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Reviewers

PRODUCTION ACCURACY CHECK USING NEURAL NETWORK STATISTICS

O. Barborák, M. Eperješi, I. Andrejcak, P. Božek

Abstract

Nowadays growing quantitative and qualitative demands are made on the engineering production. This results mainly from the present character of the market and customer demands. Innovation cycles have become shorter; there is an increasing variation in products, and demands on the quality and reliability have increased. The present machines and equipment are composed of lots of parts and components which have their dimension and have a certain role within the given machine or equipment, for which they were designed. Each component has its own life time or time of service. When this period has ended and it is necessary to replace the component with a new one, then the check of production accuracy occurs so as the given component meets the required parameters and performs the required function in a machine or equipment. In principle there are two types of production accuracy check, namely manual and automatic. Manual check is based predominantly on a sensory evaluation of a man who checks the relevant component (visually, mechanically, etc.). Therefore in this check it is necessary to take into account the human factor and possible mistakes in the measurement and check of the relevant component.

Key words

measurement, production inspection, statistical evaluation

The measurement accuracy of components parameters such as dimensions, angles, roughness, etc. in a way depends also on the correct procedure selected and the type of measuring tool. From the metrological point of view, the inaccuracy of machinery parts means deviations of the parts actual surface from the geometrical surface. At present, the neural network technology has become very popular, and that is why it penetrates into various branches of industry. In the area of ensuring operating reliability, it is possible to use it for instance in the monitoring of the status of machines (forecasting as to when a machine failure may occur as a result of vibration or acoustical load, and then the planning of preventive maintenance). Neural networks could be used everywhere where demanding decision-making and creative activities of the staff must be replaced. An artificial neural network can be defined as a parallel massive computing system, which is able to hold information and enables its further processing, whereas it models the human brain in collecting knowledge in the learning process and holding such knowledge using interneural connections.

MEASUREMENT

Arithmetic average of shaft dimensions:

m_1 = 25.966 mm

m_2 = 25.97 mm

m_3 = 25.974 mm

Mean value of arithmetic average of shaft dimensions for production batch m:

m = 25.97 mm

Standard deviation s_o:

s_o = 0.158479

NEURAL NETWORKS

Neural network is a computing model drawn up on the basis of an abstraction of the properties of biological **nervous systems**. The basic part of neural network is the model of neuron with N inputs and M outputs that processes information according to the following rule:

$$o_i^{k+1} = f\left(\sum_{j=1}^{N} w_{ij}^k \times o_j^k - \Theta_i^{k+1}\right)$$

where:

- $0 < i <= M$,
- $0 < j <= N$
- o_i^{k+1} is the output value of i^{th} neuron of k+1 layer
- k is layer index
- Θ_i^{k+1} is the excitation threshold of i^{th} neuron of k+1 layer
- w_{ij}^k is weigh of connection between j^{th} neuron of k layer and i^{th} neuron of k+1 layer
- f() is arbitrary **monotonous function**

Neural network as such is composed of several layers with different quantity of neurons, interconnected in various ways.

Classification:

In literature under (3) different **architectures** are distinguished:

- perceptron,
- multiple layer network,
- recurrent network,
- Hopfield network (weights are bi-directional),
- Kohonen network,
- Radial base

Each of the architectures is suitable for a different type of task.

Properties:

The basic property of neural networks is the ability of the **abstraction** of rules between the input and output figures presented in an adequate form and subsequent application of obtained rules to any input figures. Therefore it is often used in the regulation and simulation technology.

Abstraction process means learning and it may take place with a teacher or without any teacher. During this process the values of weight connections are updated. Several learning algorithms are described in literature. After the end of learning the values of weights do not change and the network generates output values according to the relevant rule applied to input values.

Utilization:

- Recognition of models (e.g. images and writing)
- *Universal system inverter*; is able to prepare from each system F(x), also from those which cannot be prepared otherwise mathematically.
- *Universal system approximator*; is able to model the behaviour of each system, whether physical or even mass psychology of the market.

- *Artificial intelligence*; mainly the support of decision-making, recognition of signals; in this case, however, it is often combined with standard computer algorithms, which the NS often merely transforms data that standard binary logic does not process to data which it processes. Pure artificial intelligence based on the NS only have proved to be impractical.

Some people believe firmly in that the NSs are universal (neurofetishism), and when it has been proved that often they are not, then generally they reject them.

NS is only a tool and like each tool they are optimal for a certain type of tasks only.

