

Mechanical Seal Design for Differential Pressure Applications

SAP Parts Pvt. Ltd.

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Edition : 3

Drum Cutters & TBM Cutter Rollers

Seal Design for Differential Pressure Applications.

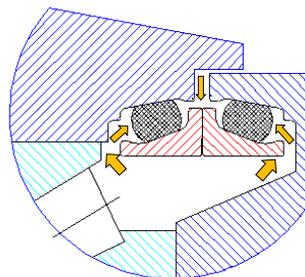
Application of Metal face Floating seals is one of the most significant developments in the disc cutter. This type of Seal uses two metal rings that are loaded axially such that they ride against each other with a film of lubricant



*The Drum Cutter and 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*

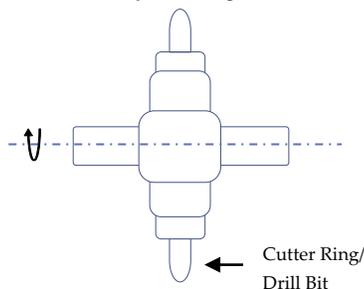
between them, creating a dynamic face-seal interface. Each ring, one on the rotating hub, and one on the stationary shaft, is sealed to the mounting gland by a rubber ring (Toric, or o O -ring), which also acts to allow a relatively generous hub-to-shaft misalignment tolerance, and as a spring to load 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.

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



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 Cutters 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.

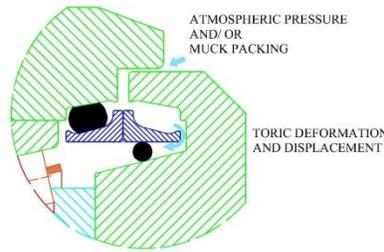


labyrinth created by the hub and seal retainers and then, given time, dries, effectively cementing one metal face seal ring to the other. When the cutter starts rolling again, the cemented metal rings may momentarily spin with each other and stretch the rubber toric holding the metal seal rings. This can rip the toric, allowing leakage of lubricant out of the cutter, as well as ingress of dirt and abrasives into the bearing cavity.

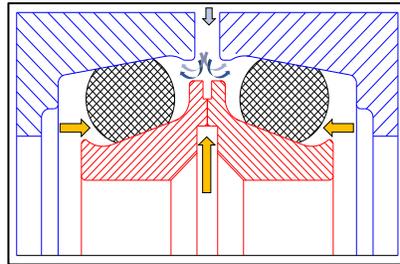
SAP Parts designed solution to resolve such problems, by designing larger cross section toric rings which minimize the amount of metal ring exposed to the slurry, that allowing the rings to break free and rotate against each other as intended.

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.

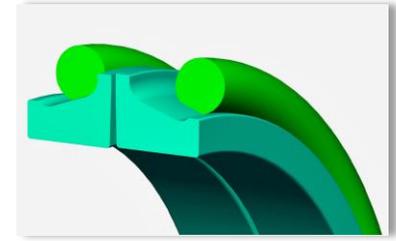
1. *The differential load balancing design avoiding undue load spikes hitting caused by impacting slurry on the outer periphery of the Metal Face seals, which chips of the seals and subsequently Cracks and failure.*
2. *The increased lubrication retention profile helps to circulate larger volume of oil 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 SOIL/ROCK CONDITIONS

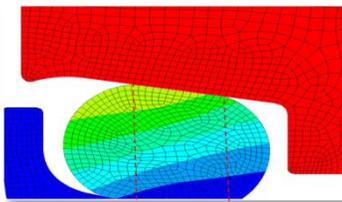
TBM Operational Conditions	TBM Issues	Seal Requirements	SAP Proposal	Metal Seal	Toric Seal
Soft Soil	Slip Over. Less Abrasive Environment.	Low Torque Oil Lubrication Outside Pressure up to 3 Bar	1	SAE 52100 Steel + WS2 Coating	Silicon
			2	Durenite Cast Iron (Ni-Hard) + Ws2 Coating	Silicon
Hard Rock	Higher Abrasive Environment. High Temperature.	Moderate Torque Grease Lubrication Outside Pressure up to 5 Bar	3	SAE 52100 Steel	Silicon
			4	High Chrome Moly Cast Iron (FC15Cr3Mo)	Silicon



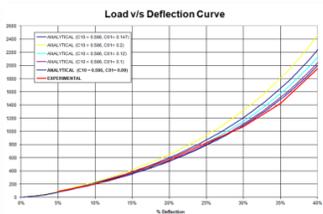
SEAL PROPOSITIONS FOR DRUM CUTTERS BASED ON APPLICATIONS



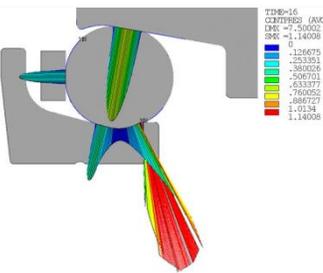
Application	Material Selection of Metal Seal + O Ring
Trenching	NBR + Ni-Hard
Tunneling	Silicon + Ni-Hard
Quarrying, Mining	HNBR + Ni-Hard
Excavation Work	NBR + Ni-Hard
Refurbishment, Demolition	NBR + Ni-Hard
Road Construction	NBR + Ni-Hard
Pile Head Cutting	NBR + Ni-Hard
Auger Drilling	NBR + Ni-Hard
Wood Grinding	HNBR + Ni-Hard
Underwater Works	Silicon + Ni-Hard- High Chrome
Steel Industry	FKM + Ni-Hard



Contact Forces, Contact Surface and Torque Analysis



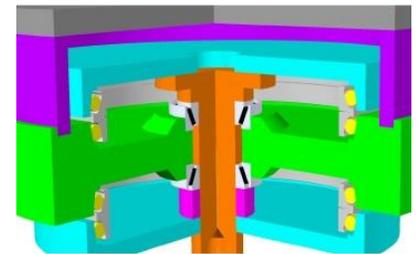
O-ring Deformation and Contact Pressure deflection Curves



Non Linear Analysis of Rubber Compression & Stress Relaxation

SAP PARTS' SEAL PERFORMANCE TEST & VALIDATION SYSTEM

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.

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