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SELECTED ASPECTS OF WEAR OF THE CATERPILLAR DRIVE PARTS

Leszek Gardyński

Lublin University of Technology

Summary. The paper presents typical wear cases of caterpillar tracks and discusses the methods of improving the wear resistance. In modern caterpillars, the wear resulting from grinding between the track and the ground and the track and the elements of the driving system is the most significant. Metal powder coating is proposed as a method of improving the track durability.

Key words: caterpillar tracks, wear resistance

INTRODUCTION

Caterpillar vehicles have a better capability to move across the raw terrain than the wheel vehicles thanks to the lower surface pressure and better use of their mass to generate friction force. Having a „private road" in the form of a caterpillar however, complicates the driving system and decreases its efficiency compared to the performance of the wheel vehicle. As a result, the caterpillar drive is less efficient in the terrain where a wheel vehicle can move. In a difficult terrain, where the wheel drive is not able to move the vehicle, the caterpillar has an unquestionable advantage. The caterpillar drive, developed first for military use, is widely used in agriculture, construction site machinery, terrain vehicles, snowmobiles, etc.

One of the disadvantages of the caterpillar drive is its poor durability. The modern metal caterpillars can withstand 8 to 10 thousand kilometres [Użycki *et al.* 1996] which is more than 10 times more than the constructions from the Second World War.

EXAMPLES OF WEAR IN CATERPILLAR DRIVES

The friction between the elements is the main cause of caterpillar wear as it generates high grinding load. The grinding occurs between caterpillar elements and the soil and between the caterpillar and drive elements themselves. The presence of soil particles and grinding grains intensifies the process. Most frequent, the natural grinding grains like sand particles (SiO_2) of various dimensions can be found among caterpillar elements.

Fig. 1. A heavy wear of a DT-75 caterpillar track

Fig. 2. Wear of a caterpillar track joining bolt (DT-75)

Fig. 3. An example of the wear of a caterpillar driving wheel (T-72 tank)

Thanks to the widespread use of rubber and metal connectors the wear in the track joints is not a critical problem today. The direct contact between metal bolts and track eyes does not occur in the majority of the constructions. The exception are the caterpillars for some agricultural and construction site vehicles (Fig. 1 and 2). The most difficult problem today is the wear caused by the friction forces between the caterpillar tracks and the ground and between the tracks and the driving wheels and other elements of the drive system (Fig. 3, 4 and 5).

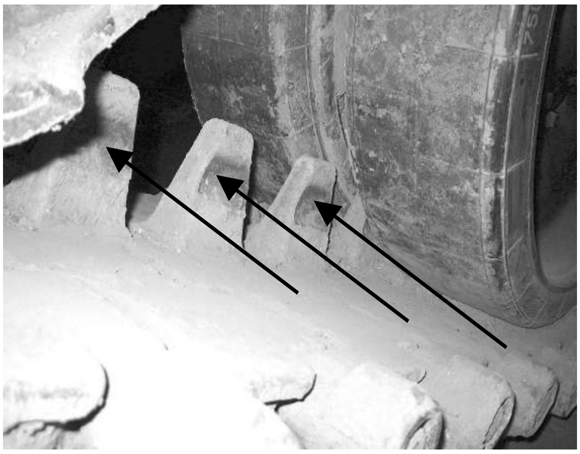


Fig. 4. Wear of the caterpillar track guides (T-72 tank)

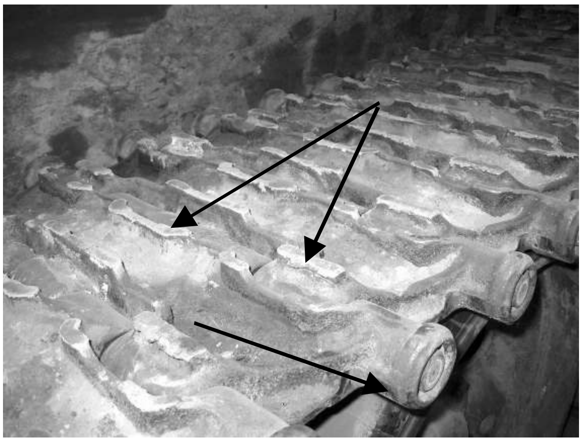


Fig. 5. Wear of the driving bolts and ground (external) part of the caterpillar track (T-72)