Advantages:

- Parallel processing of **information** making it possible to divide a calculation, in appropriate hardware, into several parallel processors.
- It does not require any information on the structure of the process to which it is applied.
- It covers the option of adaptation to a change of the parameters when applied with a learning **algorithm**.
- It is suitable for such tasks as identification, approximation, classification and sorting of models.
- Networks are fast if implemented without the learning algorithm.
- It allows the abstraction of governing rules of another regulator (e.g., a man or a regulator with long computing periods) and their replacement.
- They provide the reduction of the size of data to a smaller area.
- They represent a universal approximator which is able to approximate any **continuous function** with any accuracy.

Disadvantages:

- No methodology has been prepared for the design of network architecture and for the selection of **functions** describing the neuron. Therefore in the implementation the trial-and-error method is applied, which increases time consumption for the solution.
- It is not suitable for systems that require precise solutions (**linear systems** are better for this, with which NS can be combined perfectly).
- Learning is usually long (shorter for gradient methods, longer for mutation). However, fortunately, neuro-fuzzy systems exist, which are able to learn extremely quick.

STATISTICAL PROCEDURES

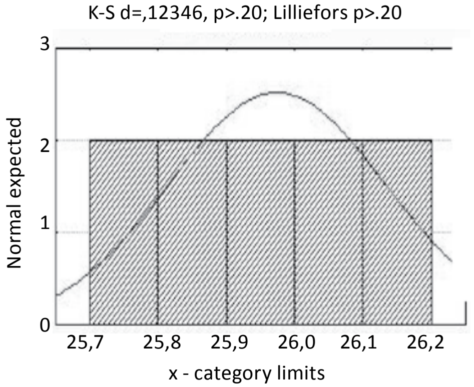
1. Use of the programme Statistika Cz.
2. Basic statistical evaluation.
3. Graphic execution of the measured values.

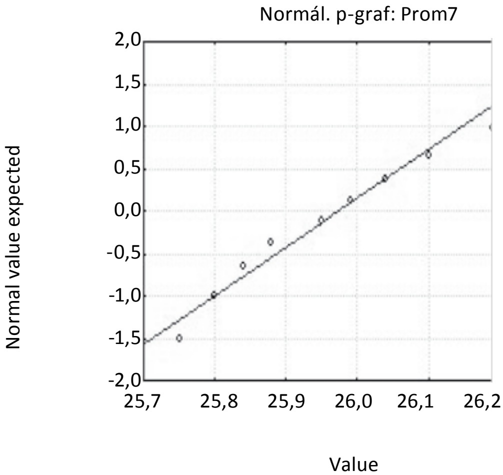
EVALUATION OF MEASUREMENT

In checking the production accuracy of the shaft dimension for production batch we found out that from the required dimension m which was 26.00 mm only two values out of thirty were identical. The minimum value in the measurement set was 25.75 mm and the maximum value in the set was 26.20 mm. Arithmetic average of shaft dimensions was at m_1 25.966 mm, at m_2 25.97 mm and at m_3 25.974 mm. The mean value of arithmetic average of the shaft dimension for production batch was m 25.97 mm. We obtained standard deviation of s_o 0.158479 from the statistics of neural networks which we used for graphic and statistical evaluation of the values obtained from the measurement.

DISCUSSION

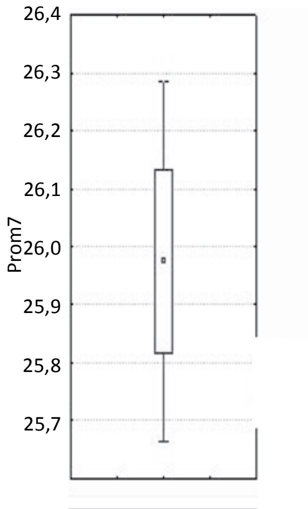
It results from the above description that the accuracy of the network results in principle depends on the amount of training models, in which we train the neural network. The aim of this demonstration example is to point out the





Overall statistics: Prom7
N valid = 10,000000
Diameter = 25,974000
Minimum = 25,750000
Maximum = 26,200000
Standard deviation = 0,158479

Diameter = 25,974
Diameter ± Standard deviation =(25,8155, 26,1325)
Diameter ± 1,96, Standard deviation = (25,6634, 26,2846)



manner in which neural networks can be designed and simulated. The said design does not include network testing using test models, but it includes only the learning of specific examples (models) of input and output. We can determine the deviation of the NS output value from the required value using a testing set of input-output data. In the case of different data we can modify the weights so that the difference between the required and the current output value is as low as possible. We have an advantage in using the STATISTICA software Automatizované neurónové síte CZ in that the programme supports the automated selection, training and testing of neural networks.

CONCLUSION

The article outlines the possible utilization of artificial neural networks in shaft dimension measurements. The said example should serve for further development of studying neural networks and their utilization in technical systems.

