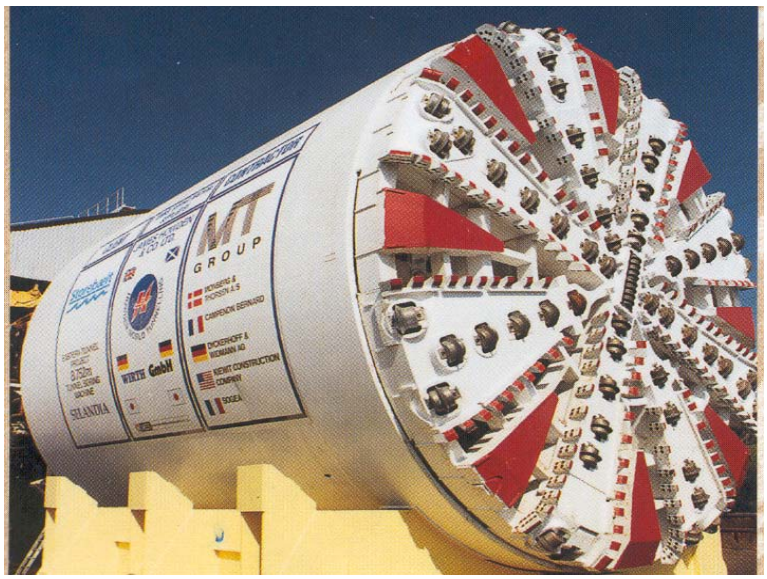
DRIVE GEAR WEAR AND TEAR MONITORING OF THE PROCESS TUNNELLING SYSTEM "TB S V – 576 H/MS Wirth"

Application of AR9300 Complex Nanoceramic Friction Modifier

1. Current wear and tear simulation of the shield drive gear



The most significant factors effecting the deterioration processes of the gear teeth are as follows: properties of the rock developed, bottom hole force values and the torque moment of the shield rotation, amount of advancing. As long as the properties of the rock developed are static in practice (in this case they are changing insufficiently together with the proposed parameter), and the measurements of the current bottom hole force values and the torque moment of the shield rotation were not carried out directly, due to evaluation restriction of the mentioned factors it was proposed to consider the current and overall amount of advancing as the main physical characteristic in the calculation.

Coordinates of the nodal points of the wear and tear parameter variation were accepted according to the results of the monthly gear tooth check measurement. The coordinates of the advancing nodal points were accepted according to the underground surveying reports LPT, record No. 3 TO-34 of JSC

Thus, a task to replace the experimental data by the deterministic functional theoretical dependence of the reference tooth wear and tear rate values and by the value of the performed advancing, i. e. interpolation was set.

Processing of the results of the shield drive gear tooth check measurement was performed using application mathematical software package "MATLAB 6.0".

1. Geometry of the gear wheel and gear first shape

1.1. Measurements of the gear wheel tooth first shape have been performed during installation of the gear unit and are given in Fig. 1.

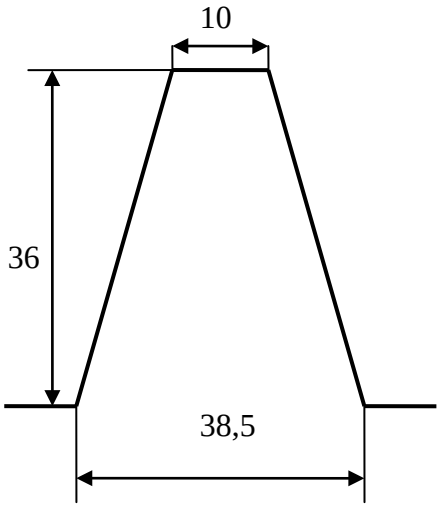


Fig. 1. Geometry of the gear wheel tooth first shape

Cinematics of the first shape engagement is given in Fig. 2.