LABORATORY TESTS OF CATERPILLAR TRACKS

To compare the wear resistance of different materials a series of tests was carried out. The following caterpillar tracks were tested:

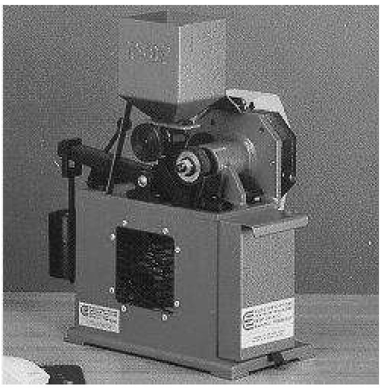
- DT-75 tractor,
- T-55/T-72 tank (Hadfield cast steel, approx. 13% Mg, austenitic structure),

– BMP-1 vehicle (hardened steel).

All the vehicles are currently used in the Polish army (mainly the BMP-1, T-72 and its modified version PT-91-Twardy). The preliminary tests included the measuring of the hardness (with Rockwell or Brinell methods) and microscope inspection of the test samples (with NEOPHOT microscope). A T-07 testing device was used to carry out the tests [Instr. obsł. 1991, Weroński and Gardyński 1996]. The testing procedure complied with the norm GOST 23.208-79. The test allowed to evaluate the resistance of the track material to the grinding wear from loose sand particles. The T-07 tester is a simple mechanism that allows to carry out a reliable grinding resistance tests. It is easy to set up proper testing conditions and exchange tested samples on this tester. The test results are reliable and the testing conditions are comparable thanks to the simple force adjustment method. The testing conditions seem to resemble those of a normal working environment. The aim of the test series was to compare the wear resistance of different materials.

The rubber counter-sample was mounted at the end of the main drive shaft. It had a cylindrical shape and was made of the 75-85o ShA rubber. The dimensions of the counter-sample were 50x15 mm. The sample (cubic, 30x35x5 mm) was pressed towards the counter-sample by the level with weight load attached.

The grinding material was fed into the testing zone between the sample and counter-sample by means of the feeder.



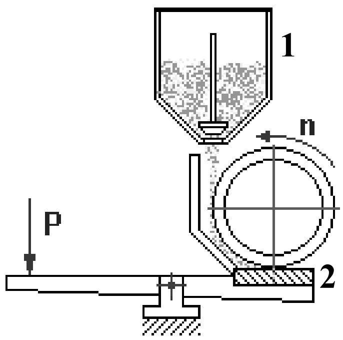


Fig. 6. T07-testing device - photography and a diagram, P – weight, n - direction of main shaft rotation, 1 – grinding material container, 2 – tested sample [Instr. obsł. 1991]

As the PN-76/M-59115 norm suggests, the silica dioxide (SiO_2, typical material causing the wear of caterpillars) was used as the grinding material. The testing environment was thus very similar to the real-life grinding conditions.

A single test was 26 minutes long. During that time the counter-sample cylinder made 1560 revolutions. The holding pressure between the sample and the counter-sample was 44 N. A precise laboratory scale (accuracy 0.00001 g) was used to measure the weight loss.

The Hadfield cast steel samples were tested twice, the second test was carried out after the sample was hardened by a series of 1kg hammer strokes (cold work). All the samples were tested on both sides so the results presented in table II are actually the average values from the two tests.