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MODIFICATION OF CAST STEEL BY LOW AMOUNT OF TITANIUM

I. Barényi, H. Mäsiar, A. Lysák

Abstract

The paper describes experimental results of mechanical properties when high strength cast steels were used after their modification by low amount of titanium. The experimental specimens, both modified and unmodified, were treated by several ways of heat and chemical-heat treatments and then their tensile strength, hardness and toughness were measured. Finally, the effect of modification by titanium was evaluated according to used treatment methods.

Key words

modification by titanium, heat treatment, cast steels, strength, toughness, hardness, HSLA

Generally, the steels consist of various alloying and additive elements that have positive influence on their utility properties as the following: mechanical characteristics, corrosion resistance, wearing resistance a. o. According to elements effect on Fe-Fe_3C binary system and consequently on the final microstructure, elements supporting formation of ferrite or austenite are known. Also the carbides and nitrides of alloying elements have important effect on steels characteristics due to their significant affinity to carbon or nitrogen. The titanium is one of listed elements, which is added to steel in very low amount, but the mechanical properties are affected significantly.

TEORETICAL ANALYSIS OF TITANIUM INFLUENCE IN STEELS

The titanium has a high affinity to carbon and nitrogen and forms compounds significantly affecting final characteristics of steel. Carbides and nitrides segregated at grain boundaries prevent to dislocations in movement and that leads to precipitation hardening of steel. These phases affected grain refinement too. They are stabile at high temperatures when preventing to grain growth by segregation at boundaries. Moreover, as titanium binds nitrogen atoms to eliminate negative nitrogen influence to steel properties (decreasing of toughness). Nitrogen forms unstable solid solutions with iron and that results in ageing of steel. [1, 2].

The titanium has the direct effect on the binary system Fe-Fe_3C along with indirect effects mentioned above. Substitutional solid solution with iron is formed that differs from that carbon. There is the section of Fe-Ti equilibrium diagram on the Fig. 1. It is obvious that titanium supports ferrite formation that results in opening of α area. Fully ferritic microstructure and therefore unhardable one can be obtained by modification with 2% of titanium in the 0.5% carbon steel.

The titanium has advantageous effect on steel properties mainly when to be dissolved in solid solutions. If it is more segregated in the form of intermetallic phases (like $FeTi_2$) then it has negative effect rather. Due to selected reasons the titanium is used as alloy element for steels in very low amounts that not exceeds level of its solubility in γ iron (0.7%).

Others advantageous effects of steels modification by titanium were detected after their nitriding. Titanium nitrides in the nitriding layer cause the increase of its hardness.

EXPERIMENTAL RESULTS

High strength cast steels 422855 and 422767 were used for experiment. Experimental specimens were made of them by investment casting process in two melts. Chemical composition of the batch was corresponded with composition of base material. Titan modification was made

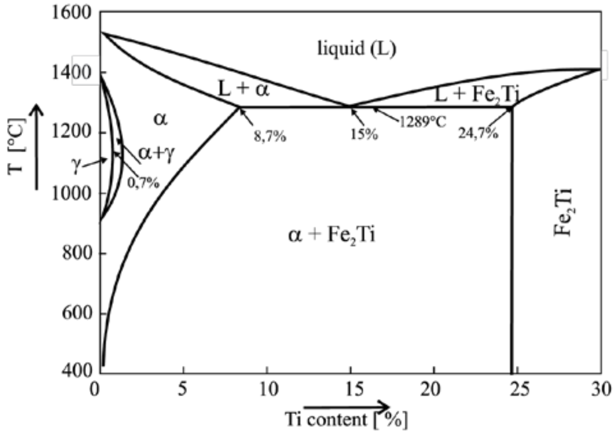

Fig.1: Section of Fe-Ti equilibrium diagram

Tab. 1: Chemical composition of experimental specimens

422855	element	C	Mn	Si	Cr	Mo	Ni	V	Ti	P	S
	[%]	0.4308	0.897	0.583	0.891	0.448	1.84	0.0175	0.0017	0.0242	0.0191
422855 +Ti	element	C	Mn	Si	Cr	Mo	Ni	V	Ti	P	S
	[%]	0.4377	0.922	0.65	0.91	0.442	1.841	0.0213	0.028	0.0249	0.0192
422767	element	C	Mn	Si	Cr	Mo	Ni	V	Ti	P	S
	[%]	0.3782	1.47	0.54	0.807	0.577	0.0969	0.3435	0.0027	0.0265	0.0203
422767 +Ti	element	C	Mn	Si	Cr	Mo	Ni	V	Ti	P	S
	[%]	0.3802	1.41	0.597	0.81	0.612	0.0988	0.342	0.036	0.028	0.0221

after second filling of the cast pan by addition of needed FeTi amount to the pan before casting. Chemical composition of cast specimens was checked by spectral analyzer SpectroLab JrCCD. Average values of elements concentrations from five measurements on various specimens are in the Table 1. Noticeable increasing of titanium contents was reached due to alloying process, as shown in Table 1.

