MEASUREMENT WEAR OF DRILL IN THE MANUFACTURING PROCESS AND ITS SIMULATION IN VIRTUAL REALITY

RADOSLAV KREHEL, MAREK KOCISKO, TOMAS VYSOCKY, ANDREA CIZIKOVA, PATRIK SZENTIVANYI

Technical University of Kosice
Faculty of Manufacturing Technologies
Department of Computer Aided Manufacturing Technologies
Presov, Slovak Republic

e-mail : radoslav.krehel@tuke.sk

DOI : 10.17973/MMSJ.2016_11_201649

Using virtual reality nowadays not only includes applications in the entertainment industry as well as use in areas in which have not yet penetrated. Such area is the manufacturing process. Due to hardware that has been designed a priority for entertainment purposes can be realized serious simulation. Measurement of various parameters during the manufacturing process and after, helped by the creation of new working tools and also for their innovation. All values that are studied differ in based on the type of wear and also the basis for the selected device that examines wear it. Progress in terms of materials and production possibilities with new trends as in the measurement, as well as in examining and subsequent production of new tools

KEYWORDS

virtual reality, simulation of manufacturing process, measurement of drill abrasion, tool, the wear

1 INTRODUCTION

Virtual reality has been used in the past to create games and wanted ti have a greater gaming experience. This technology people wanted to spill over into other sectors such as the gaming industry. It begin to be used in architecture, medicine, but also in the engineering industry. With this technology it is possible to monitor workplace layout, the manufacturing process of the product. The first product, which was simulated using VR, the production car Ford Mondeo.

The intention of this article is to bring the simulation experiment through this technology, so that the experiment gave the traceability of the external users. In addition to the simulation main task it is to check the wear of the drill, which is measured by the quality instruments and consequently these results are processed in the form of a graph [Jacko 2011].

2 VIRTUAL REALITY

Virtual reality it is three dimensional environment, which is designed by computer. This technology was created for gaming industry, but gradual evolution be getting in other areas. By means of virtual reality we can create environment, which is identically to real environment. Also is possible simulating different operation in process. Modelling is first part of virtual reality. Second basic the part is device, on which is the process displayed. The device could be computer, smartphone or minicomputer Rapsberi Pi.

3 DRILLING OPERATION AND PART OF TOOL

Drilling is operation, for which are created inner rotational surfaces. Tool creates main movement. Workpiece is holding in vice on constancy. Tool in this type of operation is drill, which make of rotary move around the axis and translation motion in Y axis. Drilling includes deep-hole boring, reaming and recessing [Orlovsky 2014].

Tool is supported in machine chuck. Drill is possible in post-mounted drill and CNC machines. The tool is using for drilling into full material and for increasing of hole. Achieved degree of accuracy is IT5 to IT7 [Jurko 2012].

Composition of drilling tool are shown in Fig. 1:
- Tool shank – clamping part
- Head – cutting part – removes and drain splinter

The basic types of drilling tools:
- helical tool
- kopin tool
- deep holes tool
- form tool
- special tool

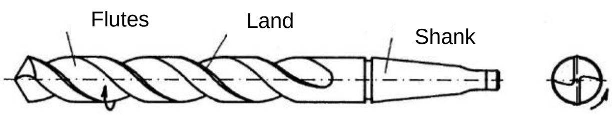

Figure 1. Parts of drilling tool

4 KINDS OF WEAR

Wear is defined than undesired change of surface or dimension of rigid bodies. Wear is caused be the interaction of functional surface or functional surface and any media that causes wear. This is reflected as a movement or removal of the worn surface of the mass particles by mechanical effects, which may also be accompanied by other results, such as. Chemical or electrical [Gaspar 2013].

4.1 Adhesive wear

Is the most common cause wear parts that functional surface are brought into contact with relative movement. It is characterized by isolation and moving the particulate material as a result of interaction between atomic halls, applying to the contact area. Of force, the roughness peaks of the surface of the plastically deformed, the atoms of the two surfaces are in close contact, and the desired formation micro contacts [Mascenik 2013].