Table 1. Comparison of the grinding resistance of the caterpillar tracks samples

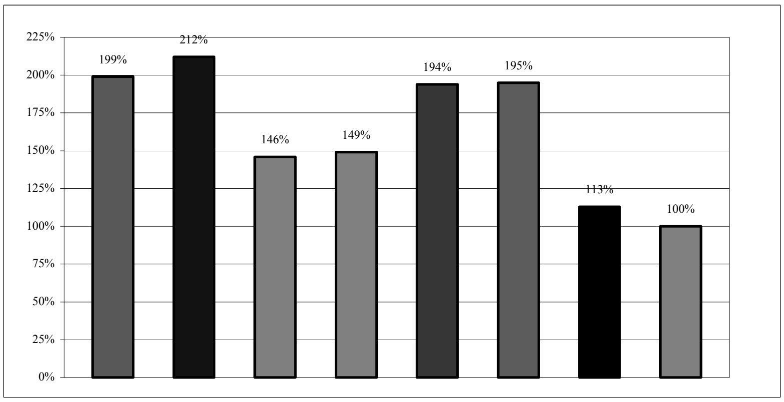
Sample origin	Material	Hardness	Weight loss during the test Z_w [g]	Relative durability K_b [-]
DT 75	11G12	<20 HRC	0,08762	1,999
DT 75	11G12, after hardening	<20 HRC	0,08263	2,12
T-55/T-72 nr 1	LG 13	<20 HRC	0,11970	1,463
T-55/T-72 nr 2	LG 13	38 HRC	0,11682	1,499
T-55/T-72 nr 1	LG 13, after hardening	<20 HRC	0,09020	1,942
T-55/T-72 nr 2	LG 13, after hardening	45 HRC	0,08970	1,953
BMP-1	hardened steel	47 HRC	0,15500	1,13
Reference sample	45 steel, normalised	190 HB	0,17410	1,000

Relative durability was calculated from the equation [Instr. obsł. 1991]:

$$K_b = \frac{Z_{ww} * \rho_b}{Z_{wb} * \rho_w}$$

where:

Z_{ww} – weight loss of the reference sample,
Z_{wb} – weight loss of the sample,
p_b – density of the sample (for Hadfield cast steel approx 7.95 g/cm^3),
p_w – density of the reference sample (około 7.90 g/cm^3).



1 2 3 4 5 6 7 8

Fig. 7. Relative durability of the tested samples

Examples of the observed micro structures of Hadfield cast steel are presented on Fig. 8. :

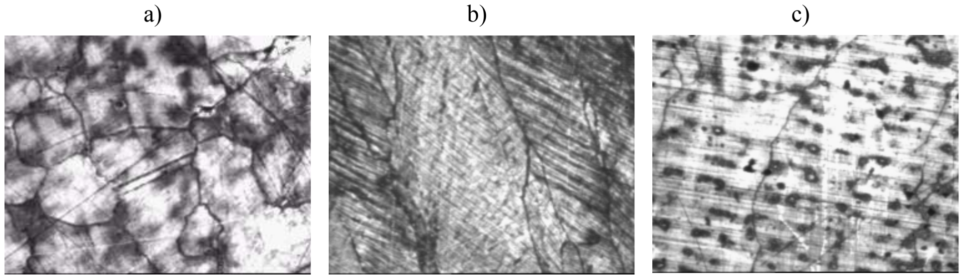


Fig. 8. The observed micro structures of austenite in the test samples: a) equal axis grains (T-55/T-72, nr 1), b) elongated grains (DT-75), c) grains with visible traces from the primary structure (T-55/T-72, nr 2). Magnification 400x etched with 3% nital

It seems useful to coat the ground contact side of the caterpillar tracks with a layer of a PMFeCr-60/P powder. The samples with plasma coated layers presented much better durability during the same test than the original samples. The PMFeCr-60/P powder contains 13% Cr, 3% Si, 2% B, 1,2% C. The coating can be performed during the production process as well as during the regeneration.

Table 2. The comparison of the relative durability of the original samples and samples with plasma spraying surfaces. The SiC grains were used as a grinding material [Weroński and Gardyński 1996]

Material	Hardness	Relative durability K_b [-]
Reference sample stal 45	190 HB	1.000
Hardened cast iron GH604805	52 HRC	1.356
Spraying surfaces PMNiCr-55/P	48 HRC	1.733
Spraying surfaces PMFeCr-60/P	60 HRC	2.493
Spraying surfaces PMCo-55/P	50 HRC	1.704

CONCLUSION

1. Hadfield cast iron tracks show greater resistance to wear than tracks made of hardened steel even if they are not as hard, which was proved by the results of the tests.
2. The wear resistance can be improved by cold work. The cold work can also appear during the normal use of the caterpillar.
3. There is a strong relation between the austenite micro-structure and the wear resistance. The lowest wear resistance was shown by the sample with uniform, equal axis grains.
4. Plasma applied metal powder coating may improve the wear resistance of tracks.

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