Experimental specimens, both modified and unmodified, were treated by selected heat and chemical – heat treatments in the following step. All specimens were normalizing and then separated to various groups according to scheduled final heat or chemical heat treatments.

Used treatments and results of mechanical properties measurements after their application are given in the table 2. The values are av-

Tab. 2: Experimental results of mechanical properties

Material/Heat or chemical-heat treatment		R_m [MPa]	$R_{p0,2}$ [MPa]	A [%]	HV5	KCU5 [$J.cm^{-2}$]
normalizing	422767	1126.04	1101.09	6.90	722	11.6
	422767+Ti	1034.31	1011.39	6.00	717	16
	422855	970.06	950.68	7.70	759	13.4
	422855+Ti	952.30	931.20	8.00	747	17.8
quenching + tempering	422767	1379.03	1232.91	4.30	543	11.4
	422767+Ti	1318.70	1173.49	4.90	551	10
	422855	1254.81	1182.88	6.30	472	19.8
	422855+Ti	1276.25	1214.98	6.60	502	14.2
nitriding without q+t	422767	967.21	939.19	4.30	670	20
	422767+Ti	956.38	944.48	4.30	701	17
	422855	847.35	824.47	5.40	590	24.8
	422855+Ti	850.82	834.14	5.10	574	21.4
nitriding	422767	1135.81	1116.59	5.70	854	14.2
	422767+Ti	1135.87	1116.64	5.70	874	8.8
	422855	1185.84	1165.77	6.60	703	16.2
	422855+Ti	1212.70	1199.41	6.30	751	11.2
nitrocarburizing	422767	1083.16	1053.91	5.10	942	8.6
	422767+Ti	1071.05	1042.13	4.90	882	10
	422855	1048.33	1020.03	5.70	824	9.8
	422855+Ti	1022.82	995.20	5.70	866	9.4

erage of five measurements. Test of particular mechanical characteristics was realized according to present STN EN standards. Strength and plasticity characteristics was evaluated by static tensile impact test following STN EN 10002-1, toughness by Charpy impact test following STN EN 10045-1 and hardness by Vickers method following STN EN 10045-1.

EVALUATION OF MODIFICATION EFFECT TO STRENGHT, TOUGHNESS AND HARDNESS

In case of material 422767 Ti content was increased from 0.0027 % to 0.036%, that means relative increase about 0.033 %. At next material 422855 original level of titanium content (0.0017%) was increased to 0.028%. i.e. relative increase about 0.026%.

From particular experimental results is obvious that the Ti modification caused the changes in values of toughness KCU5, hardness HV and strength Rm, respectively. The changes of the characteristics for both investigated materials. Depended to Ti modification are summed up in fig. 2. The graph columns show comparison of mechanical characteristic obtained from modified and unmodified specimens after the same treat by heat or chemical – heat treatments.

The changes of investigated mechanical properties after Ti modification were either positive or negative. related to heat or chemical – heat treatment. Both investigated materials were affected by Ti modification in the same way, apart from a few exceptions.

a.

b.

