the primary crushing of run-of-mine ores, readily reducing the rock to pieces 10-20 cms in size.

Towards the end of the 19th century gyratory crushers were developed. In these machines ore is crushed between a conical shaped “head” suspended within an inverted conical shaped chamber or “shell”. The head is carried on a spindle suspended from a supporting “spider” above, and seated in an eccentric sleeve below; as the head rotates (driven by an electric motor) it sweeps out a conical path within the shell. This has the effect of continually changing the space between the head and the shell. Ore fed into the top of the crusher is continually crushed as it falls through this pulsating narrowing space until small enough to pass through the small annular gap between the bottom of the head and shell.

Gyratory crushers can be thought of as an infinitely large number of jaw crushers each of infinitely small width but at any one instant ore is always being crushed. Thus gyratory crushers have much higher capacities than similar sized jaw crushers and are usually favoured in plants with large throughputs.

By the mid 20th century modified gyratory or cone crushers were being produced. In these machines the crushing head or cone is supported from beneath via a shorter spindle and bearing assembly. The shape of the crushing shell or ‘bowl’ is modified and flared to increase the fine crushing area and to rapidly remove the crushed material. These machines run much faster than gyratory crushers and consequently have greater throughput rates.

Cone crushers are supplied in two forms: Standard crushers are ideal for normal or secondary crushing and will deal with a relatively coarse feed reducing it to 0.5- to 6.0 cms whilst Short Head crushers are designed to crush finer material to 0.3- 2.0 cms.

At Geevor all three types of crushing machines were used. Before 1920 all of the ore was hoisted to the surface via Wethered Shaft. Here, after passing over a ‘grizzly’, the oversized pieces of ore were crushed by a 20 by 10 inch Blake-Marsden rock breaker. This was driven by a 25 HP electric motor and could handle 160 tons of ore a day. The crushed ore was then transported via an aerial ropeway to the “stamps bins. The sinking of Victory Shaft was commenced in 1919, and by the early 1920’s was equipped with a 12 by 10 inch Blake-Marsden 12 H.P rock-breaker to crush the
ore hoisted here. Before 1938 the output of these crushers was combined and passed to Holman pneumatic stamps for grinding. A Blake and Jones swing jaw crusher replaced the Blake-Marsden breaker at a later date and this was subsequently removed and replaced by a Bigelow crusher. The crusher gaps were set at two and a half inches.

During 1937-8 new machinery was installed for the washing, sorting, crushing, screening, grinding and concentrating the ore. The ore from the jaw crushers was passed to a 24in Symons cone crusher, operated in closed circuit with a 7/8inch aperture hummer screen for further reduction before being fed to a 7 ft Hardinge ball mill for primary grinding. This ball mill, along with smaller, secondary and tertiary mills, replaced the less efficient Holman stamps battery. The stamps were subsequently removed at the end of 1938.

With the introduction of Heavy Media Separation in the mid 1960’s a second 36in Symons standard cone crusher was installed to crush rock prior to sorting in a Wemco Drum. The “sinks” from the Wemco drum were passed to the original 24in cone crushe (now in open circuit) for final crushing before grinding in the 7ft mill. The “floats” from this process were sized in a trommel with a ¾ inch aperture and any oversize crushed in a Sheepbridge gyratory crusher.

A major extension and refurbishment of the processing plant was started in 1979/80. This included (in 1978) the refurbishment and repositioning of the primary Bigelow jaw crusher to enable the crushing of ore from extraneous sources and the installation of a Brown Lenox Kue-Ken jaw crusher to treat the ore hoisted via Victory Shaft.

In 1983 the heavy media separation plant was upgraded by replacing the 1960’s Wemco drum with a Tri-Flo Dynamic Separator. To feed this system the secondary crushing plant was also upgraded in 1984 with the installation of two 3 ft cone crushers (one Short Head and one Standard Head) and associated Mogensen screen sizers replacing the original Standard head cone crusher. These changes meant that up to a 1000 tonnes of ore (from extraneous and underground sources) could be crushed, washed and sorted each day.