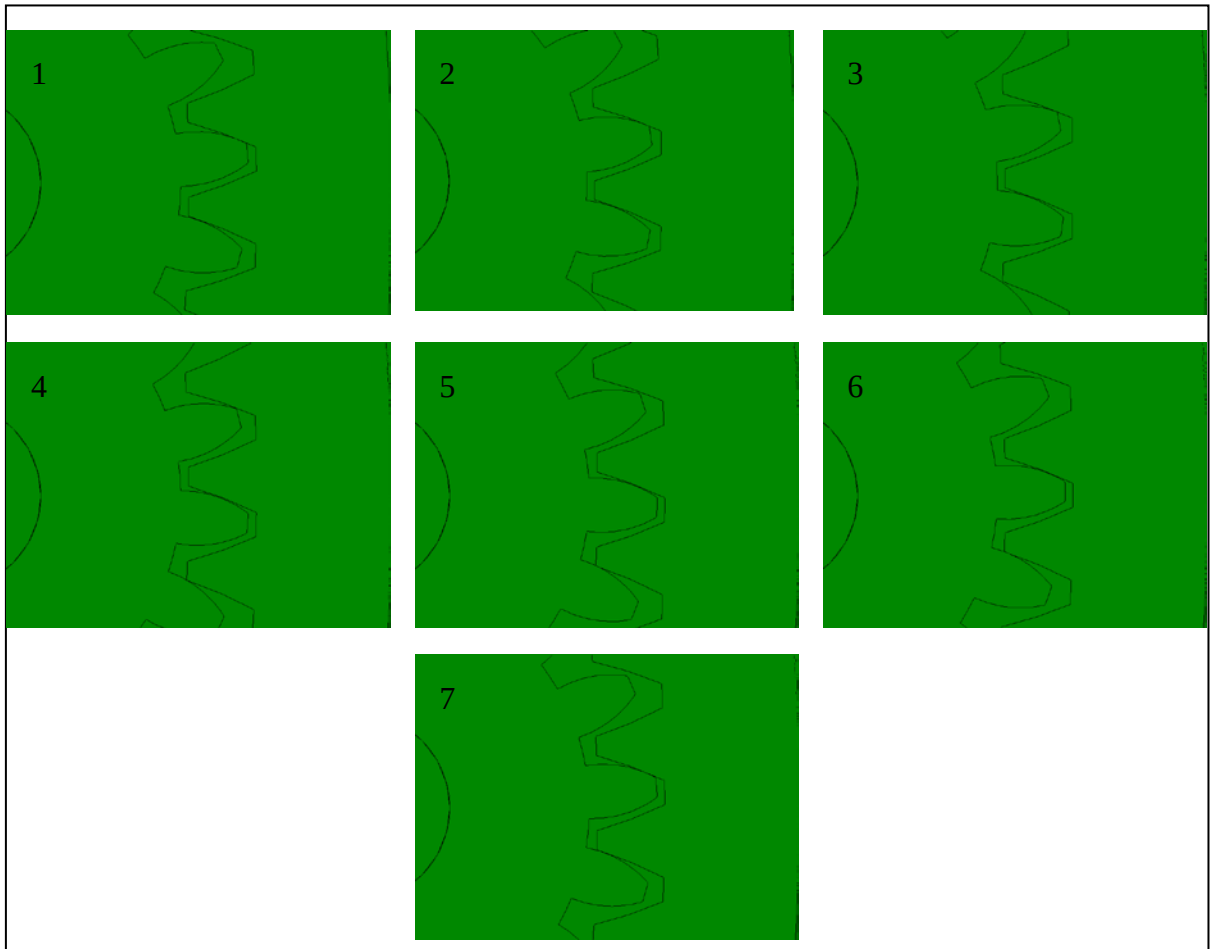


Fig. 2. Cinematics of the first shape engagement

Measurements of the wheel tooth shape are given in Fig. 3.