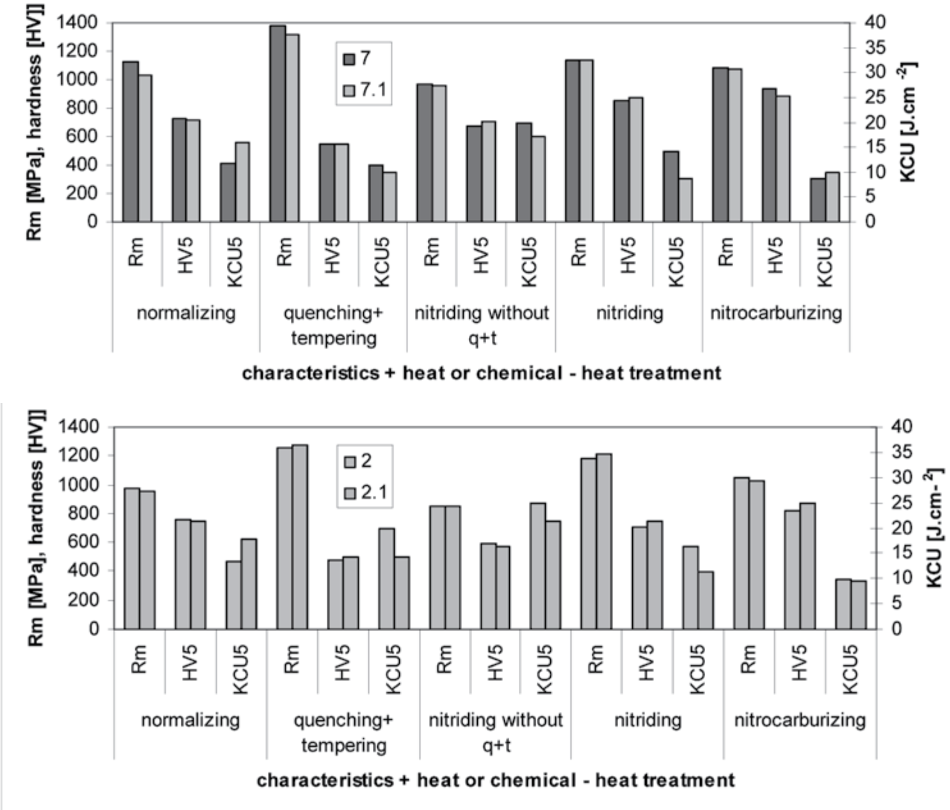

Fig.2: Effect of Ti modification on selected mechanical characteristics
a) material 422767 (7 – original. 7.1 – modified)
b) material 422855 (2 – original. 2.1 – modified)

The most significant changes were occurred in KCU5 values, specifically their decrease in normalized state and increase in quenched + tempered ones and both nitriding states. There was occurred soft decrease of KCU typical for 422855 and on the contrary to that soft increase of toughness for 422767 in the nitrocarburizing state.

In case of Rm strength was occurred its decrease after normalizing. More significant for material 422767. There was occurred its soft increase at 422855 in quenched + tempered and both nitriding states, the values were rather stagnant for 422767. In the nitrocarburizing state Rm values decreased for all investigated materials.

Hardness HV5 of all investigated materials decreased softly after Ti modification in normalized state. In quenched + tempered and nitriding (with q+t) states it increased and mainly for 422855. The increase of HV5 for 422767 was lower than the increase of HV5 for 422855. In the nitriding state without quenching + tempering were obtained different results of HV5. they increased for 422767 but decreased for 422855. On the contrary in nitrocarburizing state, HV5 decreased for 422767 and increased for 422855.

CONCLUSIONS

The effect of modification by Ti can be fully concluded in way. that it caused soft increase of HV5 hardness and Rm tensile strength in heat and chemical – heat states important for use of real high strength casting. On the other hand it caused significant decrease of KCU5 toughness. Consequently, the modification by Ti was not only positive and thus not too meaningful.

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COMPOSITE AND CERAMICS MATERIALS USED FOR BALISTIC PROTECTION OF MILITARY VEHICLES

J. Eliáš, M. Ličková

Abstract

Composites based on carbon, glass, aramid and other fibres became the common design materials also in special technology and they are greatly affecting soluting of the balistic protection. The subject of this paper are characteristics of composite and ceramic materials used for balistic protection of military vehicles.

Key words

armour, balistic protection, composites, ceramics, projectile, strength, soft steel, hardness, tough metal, military vehicles

Realized experiments with ceramics, glass, multilayer, composite materials conduce to much greater effectivities balistic protection as accountedalone homogeneous steel armour. Composites on the basis carbon, glass, aramid et al. fibers became actual construction of material not only in air force but it also in special mobile technology. Materials of armour are bipartite that depend to facilities of materials and method that deal with energy bullet. Materials of armour they need next energy of disruptived or energy of absorbent.

The materials act as upsets bullets that means affect bullet of destructive and vehicles must be made with materials of high strength, with high hard and high tensile armours of steel or materials of ceramics. The effect of materials (multilayers) is destroy incident bullet or close by impact bullet precipitantly break or close by impact bullet on armour is needed velocity head bullet analyse armour of material, rip apart bullet and to reroute energy out of roll over protective structure.

Another method protection of balistic armour rests in application so called absorbers. The absorber absorbs velosity head and so her melt into other energy form (heat).

Tough metals and composite materials affect than good absorbers although they have also mincing abilities. Bulk systems of armour to characterized by both facilities that is breach-break up bullet as well as absorbing velocity head of impinging bullet.

Armours of multilayer complex were found in forexample tank T - 80 (fig. 1) at those high sloping surface board comprise of layers high hard martensitic steel of tough steel and composite material.

Fig. 1: Russian activ tank T - 80U

The system of armour should be the best posible. Here gets off demend on reduce heaviness boards of armour and them real deployment.

Though improve ments development systems of weapon at present means, that cumulative shots they can without problems interfuse armour of steel 1 m thickness in 0,8 s. Needs facilities of balistic are attained chemistry, mechanical working and heat treatment.

Universal accession to development armour of steel with change hardness is process called surface hardening, realized cemented and hardened or pressed, rolled and so on, soft steel and hardness steel.

