

The Cutting Edge

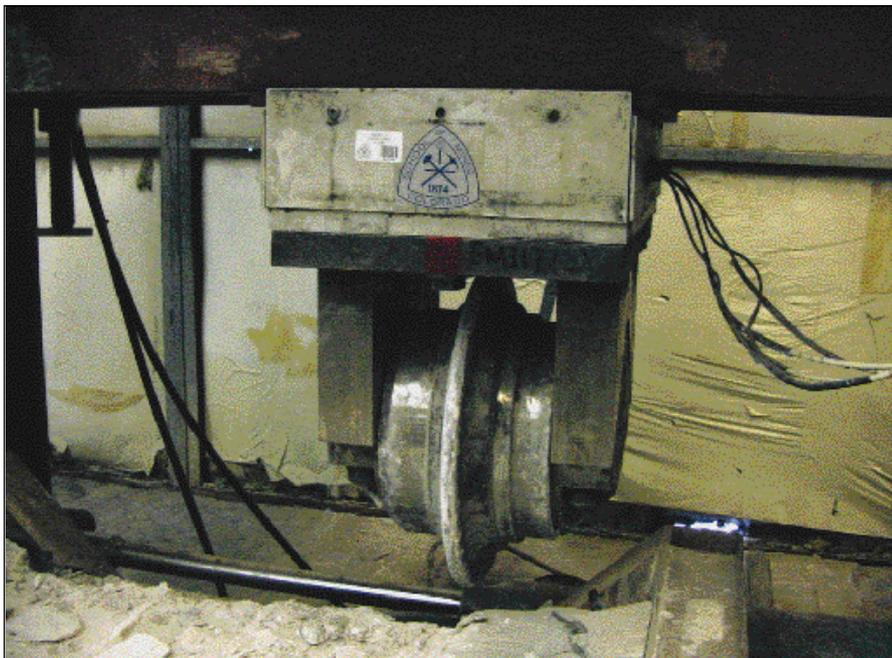
Disc cutters for use on full face boring machines were originally developed in 1956 by James Robbins. The disc cutter revolutionised the tunnel excavation industry, by being able to cut through metres of rock in a relatively short space of time. Constant testing needs to be carried out on cutters to help maximise performance and minimise wear of the bit.

Colorado School of Mines has a laboratory for such testing in the Excavation Engineering and Earth Mechanics Department. The main tests described by Colorado School of Mines are; the linear cutting and the drill tests, other tests not published are also undertaken.

The Linear cutting tests give a direct measure of rock cuttability under simulated field conditions. The Linear Cutting Machine (LCM – pictured) measures the forces acting on an individual cutter while cutting the rock. Data from the test provides information on performance prediction, machine specification, cutterhead balancing and optimisation. These full-scale tests help to decipher the uncertainties of the rock, which may not be identified by the physical property testing.

The Drill Test Fixture (DTF) is used as a performance indicator of drill bits and cutterheads less than 1.2m in diameter. The DTF has the ability to bore axially with the drill string, as well as slew, or cutting perpendicular to the drill string. The DTF is instrumented

Linear Cutting Machine in testing laboratory.



Laboratory Tunnel Boring Machine at Colorado School of Mines.

to measure all operational parameters, as well as vibrations generated by the cutting action. These measurements are digitally recorded. The testing of a full-scale cutterhead provides an accurate measure of qualifying the dynamic effects of cutting and an economic proving ground for new bits and cutterheads.

Another unique test fixture is the Laboratory Tunnel Boring Machine (LTBM –

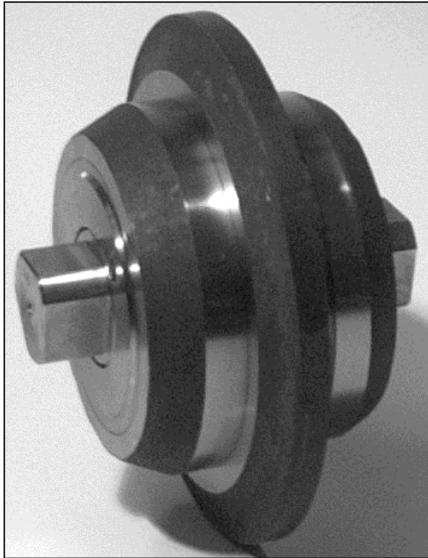
pictured). It is used to test the performance of full-scale cutterheads up to 2m in diameter. It is mounted on a swivel frame so that any orientation can be tested, from straight up to straight down, in wet or dry conditions. The LTBM data acquisition system is computer based for high resolution and accuracy. Individual cutters can be instrumented to measure actual cutter forces during boring.

Disc cutters are used in abundance for tunnel excavation. Indeed on a long tunnel the cutter contract may be more valuable than the machine sale. Tunnel boring machines are vastly expensive, but are quick and leave less ground for 'making good' after excavation. Disc cutters research and testing has allowed the machines to become more efficient in different geological environments.

For the most part, the major TBM manufacturers produce their own cutters because of the huge added value a cutter contract can bring to TBM supply. There are also a few independent companies which make disc cutters for TBMs. Some details of cutters supplied by the TBM manufacturers and the independent companies are noted below.