When the relative motion of the surface these micro contacts violated. Since the surface area of reinforced plastic deformation, the tensile strength is greater than the surface area, therefore there is no separation of material in place of the original joint surface but inside the material of one of the bodies Fig. 2 [Straka 2011].

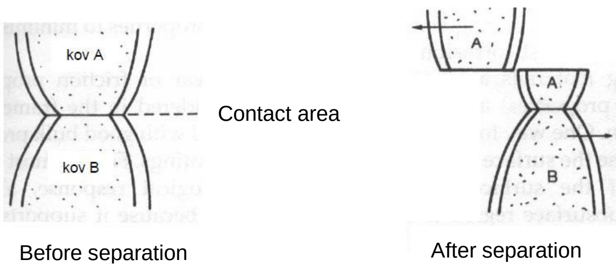

Figure 2. Schematic description representation of adhesive wear.

Adhesive wear rate can be reduced by:
- Reducing the size of the separate parts, usually by reducing the contact surface of both materials

- Reducing the density
- Increase the hardness of the two components, respectively, of the two hard elements
- by friction pair comprising one hard and one soft material

4.2 Abrasive wear

It is characterized by the separation of the particles and damage to the functional surface of the body of worn-grooving and cutting these hard particles or a rough surface of the second body, which occurs when the relative motion of two bodies of surface irregularities formed in the surface of the body hardest, softer body. A typical surface damage with abrasive wear grooves are shown in Fig. 3.

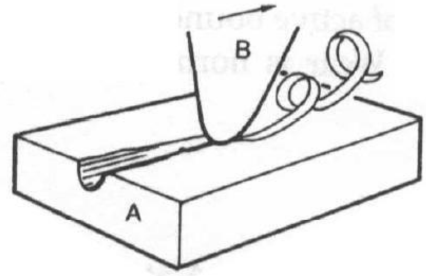

Figure 3. Schematic representation of abrasive wear

Abrasive wear can result from other types of wear during which the free particles are formed, which become harder than the base material either will intensive plastic deformation or oxidation by atmospheric oxygen.

Speed abrasive wear can be reduced by:

-Reducing the density – particles will not to depress so deep into the surface of the material will be more shallow grooves

-Increase hardness, with the same effect as in the previous option

4.3 Erosive wear

It is characterized by the separation of the particles and damage to the surface of the worn particles carried by:

-Liquid flow – erosion of pipes and pumps in the hydraulic transport of ore, coal, erosion of hydraulic turbines dirty water

-Current gas – erosion nozzles or fans

-Stream of liquid, vapour or gas droplets – functional surface of the valve which are in direct contact with the rapidly flowing gas or a liquid is shown on Fig. 4

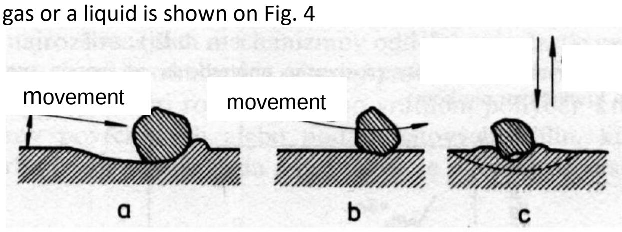

Figure 4. Schematic representation of erosive wear

The intensity of erosive wear depends on many factors:

-Debris medium – its relative speed, temperature, chemical composition

-Entrained particles – the weight, size, shape, mechanical properties, kinetic energy and the angle of incidence of the exposed surface

-Characteristic of Waste Material

4.4 Cavitation wear

It is characterized by the separation of the particles and damage to the surface of the components in an environment of flowing liquid. It is caused by the formation and disappearance of gas, respectively microscopic vapour bubbles in flowing liquid. It occurs most often on the blades of hydraulic turbines, propellers, propellers and the like. The consequence of cavitation wear the distinctive spongy structure breakdown of the material is shown on Fig. 5.