Efficiency of balistic protection any materials of armour as indicated in tab. 1.

The efficiency of balistic DHA (tab. 1) is much better as has steel HHA when will be assumed attack with armoured (AP) shots.

CHARACTERISATION COMPOSITE MATERIALS

The composite materials be used for balistic protection of armours consist of laminate matrix and reinforcement fibres. The matrix must secure continuity phase to allow load in faster and harder fibres. Typical fibred of materials are S - glass, E - glass, Kevlar, carbon fibres, boron, carbide BC and so on (disulphite W, Ti, Nb, Mo and so on). Fibres inducted of materials account relatively high specific strengths in compare with metals. For compare in the table 2 are in-

Tab. 1: Efficiency of balistic protection any materials of armour

Thickness armours, area weight distribution, values mass efficiency for quantity steel needed for protection against shots 7,62 - AP for direct shoot and impact in course normal line.				
Armour of steel	Specific gravity [kg.m^{-3}]	Required thickness boards for stopped [mm]	Areic thickness for stopped shot [kg.m^{-2}]	Values weighty efficiency [Em]
Rolled hard armour RHA (380 HB)	7830	14,6	114	1,00
High hard armour HHA (550 HB)	7850	12,5	98	1,16
Dual hard armour DHA (600 – 440 HB)	7850	8,1	64	1,78

Tab. 2: Characterisation of ceramics

Material / Properties	Al – high pureness	SiC – carbide of silicon	Titanium-diboride	BC - Boron carbide
Heaviness shot [kg.m^{-3}]	3810 – 3920	3090 – 3220	4450 – 4520	2500 – 2520
Young´s modulus [GPa]	350 -390	380 – 430	520 – 550	420 – 460
Poisson proportion	0,22 – 0,26	0,14 – 0,18	0,05 – 0,15	0,14 – 0,19
Hardness [HV]	1500 – 1900	1800 - 2800	2100 – 2600	2800 – 3400
Fracture toughness [MPa.m$^{1/2}$]	3 - 5	3 - 5	5 -7	2 - 3

Tab. 3: Characterisation of composites

Fibres	Specific gravity [g.cm^{-3}]	Failure strength Rm [MPa]	Modulus of elasticity [GPa]	Failure of deformation [%]
E – glass	2,60	3500	72	4,8
Aramid (Kevlar)	1,45	2900	120	1,9
Carbon	1,78	3400	240	1,4

ducted some characterisation of ceramics and characterisation of composites are inducted in the tab. 3.

Armours of development and balistic protection is displayed in fig. 2. Structural of design single measures balistic protection of vehicles are schematically description in the fig. 3.

The shot to fragment in hardly armour. In the air fly and turn debris. Absorber must have high and good efficiency of absorption. Definite obliqueness areas in vehicke safeguards decay array of bullet strike upon vehicke. Strength of authentic impinging shot is reduction by go up balistic protection of vehicle.

COMPOSITES WITH STEEL MATRIX

Composites with steel matrix enable achieve advisable combination facilities in material:

- high strength and spissitude by low heaviness,
- high heat and electrical conductivity,
- high wear resistance,
- good mechanical properties to warm.

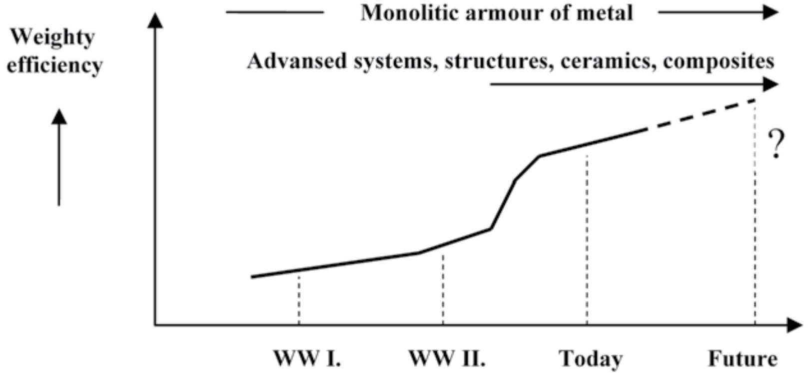

Fig. 2: Trend sused for hardness of armour (WW I.-World War I., WW II.-World War II.)