Black Diamond Cutters

Black Diamond Cutters (pictured) from Minesite Technologies are a range of hard rock and EPB disc cutters developed and manufactured in Australia ranging in size from 35.5cm to 48.2cm . The company has incorporated recent bearing design improvements,



Black Diamond Cutter.

modern metallurgical processes, and existing concepts to offer a new disc cutter design range.

The Black Diamond Cutter's patented designs were successfully trialed on the Second Manapouri Tailrace Project in New Zealand in granites in excess of 250MPa. Orders are currently in hand for other projects with a worldwide distribution network now in place. Black Diamond Cutters' design incorporates a single multi-rowed tapered bearing, coupled with a dual sealing system offering increased life and improved performance. This innovative design vastly reduces man-hours in the disassembly/assembly process, providing additional cost savings to the TBM contractor.

Black Diamond Cutters' range of rings and cutter assemblies can easily be incorporated into existing TBM cutterheads offering alternative supply to TBM manufacturer's cutters.

For more information about Black Diamond Cutters, please contact Mandy Maurer, Minesite Technologies, Unit 9, 10 Bradford Street, Alexandria, NSW 2015, Australia, or PO Box 97, Beaconsfield, NSW, 2014. Tel: +61 2 9317 5211 Fax: +61 9317 5667 E-mail: pactun@minesite.com.au Website: www.minesite.com.au

CTS/Terratec

Construction and Tunneling Services based in Kent Washington, US designs tunneling equipment and sells its own range of consumables including cutters. It has a joint arrangement with Terratec in Tasmania Australia and cutters may be sourced from either company depending on availability and convenience. CTS cutters utilise alloy steels specifically developed for maximum efficiency in rock tunnelling applications. Cutters, machined cutter parts, high capacity bearings, machine spare parts and related consumables are offered at competitive prices and accelerated delivery to suit project requirements.

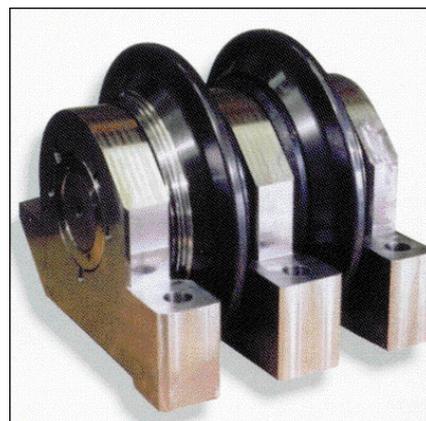
CTS, 1609 S Central Avenue, Suite H, Kent, WA 98032, USA. Tel: +1 253 859 9724. Fax: +1 253 859 9728

Terratec Asia Pacific, Box 83, Blackmans Bay, Tasmania 7052, Australia. Tel: +61 3 6229 5511. Fax: +61 3 6229 5700. E-mail: tunnel@terratec.com.au

Herrenknecht

Up until now, Herrenknecht has primarily sourced its cutters from its US operation where there is a considerable amount of cutter development expertise. However, the company is setting up a joint venture cutter plant in Aldorf Switzerland with RUAG, initially for the St. Gotthard tunnel cutter contract for the Herrenknecht machines, but which will also be able to supply cutters for other units elsewhere.

Herrenknecht reckons that the arrangement, form and design of its cutters has to fulfil the greatest demands in respect of abrasion resistance and long term durability, and that its cutters wear more slowly and evenly without chipping. The company supplies 432mm diameter single and twin disc cutters, made of high alloy tool steels and with a load capacity of up to 267kN. Herrenknecht reports that experience has shown that these dimensions represent the ideal compromise between load capacity, penetration, wear, installation standards and weight. In order to enlarge the bore diameter by up to 200mm, Herrenknecht can equip its cutterheads with stationary or, for shorter overcut sections, with hydraulically telescoping, triple overcutters.



Herrenknecht twin disc cutters.

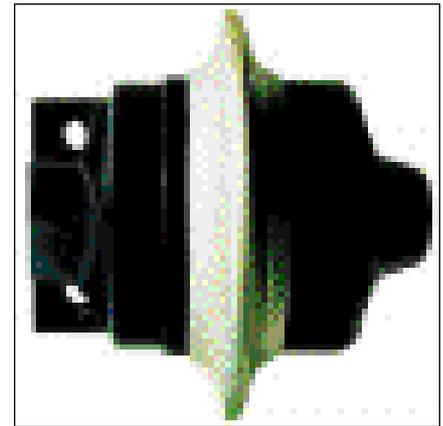
Herrenknecht Tunnelling Systems, 3701 S Lawrence Street, Tacoma, WA98409, USA. Tel: +1 253 476 4700. Fax: +1 253 476 4770.

E-mail: cutters@herrenknecht-usa.com or

HerrenknechtAG, D-77963 Schwanau, Germany. Tel: +49 7824 302-0. Fax: +49 7824 3403. Website: www.herrenknecht.de

Palmieri SpA

Family run Italian company Palmieri produces disc cutters from its own foundry. In sizes from



Palmieri disc cutter.