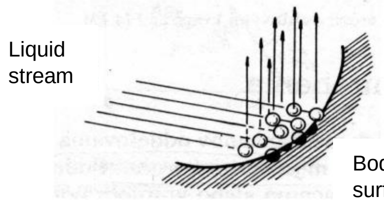

Figure 5. Schematic representation of the principle of cavitation wear

Prerequisites of cavitation cavities, the pressure drop of the liquid to the vapour pressure at a daytime temperature, e.g. in place of pipeline bottlenecks, due to the high velocity flow of the fluid in the pipe line during the starting of the pump. The resulting microscopic cavities have dimensions of the order of 10^{-2} cm. In places where it sets rebalancing pressure conditions, coupled cavities in the surrounding liquid and vapour arose into the cavity at high speed. It this is the implosion of the cavity near the wall, accelerated fluid impinges on the material, repeated shocks strain on it, and its surface is plastically deformed locally. Attack is the first surface in the form of holes and cracks, which gradually uniting penetrate deep until the structure of the mushroom violated. Cavitation wear resist material with a homogeneous structure, such as in steel are the solid solution.

4.5 Fatigue wear

It is characterized by a fault occurs in separating the particles from the surface layer of the material impact of repetitive stress contact surface of a certain size. In case of material which has low plastic deformation fatigue wear can manifest itself as a deterioration of the surface layer of brittle fracture. Fatigue wear occurs most frequently in gears, roller bearings, valves, etc. In these cases, the addition cycle and the applied voltage applied shear stress, caused by friction between the running surface. This type of wear is then called a contact fatigue wear and contact fatigue, marked by the formation of pits at a depth of a few tenths of a millimetre. For tough materials are well rounded, with materials are hard and brittle square hole.

4.6 Vibrating wear

It is characterized by the separation of the particles and damaging wear on the surface reciprocal oscillating tangential displacements of the contact surface of bodies under the action of normal load. Loose particles produced during wear, is oxidized by atmospheric oxygen, accumulates between the plug terminals and damage the surface of abrasive wear.

The intensity of the vibration of wear is affected by many factors:

.Relative movement of contact surfaces – significantly affects the size of the vibration wear

-Specific pressure – with is increasing linearly increasing the size of the vibration wear The period of vibrational wear – its course is initially parabolic, later a rectilinear, steady storyline takes place after 104 oscillations

-Character environment – the components of the atmosphere at a vibration wear significantly applied oxygen, which speeds up the damage and nitrogen, which slows down the damage

-Object temperature and humidity of the environment – again, with increasing humidity of the environment, the impact of changes in friction properties reduces wear.

When selecting material pairs that have to withstand the vibration wear, consideration should be given to the fact that the bearing surfaces creates oxide layer, which greatly influences the intensity of wear.

For structural steel is not suitable combination with aluminium, nickel, tin, as the said pairs have a very low resistance to vibrational wear. Similarly, it is not appropriate a combination of iron and magnesium, or a combination of tin or aluminium – aluminium. Suitable combinations are steel-silver, steel-lead, steel-gold or steel-PTFE.

Intensity of vibration wear can be reduced by:

-Surface treatment

-Lubrication

-Increase higher friction gauge pressure

-Rough up surface

4.7 *Combined wear*

In technical practice usually combine the types of wear, for example: for combined erosive wear and cavitation. In this case, though it is applicable more types of wear at the same time, it is referred to by both give, for example, occur simultaneously and to erosive and cavitational wear, give denoted as erosi-cavitational wear.

5 VIRTUAL ENVIRONMENT AND SIMULATION OF OPERATION

Virtual environment is created using Open Source software Blender, which involves engine for virtual reality is shown on Fig. 6.