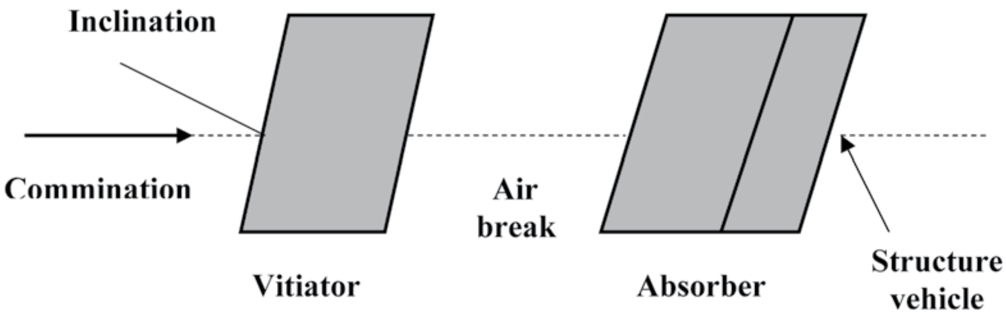

Fig. 3: Schematic description single applied measures for balistic protection of armours

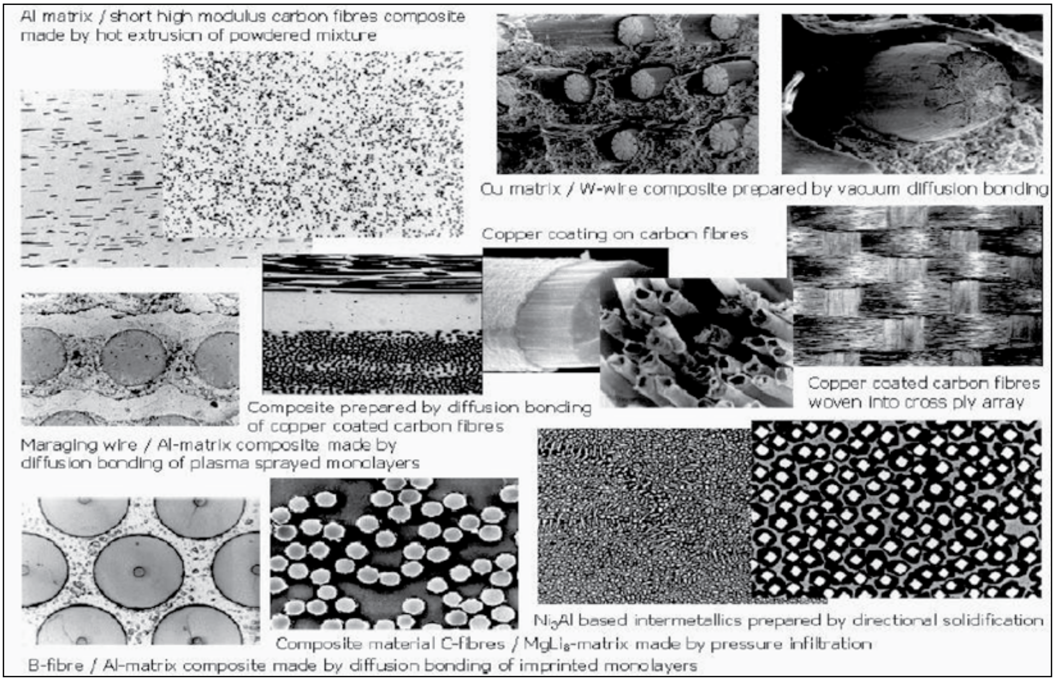

Fig. 4: Composite materials

In the fig. 4 are examples of composite materials.

CERAMICS MATERIALS

Ceramics materials are high hard and high strength materials of armour and their characteristic properties are in tab. 2. Their high hardness and relatively low specific gravity to allow their use of engineering armours systems.

The most ceramics materials is made from very fine powders where were applied heating and pressure for create hard material. The process of creating ceramics materials to call sinterisation.

In little are addition of additional materials that enable lighter production for temperature reduction needed for aplication of sintering - sintering material. As a rerult of sintering is polycrystalline material.

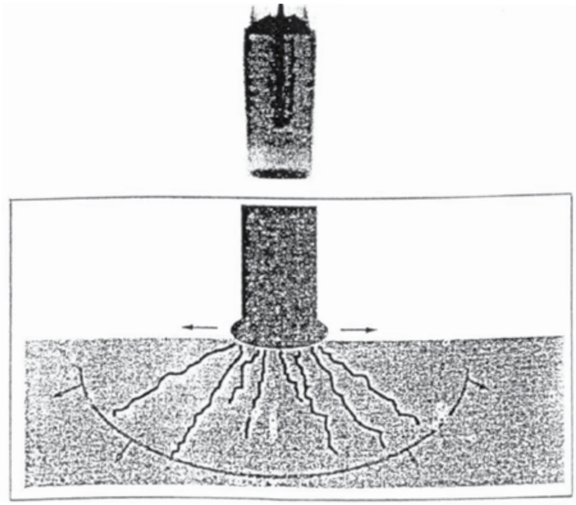

Fig. 5: Broadening cracks of ceramic

Ceramics materials for armour they have low gravity, less than half gravity of steel. Carbide of tungsten (WC) have bigger gravity as have armour of steel. Ceramics materials have relatively little of specific gravity. Boron carbide (BC) have the smallest gravity about 2,5 $g.cm^{-3}$ (it is 1/3 gravity of steel). Ceramics materials be characterized by high hardness but also strength. Boron carbide is one of hardest materials with low specific gravity. Ceramics materials are very fragile and have little levels of fracture toughness (tab. 2). At gunfight of bullet with W - backing coat at big speeds of impact are of interference incoherent at the cracking. Roughage armour of ceramics are very effective at stop of shot.

