NEW RESULTS OF CUTTING BODIES OF EXCAVATORS MATERIAL RESEARCH

WYNIKI BADAŃ MATERIAŁOWYCH ELEMENTÓW TNĄCYCH WIELONACZYNIOWYCH KOPAREK KOŁOWYCH

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The target of this article is the presentation of the first results of the project No. TH03020368 from the programme EPSILON titled „The optimisation of the shape and material of ground and mining machines research". The main topic of this article is the optimization of the tooth shape and primarily the optimization of the materials used for manufacturing of cutting bodies of the ground and mining machines. This research is necessary for increasing of efficiency of mining process in conditions of the Most Basin.

Keywords: excavator, cutting bodies, tooth, material, overburden rocks

Celem tego artykułu jest prezentacja pierwszych wyników projektu nr TH03020368 z programu EPSILON pt. „The optimisation of the shape and material of ground and mining machines research". Głównym tematem tego artykułu jest optymalizacja kształtu zęba, a przede wszystkim optymalizacja materiałów wykorzystywanych do produkcji elementów tnących maszyn górniczych. Badania te są niezbędne dla zwiększenia efektywności procesu wydobywczego w warunkach zagłębia Most.

Słowa kluczowe: koparka, elementy urabiające, zęby, materiały, nadkład

INTRODUCTION

The expense of restoring of excavators cutting bodies is increasing these days (according to statistical data the usage of tooth ranges between 2000 – 6000 tooth per one excavator per year in the condition of the Most Basin, the weight of one tooth is about 12 kg). The expense is about 2 – 6 billion Czech Crowns per one excavator. The main reason is the complicated geological situation of overburden rocks, primarily the occurrence of sands and hard structures in the overburden cuts rocks.

The excavators (contrary to decreasing of mining more than 20 excavators KU 300, KU 800 a SchRs in future) work in different open pit mines in different geological conditions. The efficiency per hour, cutting force, the shape of buckets and cutting geometry is different according to the type of the excavator. The mining of overburden cuts is more difficult than mining of the coal [6]. That is the reason of using of modern, more efficient excavators with the prospect of efficiency optimisation. The target of this optimisation is the possibility of hard rocks mining and operating efficiency increasing. The geometry of the bucket wheel is the key element of the excavator during interaction with mined rocks. The most important parameters are geometry of cutting bodies, geometry of tooth and material of tooth [3].

The conception of this project is based on key placement of the period of „Realisation and evaluation of long term measurement in situ and laboratory measurement in experimental stands. The target of the measurement is the obtaining of verified data. According of evaluation of these data we will determine the main reasons of the tooth wearing out in different geological conditions. The optimisation and operating testing of the cutting bodies shape and material will be realised after obtaining and evaluation of the results of long term measuring. The methodology of optimum tooth type and of optimum tooth material in different geological situation for mining companies will be realised in the final stage of the project.

The methodology of long term measurements is based on discovery of correlation between warming of the blade [ºC] and the wearing out of the blade [% of weigh], alternatively between power demands [kWh per cubic meter of bulk rock] and the wearing out of the blade [% of weigh] in the concrete blade geometry [cutting bodies construction] and geological situation.

The obtained correlations are very important for cutting bodies' blades usage prediction and for selection of optimum tooth geometry and material in the geological situation of the Most Basin. The aim of this project is the improvement of the Czech and European industry in present global context with application of industrial and experimental research. The results can be speedily used in mining industry, building industry and civil engineering.

TARGET OF THE PROJECT

The main target of the project No. TH03020368 from the programme EPSILON titled „The optimisation of the shape and material of ground and mining machines research" is the optimisation of the tooth shape and primarily the optimisation

of materials for manufacturing of cutting bodies in different working condition. The increasing of working efficiency, decreasing of the expense and the increasing of the mining capacity per hour will be main results of the research.

Partial target

- search of using excavators and ground machines cutting bodies, primarily bucket types, cutting bodies shape and bucket materials
- search of mining and geological conditions important for wearing out and lifetime period of buckets and cutting bodies of excavators
- search of material content of steel for manufacturing of cutting bodies of excavators
- preparing and operating testing of the methodology of tooth selection.

The proposed project is very important because of the possibility of increasing of mining efficiency. The results can be quickly used in many mining companies.

The topic of this project is compliant with National priorities of experimental research and innovations. The increasing of working efficiency, decreasing of the expense and the increasing of the mining capacity per hour can be used in coal mining, building mining and civil engineering.

