FAST-Tunn
Future Advanced Steel Technology for Tunnelling

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Project manager FAST-Tunn
Background

TBM – Applications, 1-2. June 2010
Seminar opening

What do we see in the future for TBM-tunneling?

- One machine to every possible ground conditions, no need to distinguish between different types of machines!
- Fully remote operated without any human beings at the tunnel face whilst in tunnelling modus!
- Fully capable of doing all sorts of pre-grouting and rock support all the way around
- Faster machines and non-circular profiles or mega-size > 20m
- What about the cutter technology?
- TBM’s to explore oil and gas development offshore?
- What can be done to increase the average machine utilization?

[Pie chart showing distribution of tunneling activities]
Innovative idea

- The aim is to increase cutter life by 25%
- Develop cost effective and wear resistant cutter disks for tunnelling in hard rock
- Combined with anti abrasive measures
- Develop realistic numerical models for steel/rock interaction, used in design optimization
- Develop generic knowledge and understanding of interface steel and geological material
- Introduce Norwegian manufacturing companies to the TBM industry
Norwegian Research Council

FAST-Tunn

Frame work:
- Totally 30 mill NOK
- 35% Research Council
- 35% Industrial Partners, mainly Robbins
- Innovation project
- 2011-2016
- Unique value chain in the project

WP 1: Basic models and characterization of steel and rock
WP 2: Numerical modelling
WP 3: Development of steel qualities
WP 4: Empirical prognosis models
WP 5: Fieldtesting
WP 6: Introduction of anti abrasive foam
WP 7: Project management
WP 8: Data collection and processing

Goal: 25% increased cutter life

Project manager

BMS

Research partners:
- NTNU
- SINTEF

Partners:
- BASF
- Babendererde Eng
- BMS Steel
- Norw. Railway Auth.
- LNS
- Robbins
- Scana Stål

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WP 7: Project management
What makes FAST-Tunn unique?

FAST-Tunn includes the entire value chain in TBM-tunnelling:

- Research and academia
- Steel suppliers and manufacturers
- Foam supplier
- TBM-supplier
- Monitoring developer
- Contractor
- Owner

Small scale laboratories (drillability & tribology) – theoretical and numerical approach – scaled testing – prognosis analysis – full scale TBM-sites
Technology in brief

- An efficient cutter disk should have a hard surface (to reduce wear) and a ductile bulk (to reduce spalling)
- Starting point for alloy development was a work-hardening cast alloy, currently used in rock crushing machines,
- The surface of this alloy will harden during use, and continue to harden as cutter is worn
- Numerical simulations was employed in order to optimize the design of the cutter.
- Rock fracturing, steel wear, hardening, fatigue, and temperature were considered.
R&D Challenges

• Characterize and test steel/rock interaction
• Develop a cost-effective manufacturing process
• Highly complex numerical models are required to model steel degradation and rock fracturing.
• Establishing a link between numerical simulations and NTNU Prognosis Model.
• Match the findings with various laboratory testing at NTNU/SINTEF drillability laboratory
R&D Challenges

Further develop the NTNU Prognosis Model and accompanying laboratory tests

OUTPUT FROM PROGNOSIS MODEL

- Net penetration [m/h]
- Weekly performance [m/week]
  - Utilization
- Cost [NOK/m]
- Lifetime cutter ring
- Lifetime cutter bearing and hub

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WP 1, WP 2 and WP 3

• Casted and tested 7 different alloys including the most common one in use today
• Numerically model and understand the breaking mechanism in both steel and rock
• Developed new testing methods and even a prognosis model for cutter wear
WP 5, Field testing

SBU Støren, 6,5 inches test cutters

Linear cutter testing in Korea

Full scale testing of best steel at AMR in India
WP 6, Anti Abrasive foam

• Important part of the project to test Anti Abrasive foam
• Initial tests were done at AMR in India
• Tests were done using Anti Abrasive foam in lab test
WP 8 Data collection and processing

• Early in the project it was found that field testing could only be performed successfully if a data collection and processing system to handle the comprehensive amount of data was employed.

• Consequently, TPC Tunnelsoft, a member of Babendererde Engineers GmbH joined FAST-Tunn
PhD-candidates

- Javier Macias (BAT)
- Solveig Vassenden (IGB)
- Yongbeom Seo (BAT) (Private financing)
Main goal

Identify an economical and practical way to analyze the impact of the cutters to:

- Demonstrate how the rock breaking takes place underneath the cutters.
- Identify the impact of cutter-related or operational changes produced.

"Mechanical properties of geological material influencing abrasion of cutter steel for TBM-boring"

Supervisor: Eivind Grøv
Co-supervisor: Charlie Li
Used samples from AMR in India and Røssåga in Norway.

Samples taken from different combinations of geology and operating modes of the TBM.

Great advantage to use samples from one TBM which is encountering different geology.

Comprehensive mapping is needed to have a baseline of local structures.
"Numerical modeling of rock breaking in hard rock in TBM tunneling"

Supervisor: Amund Bruland

Main goal: To include rock breaking in a numerical model
"Estimation of TBM Performance and Tool Life"
Supervisor: Amund Bruland
Co-supervisor: Eivind Grøv

Main goal: To update the NTNU Prognosis Modell.
What did we achieve?

• Developed a new numerical tool to estimate cutter wear
• Tested and compared characteristics of 7 alloys
• Developed new small scale laboratory testing apparatus
• PhD-candidates have achievements they will report themselves so that they can take credits of their work
• One steel alloy is unprecedented amongst the others
• Further testing is required for the casting method
• Anti abrasive foam has an impact, not able to quantify properly
• Did we fulfil our goal to obtain 25% increase? Difficult to say!
Thank you!