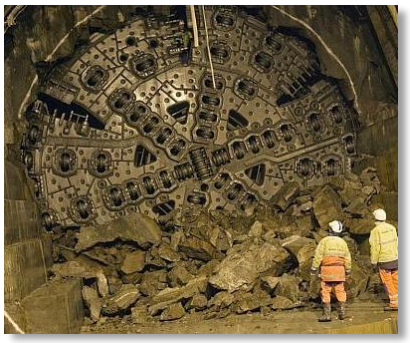
Mechanical Seal Design for Differential Pressure Applications

SAP Parts Pvt. Ltd. 13/04/2020 **Edition : 4**

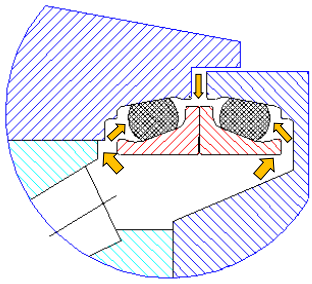
TBM Cutter Rollers

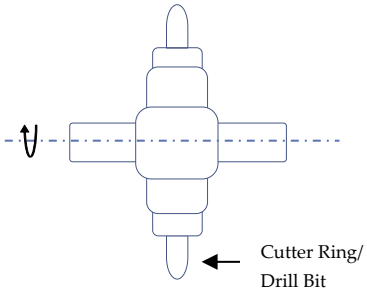
Seal Design for Differential Pressure Applications.

Application of Metal face Floating seals is one of the most significant developments in the disc cutter. This type of Seal uses two metal rings that are loaded axially such that they ride against each other with a film of lubricant between them, creating a dynamic face-seal interface. Each ring, one on the rotating hub, and one on the stationary shaft, is sealed to the mounting gland by a rubber ring (Toric, or o O -ring), which also acts to allow a relatively generous hub-to-shaft misalignment tolerance, and as a spring to load one seal ring against the other. Although proven effective for years together, in hard rock disc cutter applications, there observed problems associated with the seals in some specific applications.



TBM roller cutters are specially designed for a specific system. Large journal bearings and maximized bearing configurations enable each roller cutter to withstand an extremely high load. The bearing is a roller-ball-roller configuration, consisting of large diameter rollers and balls. The roller cutters utilize proprietary ***mechanical face seals*** *and lubricating oil. The mechanical face seals are pre-loaded and vacuum tested to ensure seal effectiveness. The lubricating oil contains special additives for high*





One of the problems encountered with the Mechanical face seals Employed in cutter Roller is when a slurry of certain rock types pushes through the labyrinth created by the hub and seal retainers and then, given time, dries, effectively cementing one metal face seal ring to the other. When

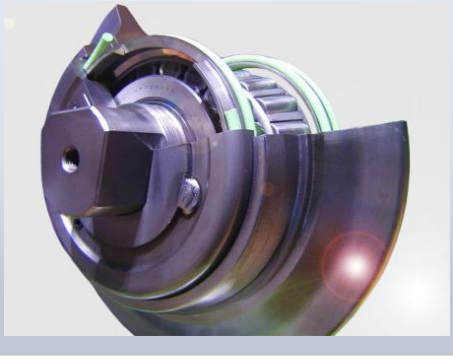
Issues causing Consequential Seal Failure in Differential Pressure Applications

Seal failure can lead to a potential consequences in a mechanical system, mainly that of Rock Breaking Machines, Drum Cutter s and cutter rollers of TBM in an underground environment.

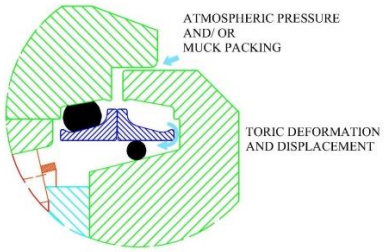
During the Failed Cutter Roller assembly analysis, it is seen that the most commonly needed first part to be removed is Failed Mechanical Seal. The severity of failure in some cases shows the Torric Rings burn outs and smoke thereto. However quite often the mode of failure isn't so obvious. Complicating things ahead, it is not always easy to determine the cause of failure once the failure mode is isolated.

Modes of Seal Failure:

- Damaged O -Rings.
- Fused Faces.
- Abrasive Wear
  Causes of Seal Failure
- Assembly Error
- Too much Drag
- Too Low face Pressure
- Rust after pronged not in use time.

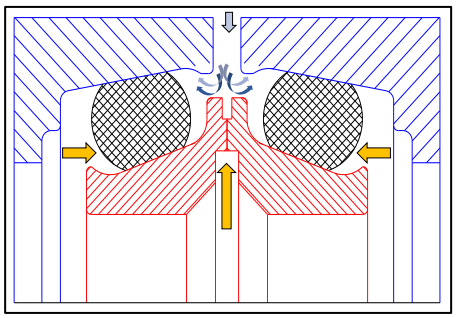


the cutter starts rolling again, the cemented metal rings may momentarily spin with each other and stretch the rubber toric holding the metal seal rings. This can rip the toric, allowing leakage of lubricant out of the cutter, as well as ingress of dirt and abrasives into the bearing cavity.