METHODOLOGY OF RESULTS ACHIEVEMENT

The whole project solving will be guaranteed by own sources of the main applicant of the project (and co – applicants – universities, research institutes, mining companies). The material,

Fig.1. Geometry No. 1
Rys. 1. Geometria nr 1

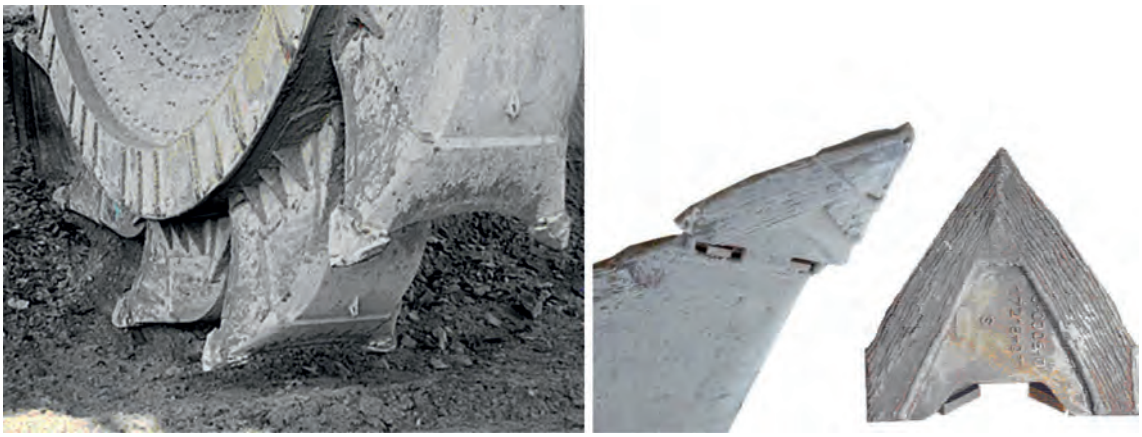

Fig. 2 Geometry No. 2
Rys. 2. Geometria nr 2

Fig. 3. Geometry No. 3
Rys. 3. Geometria nr 3

methodical, technological and personal equipment of main project applicant is sufficient for solving of the following problems:

1) Evaluation of mining process and analysis of all important influences. Correlations between digging force and digging resistance, evaluation of abrasiveness. Utilization of mining companies experience.
2) Simulation of fatigue processes, Contact, degradation and fatigue functions. Evaluation of lifetime period of cutting bodies.
3) Computer modelling CAD and MKP with application of material engineering.
4) Development of the cutting bodies new types, application of these bodies in selected excavators and operation testing.
5) Realisation of kryogenic method and nanotechnologies in selected excavators and its operating testing.
6) Realisation of long term testing in laboratory stands. Measuring of abrasive wearing out, SEM analysis, measuring of hardness, analysis of chemical content.
7) Realisation of long term measurements in situ. Tensiometric measurement, thermometric measurements, electrical measurements, efficiency measurements, digging resistance measurements.
8) Evaluation of realised measurements.
9) Realisation of the methodology of attendant diagnostic services.
10) Debugging of final results
11) Final adjustment of partial results and preparing of final expert review.
12) Cooperation with excellent universities and research institutes.

At the beginning of the project the following research has been realized:

Application of cryogenic modification

The Brown Coal Research Institute received the sample of 16 pieces of tooth. The first measurements of the weigh and basic geometry was realised in the laboratory of the technical diagnostic. We relocated the sample after these measurements to specialized company to the deep cryogenic modification. Cryogenic is the field of physic focused to achievement of very low temperatures and to evaluate the influence of these temperatures to different materials. It is possible to use cryogenic modification in lots of fields of industry, primarily in modifications of metal materials. The main benefits of cryogenic modifications are lifetime period increasing, the expense decreasing and failure rate decreasing. The main benefit of tooth cryogenic modification was increasing of resistance against abrasiveness influences. The tooth samples after cryogenic modification are tested. The testing in situ during hard rocks mining will be the next step of research.

Bimetal tooth – the important part of the project solving is the development of the bimetal tooth. It consists of internal basic body (high quality steel) and external crust (material with high resistance against abrasiveness). The internal body of this new type of tooth consists of ordinary tooth 2673. The main benefit of this new type of tooth is the increasing of lifetime period during mining in abrasive rocks (sands) and hard structures. Expected realisation is shown in the Fig. 6.

Nanotechnology – We undertaken preliminary contacts with companies specialised in the field of nanotechnology. Nanotechnology is the field of technology working with extremely small products in the scale of nanometers (usually about 1–100 nm these days), it is 10^{-9} m. We can define nanotechnology as an interdisciplinary technology. The aim of nanotechnology is the using of new and unusual parameters of nanomaterials for the new structures, materials and equipment construction. The use of nanotechnologies and nanomaterials is very large in lots of fields of engineering. The development of extreme hard surfa-