15cm to 50cm in diameter and claims to be one of the world's biggest suppliers of TBM cutters. Palmieri produces many other items besides disc cutters. The equipment produced includes; roller cutters, teeth and bits, as well as complete cutter heads for vertical drilling and Down the Hole or DTH bits and HDD tools. Palmieri has supplied many world-wide projects with equipment with an emphasis on micro tunnelling.

For details: Palmieri SpA, via dell Industria 58, I-40041 Gaggio Montana, Italy. Tel: +39 0534 32511. Fax: +39 0534 32501.

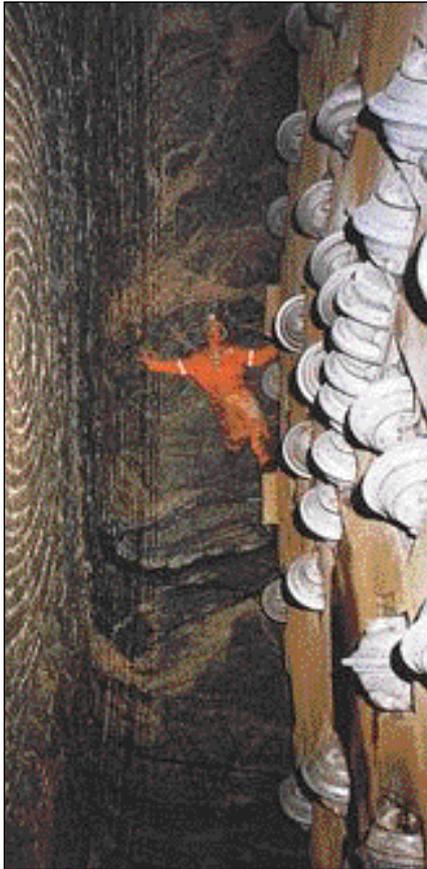
Robbins

Major TBM manufacturer, Robbins, produces its own cutter lines for a wide range of machines. Disc cutters are manufactured from 280mm to 483mm in diameter and are available in a wide range of materials, each material and process type being specifically designed for the requirement of geology and project economics. For really demanding hard rock applications, cutters with tungsten carbide insert rings can be produced.

Cutter discs are produced in different grades of steel and with different profiles with a variety of tip widths for optimum performance in different rock types. A continual process of cutter development is undertaken in materials and processes to balance the residual stress within the disc, increasing rolling life and minimising chipping and cracking of the cutting material. Heat treatment modifications have also been made to help improve durability and these ongoing developments are continually being introduced into the latest cutters.

Robbins also manufactures cutters specifically designed for softer ground EPB type machines.

Robbins' Wedge Lock™ mounting system used with its 432 and 483mm is one of the leading mounting systems on the market. It isolates saddle bolts from cutter loads and is claimed to reduce downtime caused by broken hardware and saddle damage. It features a simple design with a minimum



Robbins cutters.

number of parts making for fast rebuild, and the hardened ring seat area maximises hub life. Cutter assemblies fit in both front and back loading cutterheads, reducing the need to stock additional parts, while the simple system makes for more rapid cutter changes.

Robbins, 29100 Hall Street, Solon, OH 44139, USA. Tel: +1 440 248 3303. Fax: +1 440 248 1702. Web: www.robbinstbm.com

Wirth Disc Cutters

Wirth supplied cutter heads are designed for front installation depending on the requirements of the respective project. Customers' rock specimen are analysed on the latest test equipment by experienced staff in the company's laboratory so that the most appropriate cutter design can be selected.

Wirth mono-disc cutters have been substantially developed over the years. Originally these were limited to thrusts of some 120–140kN per cutter, but improvements in design and materials now mean that thrust forces of some 250 to 300kN per cutter are achievable today. Cutters now incorporate hard, fine grained carbides which are firmly integrated into the matrix of the disc material and help avoid rapid abrasive destruction of the discs by abrasive materials in the rock being cut.

Increasing hardness, however, has its own problems and can decrease the toughness of steels. The demands on the material of disc rings are extremely high. Consequently, so-called 'cold-work steels' are used distinguished by a high hardness (good wear resistance = long cutter life) concurrent with a relatively high toughness (low rupture risk). With increasing hardness the toughness decreases, i.e. at shock-type charges in faulty, blocky rock formations the hardness of the discs should be reduced in favour of the toughness.

As manufacturers of tunnel boring machines, Wirth has manufactured and supplied more than 50,000 cutters for operation in various rock formations in the past 30 years. Among the rocks which have been cut were, for example, granite with a compressive strength exceeding 550MPa and a quartzite with a proportion of abrasive minerals exceeding 95%. More than 750km of tunnel have been bored so far with WIRTH tunnel boring machines moving over 15 million cubic metres of rock.

For more information about Wirth and their products please contact: Marie-Anne Stoll, Wirth Maschinen- und Bohrgerätefabrik GmbH, Kölner Strasse 71–73, D-Erkelenz, Germany. Email: Marie-Anne.Stoll@Wirth-europe.de Website: www.Wirth-europe.com