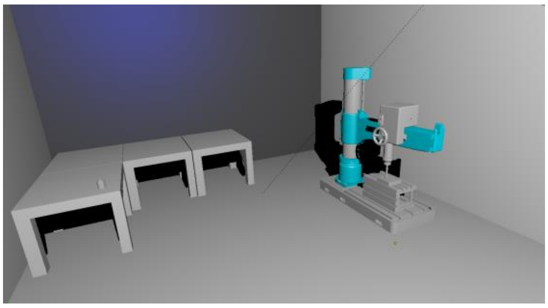

Figure 6. The scene in VR environment

The basis of the entire environment is a machine that is by design page identical to real machine. Also, the whole process simulation is the same with the real operation Fig. 7.

Figure 7. View in VR glasses.

The visual aspect of the machine is inserted into an environment that was similar to a small production workshop.

The blender is using the python programming language to activate the simulation of the operation. The simulation consists of the labor movement of the tool and arm device. The tool causes a rotational movement and sliding arm in Vertical direction. The simulation exactly mirrors the real process, which produces a tool wear. In addition to the simulation of the operation we are able to move around the device, and watch as the operation of several possible angles. Also by external elements, the driver is able to approach the tool.

The whole simulation is shown on the display, which is embedded in the glasses. In this display, the image is displayed as a split screen, so double display.

6 MEASUREMENT PROCEDURE AND USED DEVICES / TOOLS

6.1 *Used devices*

The main devices used in the experiment was created is radial drilling machine VR4. The manufacturer of this device is Kovosvit, and production was in 1983 is shown on Fig. 8.

Figure 8. Radialna vrtačka VR4

Its basic features are drilling diameter in steel strength of 588MPa 40mm and 50mm gray cast iron 245MPa, the largest thread in the steel strength of 588MPa M24 and M36 245MPa a gray cast iron. Also, pitch circle drill holes from 935 to 2825 mm and the distance from the base end of the spindle is 270 to 1290 mm. Another devices using is an optical microscope NEOPHOT 32. This device is and inverted microscope for materials science made by VEB Carl Zeiss Jena. The possibility of magnification of the microscope is 2000x and the carrying capacity for storing samples is 5kg. As the light source used, the halogen lamp or xenon lamp, which is part of the device. To view simple sets and use the projection disc or photomicrographic device is shown on Fig. 9 .

Figure 9. Optical microscope NEOPHOT 32

6.2 *Tool used for measure*

As a cutting tool that is used to measure the Taper shank diameter 10mm DIN 345 is shown on Fig. 10. Recommender performance drill for drilling in components of alloy and non-alloy steel, cast steel up to 900 N/mm², gray, malleable and wrought iron, sintered steel aluminium alloys short chipping.

Figure 10. Used tool

In addition to the drill it is also used for reducing bush drill bit and ejector wedge.

6.3 *Measurement procedure*

Opening is not the preliminary drilling. Drills by hand approaches the workpiece at l distance of 11mm activities the selected speed and cooling, the machine feed. For comparison tests of durability it is essential to choose a certain degree of war, so The criterion of durability of the cutting edge. Is understood beneath a preselected degree of wear and tear, or another agreed value, which may be operation conditions:

Time tool works under the same operating conditions, the time of the exchange, loss dimension of the cut surface, tool distance travelled, amount of metal, the same number of machined components for durability.

Measurement of wear, we implemented the optical microscope at a magnification of 32 NEOPHOT 25.6 – 40x. After boring drill 5 holes are cleaned and mounted in preparation so that the main cutting edge is parallel to the plane of the trolley microscope. In this way, measurement was made of wear of the cutting edge. When measuring the wear on the lateral cutting edge mounted drill perpendicular to the trolley. The drill was drilled every 40 holes and the procedure is repeated for each change of cutting conditions. At the same time during each drilling a fifth hole was measured vibration values at two measuring points. The measured vibration values are entered in tables. The result of measurement was found correlation between the drill wear and vibration.

