NFM Technologies | Research & Development
creating the future of tunnelling
Cutter tools replacement becomes risk-less and efficient with HECTOR

Cutter tools maintenance as a part of the tunnel excavation process

Drag bits and disc cutters are submitted to intense abrasive wear and their replacement is required all along the progress of the TBM excavation. Maintenance interventions in order to replace worn cutter tools have a serious impact on the TBM availability and expose the operators to several types of risks* when working in the excavation chamber and cutter head. Especially, this issue is critical in EPB or Slurry machines used in soft grounds, where cutter tools replacement requires hyperbaric interventions.

Cutter tools replacement can be fast and safe

HECTOR** is a robot designed to replace the drag bits and disc cutters through a remote controlled system in EPB and Slurry machines. The operation of the system in the hazardous environment of the chamber and cutter head (high pressure, humidity, and temperature) is ensured by using heavy duty mechanical and hydraulic technologies.

During TBM excavation the robot is kept in a sealed storage room placed in the upper part of the shield (12 o’clock) while the man lock is placed on the side (2 o’clock). The replacement of worn cutter tools is performed by two interchangeable grippers (one for disc cutters and another one for drag bits). A special locking mechanism for cutter tools was developed to facilitate handling by a single handed robotic system. Cutter tools with this locking system are also much easier to handle when changed manually by an operator.

The robotic arm is equipped with high definition cameras for remote control and autonomous devices to clean the cutter tools before replacement.

Benefits of HECTOR

- Increase the overall TBM advance rate thanks to shorter tools replacement cycle time and elimination of the decompression idle time
- Reduce Health and Safety risks by minimising human presence in the cutter head
- Best approach of cutter tools maintenance in term of cost, productivity, and impact on the TBM design

**Operational characteristics**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Machine type</td>
<td>EPB and Slurry</td>
</tr>
<tr>
<td>Machine diameter</td>
<td>starting from 8.5 m</td>
</tr>
<tr>
<td>Operating pressure</td>
<td>10 bar maximum</td>
</tr>
<tr>
<td>Handles disc cutters</td>
<td>yes (17&quot; and 19&quot;)</td>
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<tr>
<td>Handles drag bits</td>
<td>yes, including peripheral ones</td>
</tr>
<tr>
<td>Intervention area</td>
<td>top vertical radius of the cutter head</td>
</tr>
<tr>
<td>System performance</td>
<td>80-85% of all replacement operations</td>
</tr>
<tr>
<td>Operation modes</td>
<td>semi-automatic, with remote control through video feedback from operator located in a non-pressurised area</td>
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<tr>
<td>Nominal cycle time</td>
<td>approximately 20 min for 1 disc cutter replacement</td>
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</tbody>
</table>

* Maintenance interventions can expose operators to musculoskeletal trauma due to heavy weights and difficult handling conditions, and to decompression illness and diseases due to repeated compression/decompression cycles

** Patents pending
Impact of the geological conditions on tunnel excavation

Prediction of the geology ahead of the tunnel face is essential for two main reasons: safety of the TBM and surrounding structures, and cost related to the possible delays in the construction. Dangerous accidents and expensive delays can occur if major voids, water-filled fractures, changes in the soil type are encountered unexpectedly during tunnelling. Unfortunately, preliminary geotechnical studies conducted at the design stage of tunnel projects do not provide detailed enough information about the ground conditions and therefore are not able to minimise the safety risks while excavating.

Forward ground prediction with TULIPS

TULIPS is a revolutionary ground prediction system*** addressed mostly to soft soil TBMs that aims to identify large obstacles (cavities, boulders, foundations, etc.) and ground changes ahead of the excavation front. It is designed to operate with zero impact on the TBM progress. TULIPS combines seismic and radar subsystems that allow to extend the range of the geology covered by the system. The seismic system using S waves is more effective in soft soil, while the radar system is more effective in harder grounds and rock. The radar antennas and the seismic sources and sensors are fully integrated in the cutter head and oriented forwards. Coupled with specific image processing algorithms, the TULIPS ground prediction system provides a complete coverage of the excavation front surface.

The Data Fusion module takes input from the radar and seismic subsystems and through tracking of features from ring to ring produces the most probable interpretation of the geotechnical events ahead. TULIPS provides real time warning signals to the jobsite team and delivers an updated 3D geological profile highlighting the ground conditions and possible obstacles ahead of the cutter head.

Benefits of TULIPS

- Reliable ground investigation with extended range allowing to avoid damage to the surrounding structures and jamming, breakdown, or flooding of the TBM
- No impact on the TBM productivity
- Real time outputs and visualisation of detected features
- Web-based system for remote access

*** Patented concept
Ranked amongst the most important tunnel-boring machine manufacturers on the world market, **NFM Technologies** provide their customers with tunnelling machines of 4 to more than 15 metres in diameter, suited to all types of geology, acknowledged for their reliability and robustness. Our teams’ expertise has enabled us to define our own processes for developing tailored technical solutions for tunnel excavation.

Beyond tunnel boring machine design and manufacturing, we provide all services required for perfect work site operation: technical assistance, maintenance, delivery of consumables and spare parts, regular cutting tool inspections and replacements.

To offer optimised solutions perfectly matching the specific needs of each customer, NFM Technologies are constantly investing in research and development activities. NFM Technologies developed the HECTOR and TULIPS systems in collaboration with NeTTUN consortium partners. The NeTTUN project started on the initiative of NFM Technologies, aiming to improve the underground works technologies for intelligent mining and for the inspection, excavation, and maintenance of tunnels.

**NeTTUN in key figures:**

> - **23 partners** from 9 EU countries
> - **14.8 M€** of budget including 9.98M € funded by the European Commission
> - **54 months** project, started in September 2012
> - **12 work packages** focused on the development of **6 innovative products**

For more information about the project, please check the NeTTUN website: [www.nettun.org](http://www.nettun.org) or contact the project manager, Thomas Camus, by email: [thomas.camus@nfm-technologies.com](mailto:thomas.camus@nfm-technologies.com)