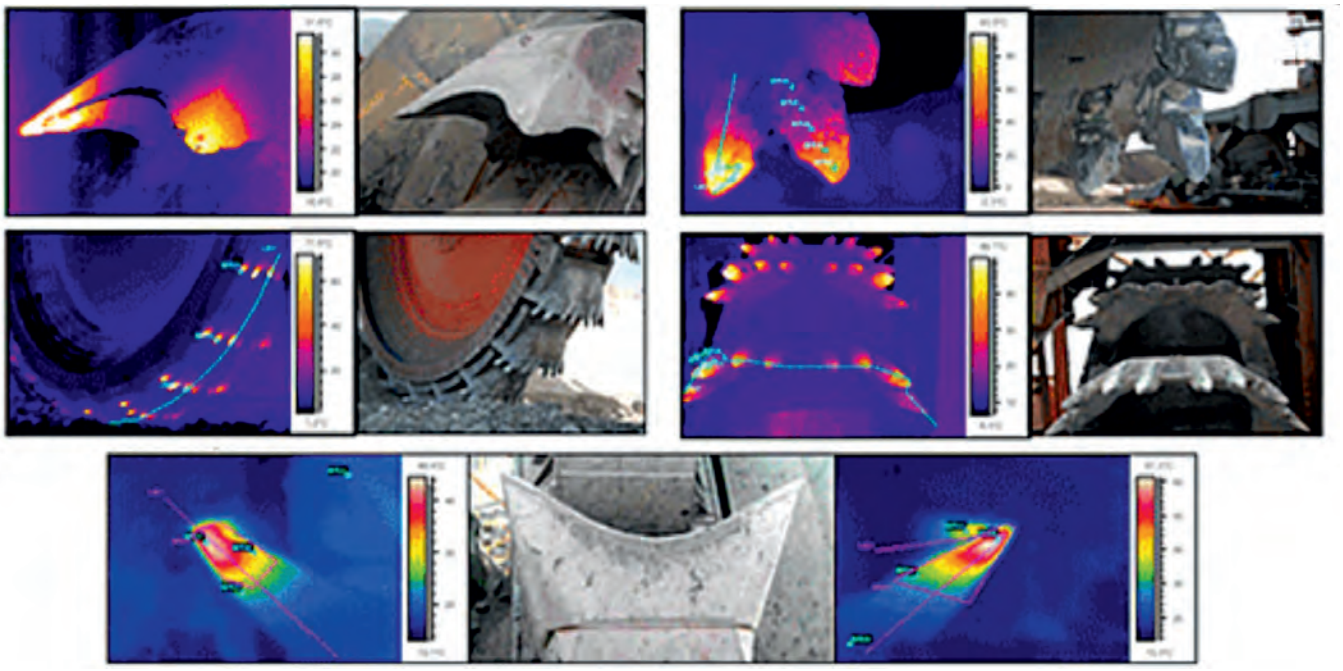

Fig. 4: Demonstration of tooth warming
Rys. 4. Proces nagrzewania się zęba

Fig. 5. The sample of tooth (tooth 2673) before cryogenic modification
Rys. 5. Zęby przed modyfikacją kriogeniczną

Fig. 6. Expected realisation of bimetal tooth
Rys. 6. Oczekiwana realizacja zęba bimetalicznego

ces with high level of resistance against abrasiveness is very important for solving of this project.

Using of new materials – the selection of materials is based on correlation between abrasiveness and dynamic stress. The Hadfield steel discovered in 1882 is according to experience of the majority of experts the best possibility in the case of cutting bodies. It is historical „benchmark". This steel can be problematic in bad conditions (minimum plastic deformation of upper crust and no deformation strengthening). It is possible to use in this situation:

- *modification of usual construction steels with martenzitic structure* – typical example is the steel VP7 used for manufacturing of tooth in the Czech Republic.
- steels with structure. *CFB (carbide free bainite)*
- these steels can be very prospective. The reason is optimum combination of high hardness and good compaction. Typical parameter of this steel is transformational compaction during „impact abrasion".
- *ADI (Austempered Ductile Iron) formable cast iron* - ADI is thermic processed cast iron. Typical property of this material is very good combination of dynamic strength, ductility and resistance against abrasiveness. The basic matter of ADI structure is similar to bainite. It consists of ferrite and C - austenite. In comparison with bainite no carbides were discovered.

We will realise complex long term operating test of selected excavator in the final stage of project solving. The bucket wheel will be equipped by two buckets with newly manufac-

tured tooth. According to results we can realise summarisation of partial conclusions of the project and comparison of these conclusions. The practical using of the project results can be for instance manufacturing of the new cutting bodies prototypes. We will realise the testing of the new materials in situ and in laboratories too.

CONCLUSION

We started the solving of the project No. TH03020368 from the programme EPSILON titled „The optimisation of the shape and material of ground and mining machines research" at the beginning of 2018. We expect the increasing of the lifetime period of the mining and ground machines cutting bodies. The next benefit can be better planning of investments, decreasing of the expense, decreasing of downtimes and failures. More than 20 excavators (KU 300, KU 800 a SchRs) will work in the Most Basin in the future. The mining companies can (according to the project results) optimise the selection of tooth according to parameters of mined overburden rocks. The database of new materials suitable for tooth manufacturing in the different conditions will be very important part of project results.

The project offers lots of economic benefits for the main applicant of the project, for co – applicants, for partners of the project and for final customers as mining companies, owners of quarries, companies in the field of building industry, civil engineering, agriculture, forestry etc.

Please, contact us in the case of the interest of described research problems. We can consult it and discuss about our experience. We look forward to potential collaboration.

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