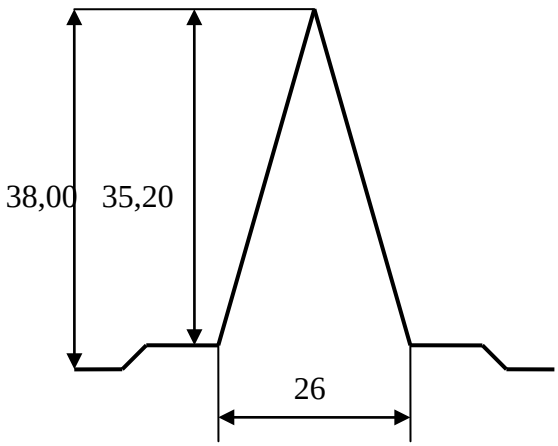


Fig. 3. Geometry of wheel tooth shape РК 36+40

2.2. Cinematics of engagement is given in Fig. 4.

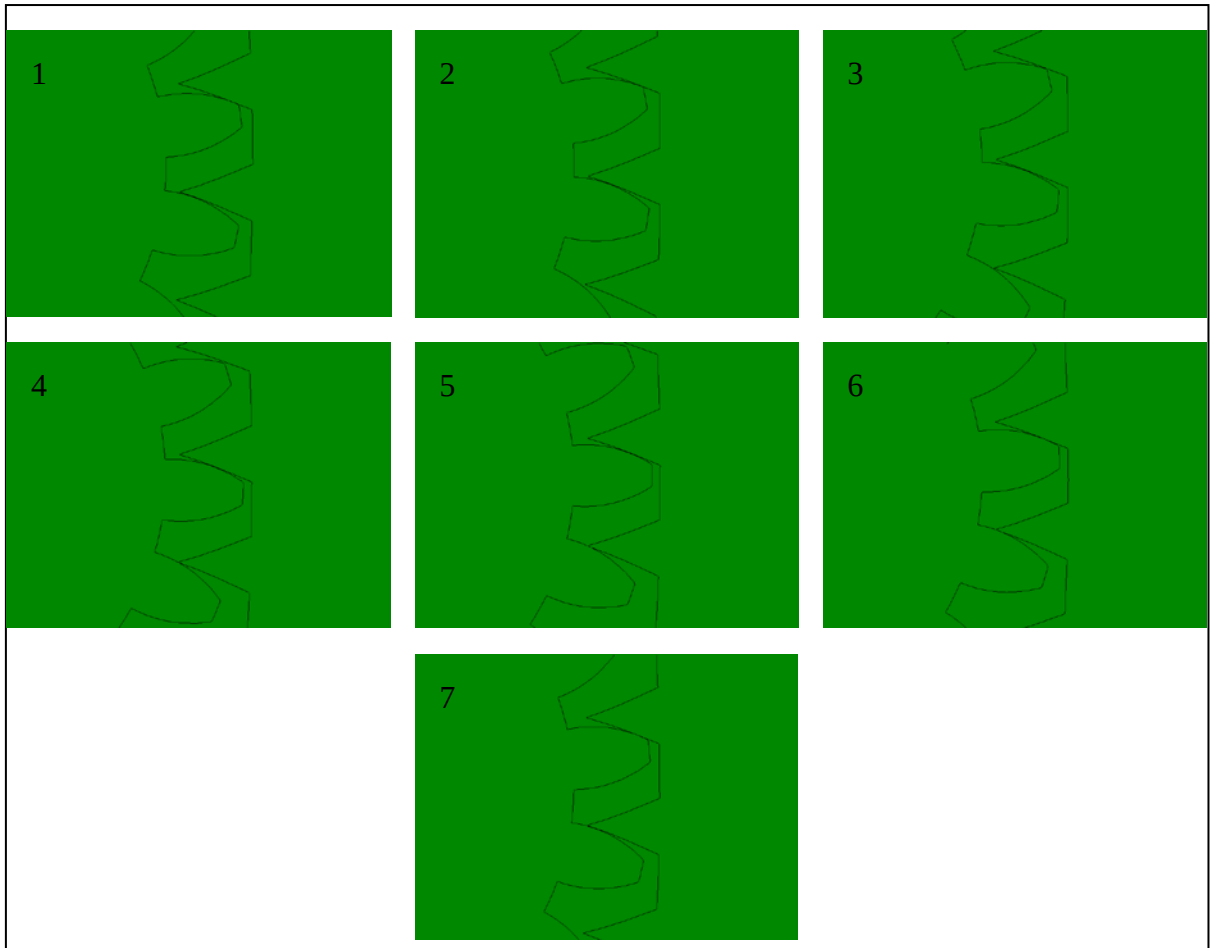


Fig. 4. Cinematics of the wheel tooth shape engagement on PK 36+40

1.1. Simulation of the reference tooth thickness variation at a height of 3 mm from the top.

Several options of experimental data interpolation are proposed: linear, quadratic, cubic, spline, hermitian and other methods of interpolation.

The processing results of the shield drive gear tooth check measurement reports data at the tooth height of 3 mm from the top (visualization, error estimation, functional linear theoretical dependence) are given in Fig. 1.