SAP Parts designed solution to resolve such problems, by designing larger cross section toric rings which minimize the amount of metal ring exposed to the slurry, that allowing the rings to break free and rotate against each other as intended.

Another problem observed when the cutters are used in high pressure applications, such as on Drum Cutter, TBM and slurry machines. The standard seal is exposed to much higher pressures than it is designed for, while working deep down more than 30 m of the water tables and tunnels. The problem that arises with higher pressure is the fluidized slurry pushes against the toric, forcing it down the seal gland ramps. This forces the metal rings tighter against each other, increasing face contact pressure of the seal



surfaces, causing the seal rings to act as a brake. This has the effect of 'locking up' the cutter, preventing it from rolling in softer material. In extreme cases, a portion of the toric on the non-rotating side of the seal can push past the back of the seal, causing a major leakage.

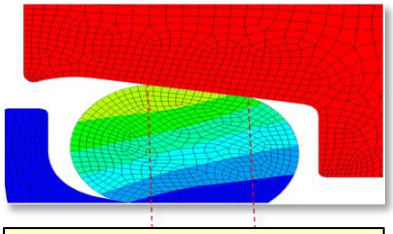
SAP Parts innovative Seal Design has the answer to such Problems.

1. *The differential load balancing design avoiding undue load spikes hitting caused by impacting slurry on the outer periphery of the Metal Face seals, which chips of the seals and subsequently Cracks and failure.*
2. *The increased lubrication retention profile helps to circulate larger volume of oil dissipating the excessive heat generated at seal contacts, thus preventing seals form thermal shock and consequential failures of torric rings.*

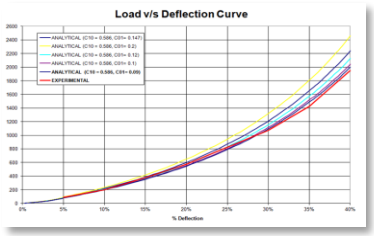
SEAL PROPOSITIONS FOR TBM CUTTERS BASED ON DIFFERENT CONDITIONS

Based on the specific application conditions, SAP Parts provides multiple version of Face Seals for TBM cutters. Categorically SAP Seals are designed to address characteristic TBM functional specifications to a considerable extent. Typical SAP Seals for TBM is has Differential Pressure Capability >7 Bar, Higher Working temperatures up to 200°C, High Starting Torque Capability up to 45 NM. These designs are offered in various material combinations in view of the application requirements. For any further customized sealing solutions customers are advised to approach to SAP Parts' Engineers at R&D department who can propose the most appropriate & design validated sealing solution.

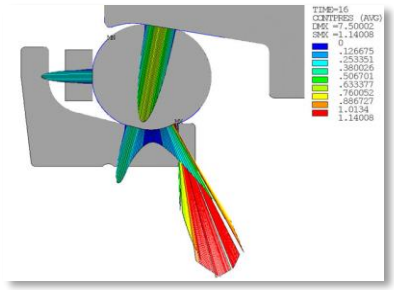
SAP PARTS' SEAL PERFORMANCE TEST & VALIDATION SYSTEM



Contact Forces, Contact Surface and Torque Analysis

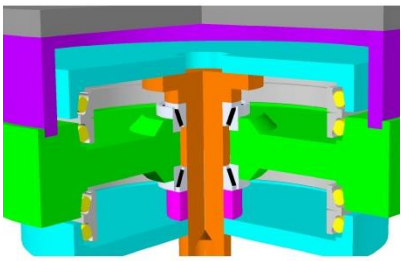


O-ring Deformation and Contact Pressure deflection Curves



Non Liner Analysis of Rubber Compression & Stress Relaxation

Sealing solutions provided by SAP Parts for differential pressure applications are validated for performance, on the test bench at its seal Testing center, simulating the application conditions of Drum Cutters and Cutter roller for TBMs at severe test cycle with incremental ramp up and ramp down cycles, fully controlled by advance Testing and validation system controlled by computer systems.



Differential Pressure Sealing Test

Sr.	*Oil Pressure – Bar (Internal)*	*Ramp Up Direction*	*Water Pressure - Bar (External)*	*Test Duration Hrs*
1	*1*	←	*0*	*0.5*
2	*1*	→	*1*	*1.0*
3	*2*	←	*1*	*1.0*
4	*2*	→	*2*	*0.5*
5	*2*	→	*3*	*1.0*
6	*2*	→	*4*	*1.0*
7	*2*	→	*5*	*0.5*
8	*2*	→	*6*	*1.0*
9	*2*	→	*7*	*1.0*
10	*2*	→	*8*	*0.5*
11	*2*	→	*9*	*1.0*
12	*2*	→	*10*	*0.5*
				9.5 Hrs
		If no failure observed in above cycles , repeat the test for another 16 Hrs.		