7 MEASUREMENT RESULTS

Used tool	Radial drill machine VR4		
Type of drill tool	Taper Shank ∅10 DIN 345		
Drilled material	11 500 / E295		
Test conditions n =... [min^{-1}]	180	355	500
s = ... [mm.ot]	0,1	0,25	0,4
Drilling depth [mm]	30	30	30
Used cooling	5% cooling liquid, Q = 5 1.min^{-1}		

Table 1. Test Conditions drilling

The first measurement was to drill built the first speed value 180[min^{-1}] and reaching 0,10[mm.rev] Subsequently was measured vibrations in the rest of the machine. When you turn of drill were zeros and not after switching on the electric motor has been measured vibration value 0,8[mm.s^{-1}] After boring the holes 40 have changed cutting conditions and the measurement was repeated. The drill has been re-sharpened with an aperture angle of 118° in Table 2,3,4 and Figure 11,12.

a	5	10	15	20	25	30	35	40
s – 0,10	1,1	1,1	1,1	1,1	1,1	1,1	1,1	1,1
s – 0,25	1,1	1,1	1,1	1,1	1,1	1,2	1,2	1,2
s – 0,4	1,1	1,1	1,1	1,2	1,2	1,2	1,2	1,2

Table 2. The values measured number 1 at a speed of 180 [min^{-1}] in point 1

a	5	10	15	20	25	30	35	40
s – 0,10	1,1	1,1	1,1	1,2	1,2	1,3	1,3	1,3
s – 0,25	1,2	1,2	1,2	1,3	1,3	1,4	1,4	1,5
s – 0,4	1,6	1,8	2,2	2,5	2,8	3	3,2	3,5

Table 3. The values measured number 1 at speed of 180 [min-1] in point 2

A	5	10	15	20	25	30	35	40
QS	0,02	0,03	0,6	0,1	0,13	0,15	0,17	0,21
HS	0,02	0,04	0,07	0,12	0,015	0,18	0,20	0,25
QS	0,01	0,01	0,02	0,04	0,08	0,10	0,12	0,15
HS	0,02	0,03	0,05	0,07	0,09	0,15	0,20	0,29
QS	0,04	0,07	0,09	0,12	0,15	0,2	0,22	0,25
HS	0,02	0,05	0,015	0,25	0,30	0,36	0,4	0,62

Table 4. The measured values of measuring wear number 1

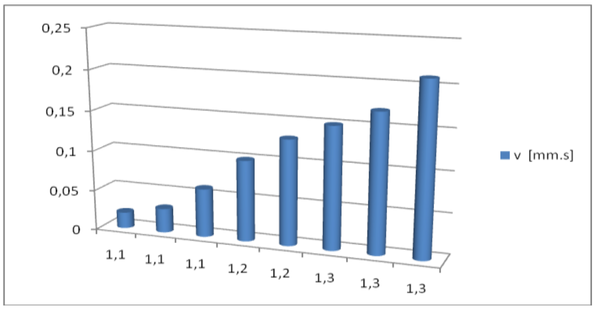

Figure 11. Dependence of the measured vibration and wear QS in point 2 at a speed if 180 [min-1] and feed 0,1 [mm.ot]

From the measured values we can construct the course of the lateral wear of the cutting edge during drilling. Point 2 was found a greater range of vibrations as in 1, therefore construct a graph of bit wear and vibration only for point 2.