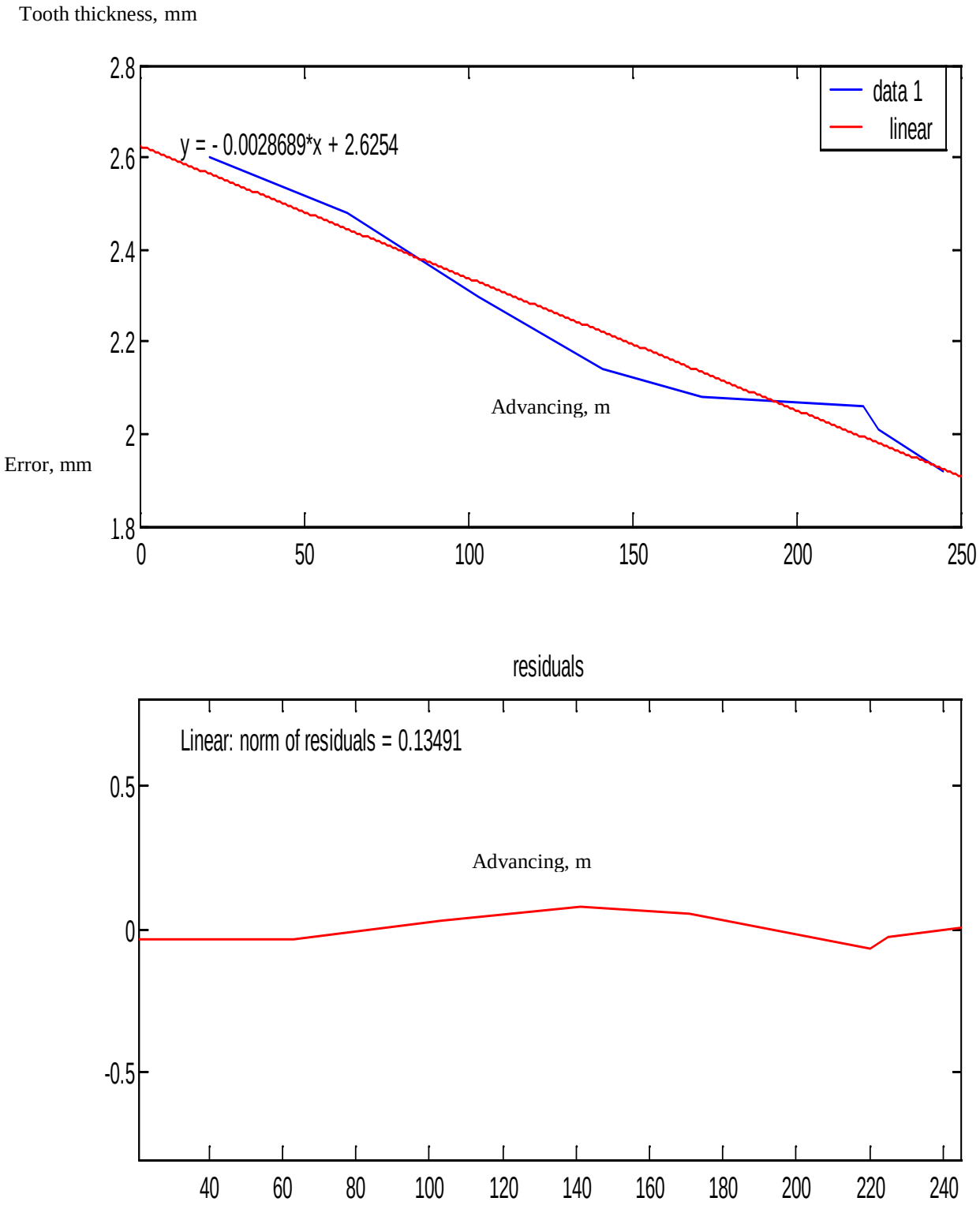


Fig. 1. Tooth wear and tear at a height of 3 mm and approximation error estimation

1.2. Simulation of the reference teeth thickness variation at a height of 10 mm from the top.

The processing results of the shield drive gear tooth check measurement reports data at the tooth height of 10 mm from the top (visualization, error estimation, functional linear theoretical dependence) are given in Fig. 2.

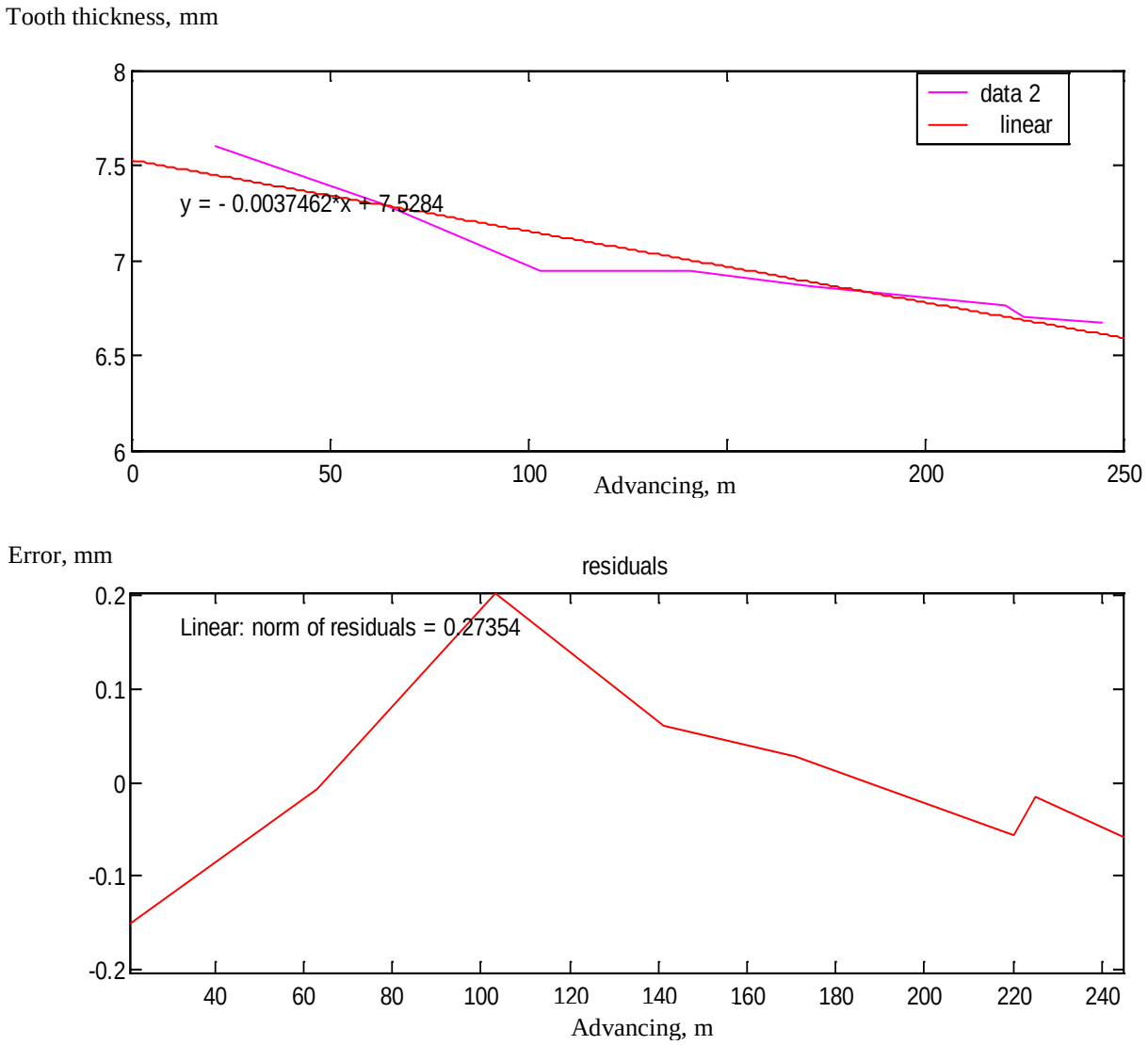


Fig. 2. Tooth wear and tear at height of 10 mm and approximation error estimation

1.3. Simulation of the reference teeth thickness variation at a height of 15 mm from the top.

The processing results of the shield drive gear tooth check measurement reports data at the tooth height of 15 mm from the top (visualization, error estimation, functional linear theoretical dependence) are given in Fig. 3.