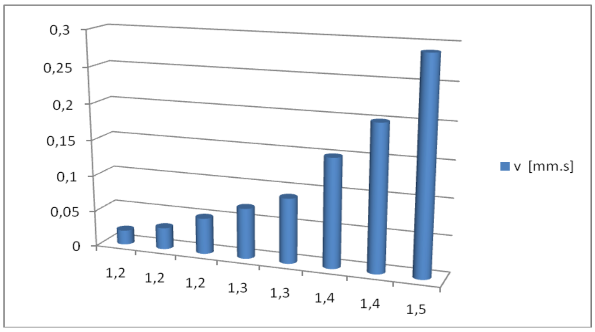

Figure 12. Dependence of the measured vibration and wear HS in point 2 at a soeed 180 [min^{-1}] and feed 0,25 s [mm.ot]

Next measurements were made at a speed of 335 [min^{-1}] in two points.

a	5	10	15	20	25	30	35	40
s – 0,10	1,2	1,2	1,2	1,2	1,2	1,3	1,3	1,3
s – 0,25	1,2	1,2	1,2	1,2	1,3	1,3	1,3	1,3
s – 0,4	1,2	1,2	1,2	1,2	1,3	1,3	1,3	1,4

Table 5. The values measured number 1 at speed of 335 [min^{-1}] in point 1

a	5	10	15	20	25	30	35	40
s – 0,10	1,4	1,6	1,6	1,6	1,7	1,7	1,8	1,8
s – 0,25	1,4	1,4	1,4	1,5	1,5	1,6	1,6	1,7
s – 0,4	1,4	1,4	1,6	1,8	2	2,1	2,5	2,8

Table 6. The values measured number 1 at speed of 335 [min^{-1}] in point 2

A	5	10	15	20	25	30	35	40
QS	0,01	0,03	0,05	0,10	0,14	0,18	0,2	0,25
HS	0,00	0,01	0,02	0,03	0,08	0,18	0,25	0,30
QS	0,0	0,01	0,03	0,08	0,13	0,16	0,18	0,2
HS	0,01	0,02	0,05	0,1	0,16	0,203	0,26	0,33
QS	0,05	0,1	0,18	0,25	0,35	0,50	0,58	0,69
HS	0,02	0,15	0,20	0,30	0,45	0,60	0,75	0,90

Table 7. The measured values of measuring wear number 2

Practical bit wear measurement using proven methods of influence vibrodiagnostic bit wear on the size of the working vibration system. Vibrations of the drill are improper effect on the machining process and hires due to the impact on the resulting quality parameters of the process considered.

8 CONCLUSION

Using vibration diagnostics, using spectral analysis can identify errors and other devices. The basic principle is that each rotary machine is in operation causes tremors. The size of this vibration indicates the status of the device. Each rotary component causes jitter at a certain frequency, that frequency of specific points on the component. The increased robustness is shake component failure. If using vibrodiagnostics identifying hidden bugs and then will be removed to create the conditions to maximize the service life. View of the edge of microscopy and analysis of what makes her wear visible, allows you to check the suitability of durability, its reliability and even the possibility of extension. For each machining process there is an “ideal” course of wear. Right tool and cutting conditions appropriate, qualified professional help, self-experience, good quality workpiece material and good conditions for machining are important prerequisites for the emergence of “ideal” during wear.

ACKNOWLEDGEMENT

Project code: K-14-008-00; ITMS project code: 26220220125; Operational Programme Research and Development support research activities

REFERENCES

[Cacko 2014] Cacko, P., Krenicky, T., Dobransky, J. Impact of an excessive wear of bearing on the mechatronic devices, Applied Mechanics and Materials, 460 (2014) 99-106

[Gaspar 2013] Gaspar, S., Pasko, J. Influence of technological factors of die casting on mechanical properties of castings from siluin, In: Lecure Notes in Electrical Engineering. Vol. 240 (2013) 713-722

[Fedak 2012] Fedak, M, Semanco, P, Micko, M. Statistical process control method based on weight percent of al-si alloy for melting and holding process in die casting. Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering 2012, 62 (2012) 188-90.

[Gaspar 2012] Gaspar, S., Mascenik, J., Pasko, J. The effect of degassing pressure casting molds on the quality of pressure casting, Advanced Materials Research. 428 (2012) 43-46.