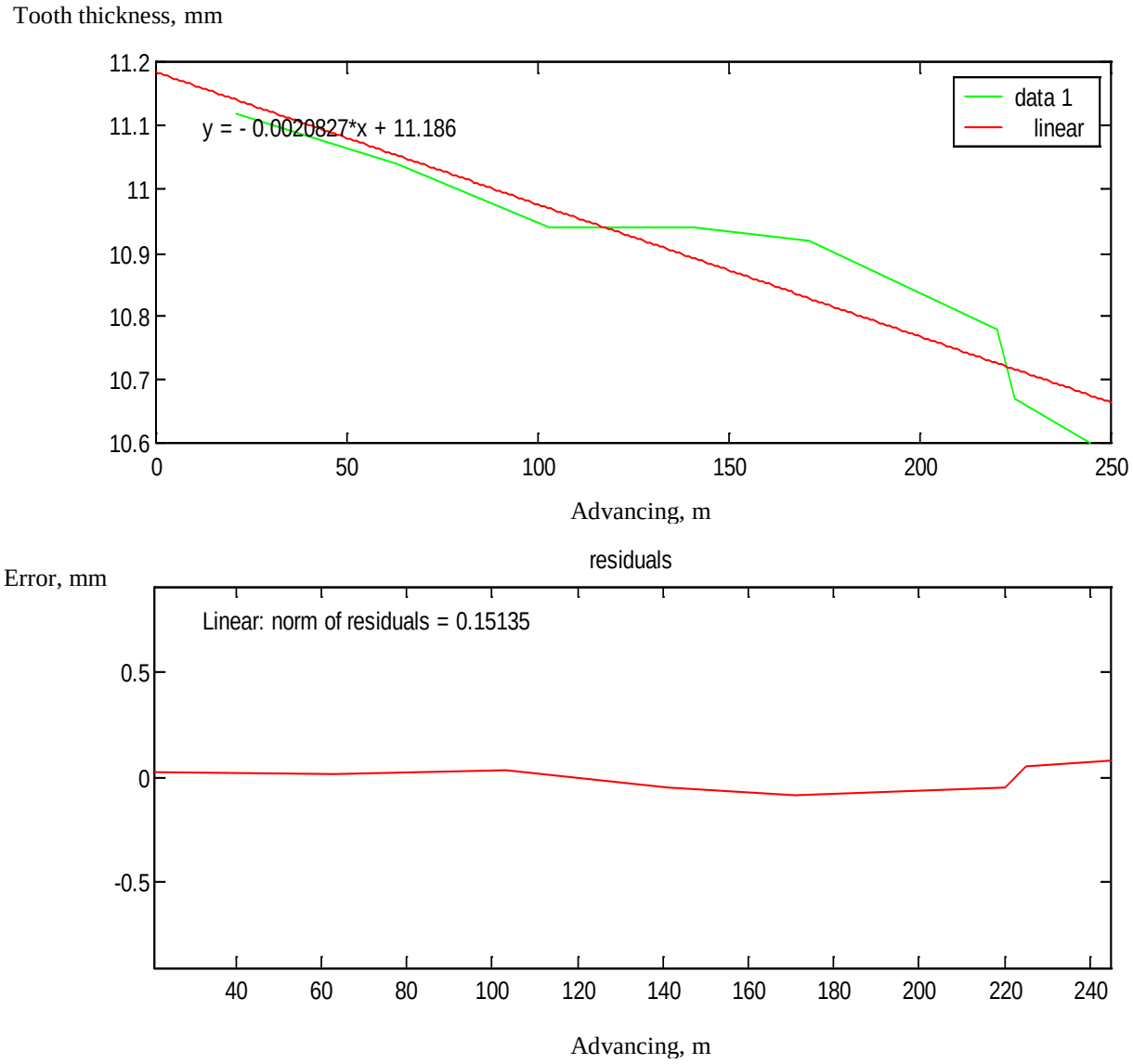


Fig. 3. Tooth wear and tear at height of 15 mm and approximation error estimation

2. Wear and tear prediction of the shield drive gear

The notion “monitoring” for wear and tear cases includes not only a description, but also a prediction of a state transition of the shield drive gear teeth. The patterns obtained in i.1 shall be considered applicable for a certain area not determined by the proposed patterns, at the same time omitting their accuracy estimation. Therefore, deterministic theoretical prediction values of the required parameters are accepted.
The prediction results in the most convenient way are given in a numerical table:

Prediction of the tooth thickness

Table 1

Advancing, m	3 mm height	10 mm height	15 mm height	Advancing, m	3 mm height	10 mm height	15 mm height	Advancing, m	3 mm height	10 mm height	15 mm height
250	1.91	6.59	10.7	420	1.42	5.95	10.3	590	0.933	5.32	9.96
260	1.88	6.55	10.6	430	1.39	5.92	10.3	600	0.904	5.28	9.94
270	1.85	6.52	10.6	440	1.36	5.88	10.3	610	0.875	5.24	9.92
280	1.82	6.48	10.6	450	1.33	5.84	10.2	620	0.847	5.21	9.89
290	1.79	6.44	10.6	460	1.31	5.81	10.2	630	0.818	5.17	9.87
300	1.76	6.4	10.6	470	1.28	5.77	10.2	640	0.789	5.13	9.85
310	1.74	6.37	10.5	480	1.25	5.73	10.2	650	0.761	5.09	9.83
320	1.71	6.33	10.5	490	1.22	5.69	10.2	660	0.732	5.06	9.81
330	1.68	6.29	10.5	500	1.19	5.66	10.1	670	0.703	5.02	9.79
340	1.65	6.25	10.5	510	1.16	5.62	10.1	680	0.675	4.98	9.77
350	1.62	6.22	10.5	520	1.13	5.58	10.1	690	0.646	4.94	9.75
360	1.59	6.18	10.4	530	1.1	5.54	10.1	700	0.617	4.91	9.73
370	1.56	6.14	10.4	540	1.08	5.51	10.1	710	0.588	4.87	9.71
380	1.54	6.1	10.4	550	1.05	5.47	10	720	0.56	4.83	9.69
390	1.51	6.07	10.4	560	1.02	5.43	10	730	0.531	4.79	9.67
400	1.48	6.03	10.4	570	0.99	5.39	10	740	0.502	4.76	9.64
410	1.45	5.99	10.3	580	0.961	5.36	9.98	750	0.474	4.72	9.62

3. Use of AR9300 Complex Nanoceramic Friction Modifier

In view of the mentioned above, in July 2001 Tunneling Complex "VIRT" applied "AR9300. The composition was supplied directly onto the shield drive gear teeth. "AR9300 had been used during one and half year until October 2002. The overall advancing length was 242 meters according to the underground surveying reports. Alteration of the tooth thickness by three reference points (3, 10, 15 mm) according to the gear teeth measurement reports was:

1. 3mm – 0.23mm 2. 10mm – 0.44mm 3. 15mm – 0.38mm

Taking the measurement results to the dependence for every 100 meters of the advancing, the following results of the wear rate can be obtained:

1. 3mm – 0.09mm/100m 2. 10mm – 0.18mm/100m 3. 15mm – 0.15mm/100m

Comparison of the measurement results with "NIOD-2" and the results predicted is impossible since the prediction is made beginning from 250 meters of the advancing.

In August 2006 AR9300 was applied on the main drive gear of Tunneling Complex "VIRT" (automatic restoration of friction surfaces) by the AR9300 specialists. A geodensifier was used as per the original technology developed by "UIC" on the complex drive gear teeth. The overall advancing length at the time of making the report was **901** meters. Along the advancing AR9300 was used three times: every 300-400 meters of the advancing. The measurement results of the drive gear tooth thickness by three measurement points are given in the Table below:

Table 1

Date	Overall advancing, m	Tooth thickness at 3 mm height	Tooth thickness at 10 mm height	Tooth thickness at 15 mm height	Tooth height from the base, mm
20.09.06	0	1.91	6.59	10.7	35.20
02.11.06	69	1.87	6.72	10.63	35.00
06.12.06	137	1.81	6.79	10.70	34.90
28.12.06	200	1.73	6.78	10.60	34.50
27.01.07	266	1.73	6.73	10.57	34.45
19.02.07	335	1.62	6.75	10.56	34.30
13.03.07	386	1.71	6.81	10.54	34.15
05.04.07	455	1.80	6.75	10.56	34.10
31.05.07	623	1.75	6.96	10.56	33.90
30.06.07	710	1.75	6.95	10.56	33.90
25.07.07	753	1.74	6.90	10.56	33.89
18.09.07	768	1.74	6.88	10.55	33.90
25.1107	805	1.73	6.85	10.51	33.85
31.1207	820	1.76	6.86	10.60	33.80
27.01.08	856	1.79	6.89	10.65	33.70
31.03.08	901	1.81	6.95	10.77	33.12
10.04.08	1100	1.83	7.00	10.80	33.10
23.05.08	1200	1.91	6.70	10.70	32.90
05.06.08	1400	1.87	6.85	10.70	32.90
21.07.08	1560	2.00	6.65	10.50	32.55
					Total: 2.65 mm

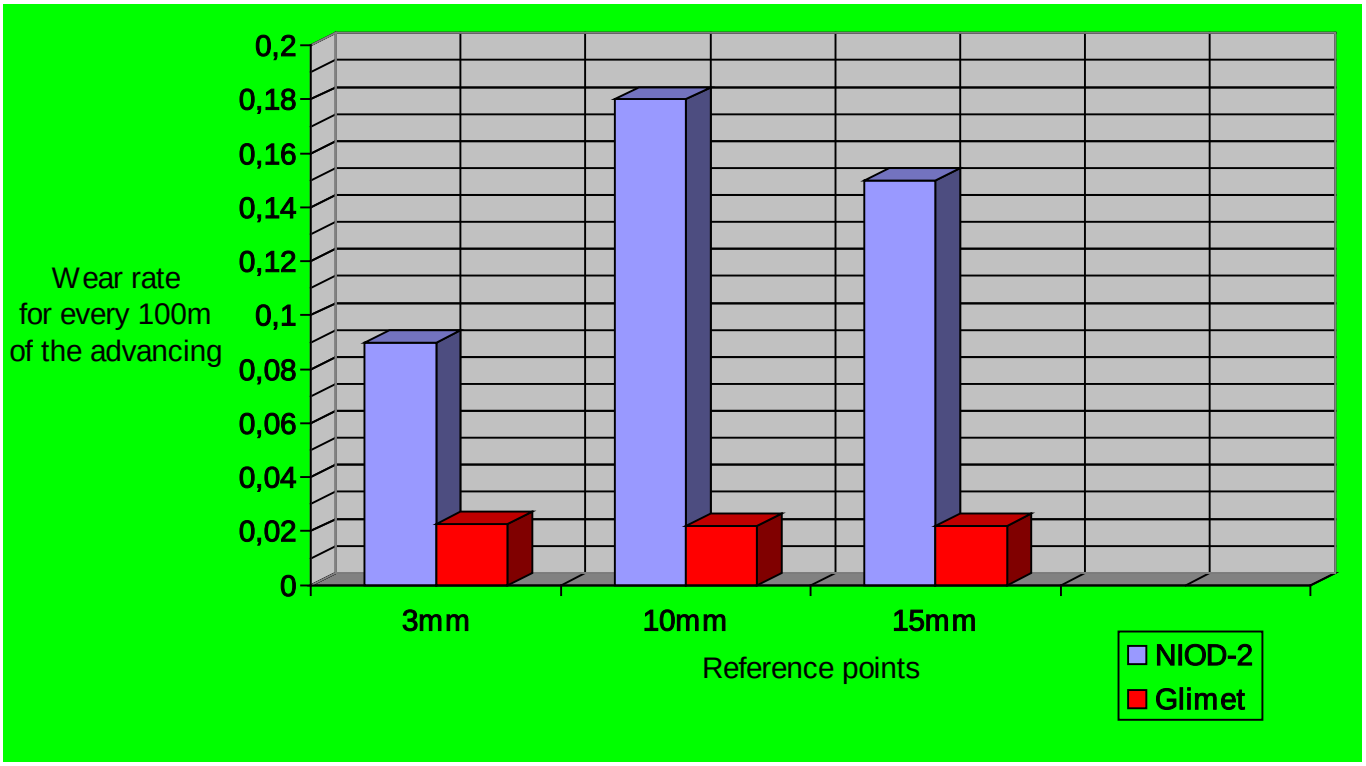
Taking the measurement results to the dependence for every 100 meters of the advancing, the following results of the wear rate can be obtained:

1. 3mm – 0.025mm\100m

2. 10mm +(0.11-0.17)mm material gain taking into account the measurement error

3. 15mm – 0.022mm\100m

A comparison diagram showing the wear rate for every 100 meters of the advancing is as follows:



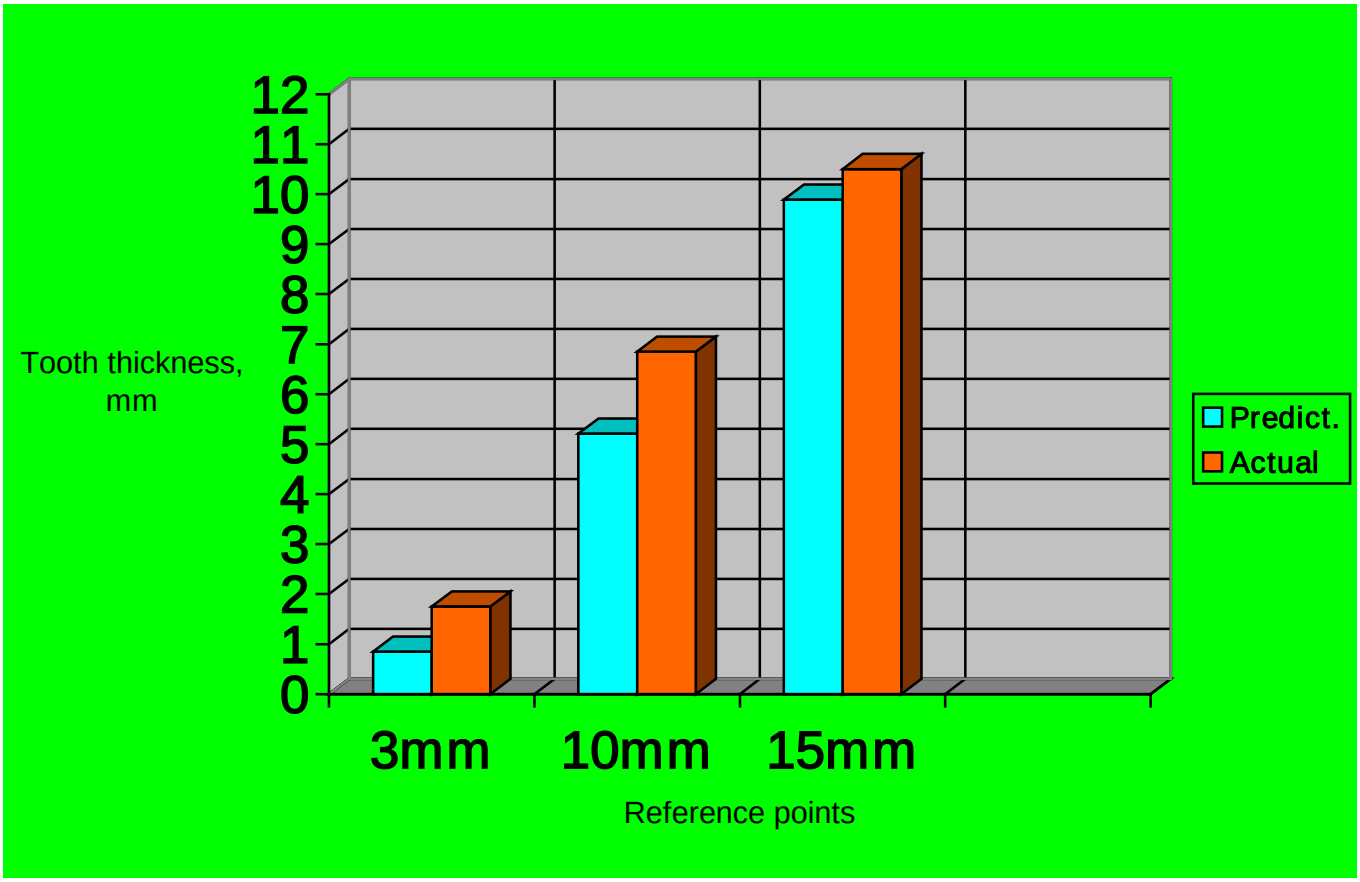
1. Comparing the tooth wear rate results for every 100 meters of the advancing using "NIOD-2" composition and UIC geodensifier, the following data by the measurement reference points can be obtained:

1. 3mm – wear intensity rate reduction of the drive gear of Tunneling Complex "VIRT" by **3.6** times.

2. 10mm – material gain of the drive gear teeth of Tunneling Complex "VIRT" by **0.11-0.17mm**.

3. 15mm – wear intensity rate reduction of the drive gear of Tunneling Complex "VIRT" by **6.8** times.

2. Comparing the results of the predicted wear by the reference measurement points at the advancing point of **1560th meter** and the actual results of the measurements, the following data can be obtained:



The above diagram shows that the use of UIC geodensifier allowed retaining from 0.9 to 1.64 mm of the Tunneling Complex "VIRT" drive gear tooth thickness by the reference measurement points at the advancing point of 1560th meter.

Chief Mechanic of Tunneling Complex "VIRT" V.N. Zarinov