[Gots 1995] Gots, I., Zajac, J., Vojtko, I. Vorrichtung zum Messen des Abnutzungsgrades von Schneidwerkzeugen, Technisches Messen /carent/, 62 (1995) 8-11.

[Jacko 2013] Jacko, P., Krenicky, T., Salokyova, S. and Rimar, M. Vibration detection technology heads in the process of cutting water jet, Strojarstvo extra 2011, 46 (2013) 1-3

[Jurko 2012] Jurko, J., Dzupon, M., Panda. A., Zajac, J. Study influence of plastic deformation a new extra low carbon stainless steels XCr17Ni7MoTiN under the surface finish when drilling, Advanced Materials Research 2012, 541 (2012) 1312-1315

[Jurko 2014] Jurko, J., Panda, A., and Pandova, I. Analysis of the tool wear of screw drill during the drilling of steel X04CR16Ni12MnTiN. Applied Mechanics and Materials 2014, 599-601 (2014) 32-5

[Mascenik 2013] Mascenik. J., Pavlenko, S., Bicejova, L. Component selected parameters geometrical tolerance value experimental specification, Applied Mechanis and Materials 2013, 389 (2013) 1096-1099

[Monkova 2013] Monkova, K., Monka, P. Vibrodiagnostics and its application in manufacturing practice. Applied Mechanics and Materials 2013, 390 (2013) 220-224.

[Novak-Marcincin 2012] Novak-Marcincin, J., Fecova, V., Novakova-Marcincinova, L., Janak, M., Barna, J., Kocisko, M. Virtools and its application in MOCAP and creation of the scripts for animations of models. Engineering Review 2012, 32 (2012) 96-102.

[Orlovsky 2013] Orlovsky, I., Hatala, M. and Duplak, J. Balance equation – an essential element of the definition of thy drying process. Advanced Materials Research 2014, 849 (2013) 220-4

[Salokyova 2011] Salokyova, S, Jacko, P., Rimar, M. Effect of grain size and type of abrasive spectrum of vibration acceleration in the process of water jet cutting, 5 (2011) 39/1-39/4

[Smeringaiova 2011] Smeringaiova, A., Valicek, J., Hloch, S., Goban, J. Three views on kinematic analysis of crank mechanism in educational process. International Scientific Geoconference and EXPO, 3 (2011) 1309-1314.

[Straka 2011] Straka, L., Rimar, M,. Corny, I. and Mihalcova, J. Increasing oc operational reliability of technical system. Paper presented at the Annals of DAAAM and Proceedings of the International DAAAM Smposium, (2011) 1089-1090

[Straka 2014] Straka, L. Operational reliability of mechatronic equipment based on pneumatic artificial muscle. Applied Mechanics and Materials. 460 (2014) 41-8.

[Svetlik 2014] Svetlik, J., Baron, P., Dobransky, J., Kocisko, M. Implementation of computer system for support of technological preparation of production for technologies of surface processing. Applied Mechanics and Materials 2014, 613 (2014) 418-25.

[Vagaska 2014] Vagaska, A. Mathematical description and static characteristics of the spring actuator with pneumatic artificial muscle. Applied Mechanics and Materials 2014, 460 (2014) 65-72.

[Vojtko 2014] Vojtko, I., Simkulet, V., Baron, P., Orlovsky, I. Microstructural characteristics investigation of the chip-making process after machining. Applied Mechanics and Materials 2014, 616 (2014) 344-50.

CONTACTS:

Ing. Radoslav Krehel, PhD., doc. Ing. Marek Kocisko, PhD.,
Ing. Tomas Vysocky, Ing. Andrea Cizikova, Ing. Patrik Szentivanyi
Technical University of Kosice
Faculty of Manufacturing Technologies
Sturova 31, 080 81 Presov, Slovak Republic
e-mail: radoslav.krehel@tuke.sk, marek.kocisko@tuke.sk
tomas.vysocky@tuke.sk, andrea.cizikova@tuke.sk
patrik,szentivanyi@tuke.sk