Influence of penetration at ceramics board for shatter speed 2 500 $m.s^{-1}$ is in the fig. 5. At the ceramic to see broadening of cracks.

CONCLUSION

In special technology are materials of composite the most widespread as alternative of armours for increase balistic hardiness actual of armours - the most effective adverse of armour are composition layers by various materials as ceramic, carbide of metals, metals and composite materials.

The efficiency of composites at mission of supplementary protection heighten reality that spped of bullet and flinders is lowered chief armour materials of composite are more efficient against penetration at low of shatter speeds.

In the area of exploitation composites in special mobile technology intensive development. As a results are modules of additional armours ceramic - composite modules (modular additional armour) protective lining interiors towers and of action areas layer until 20 mm thickness of shaped details. The destinations balistic protection of vehicles is reduction laden weight thirty percent compared to achievement heaviness is combat of vehicles.

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DEFINING THE MODULE TESTINGS OF THE PASSENGER FRONTAL AIRBAG

Z. Jamrichová

Abstract

Defining the module testing of the passenger frontal airbag is ruled by the norm GMWxxx2. Airbag is tested by means of static tests and in various climatic conditions. There is in accordance with the norm corresponding testing equipment with the accessories.

Key words

static module airbag tests, cyclic vibration test while temperature changing, thermal shock , humidity resistance test, corrosion resistance test and service test

1ST COMPONENTS OF THE FRONTAL AIRBAG MODULE

Passenger and driver frontal airbag is there to protect the persons sitting on the front seats against the head and chest injury while front bump into the fixed barrier in the speed up to 60 km/h.

While the front bump between two vehicles the frontal airbags can protect up to the speed 100 km/h. To do so, airbags have different filling amount and different development of pressure growth according to its placement, kind of vehicle and its version.

The function of airbag activation is secured by different components such as control unit, slowdown scanner and energy power source. Passenger frontal airbag is generated by the basic parts, as airbag module, „guiding tunnel" of airbag, airbag doors and the grip console. Airbag module is made of components: sapper booster (mover), gas generator in the fixed cover with filters, folded airbag, airbag module wrapper.

Individual components of module are located in the airbag wrapper, that is mounted to the cross girder of the vehicles frame (CCB – Cross Car Beam) through the grip console. It is either under the industry panel or in the industry panel from the inside or it is mounted to both. Grip console is either welded or screwed. The guiding tunnel of airbag is wide plain plastic ringlet creating passage, which is responsible for guiding the airbag while its inflating and it stops capturing of the airbag into the fixed parts of the industry panel. It stops the airbag to get under the vehicles industry panel. Airbag doors are built-in into the industry panel.

Safety requirements put on airbag system, which is integrated as an interior component are: airbag opening in the exact stated time, ruled and exact external airbag wrapper disruption (doors) while all climatic conditions (-35°C to +75°C), no airbag pillow damage while explosion and inflation and none cut off particles ripped out of external wrapper while explosion.

2ND DEFINING PASSENGER FRONTAL AIRBAG TESTING

Conditions and requirements of testing for the frontal interior airbags General Motors. GM are stated over the could be world-wide by the used technical norm GMWxxx2 founded by firm GM. Norm deals with accuracy control and procedure validity and requirements for drivers frontal airbag testing, passenger and knee airbag used for frontal security systems in vehicles. Airbag moduls are assigned for completing safety belts as security system while frontal bumps. The main objective of frontal airbag system is to spread the pillow and to lower the contact rate while frontal bump typical for specific slowdowns. (bumping impuls) while car accident. Airbag serves to decrease possible injury while frontal car accidents where the passengers could be seriously injured.

Airbag Module Classification following the norms GMWxxx2

- (DAB – Driver Airbag Module),
- (PAB – Passenger Airbag Module),
- (KAB – Knee Airbag Module), that is divided into DKAB (Driver Knee Airbag Module) and PKAB (Passenger Knee Airbag Module).

3RD STATIC TEST

The main aim of the static test system PAB (Passenger Airbag Module) is to find out the reliability of airbag in static position. Testing is done by the equipment which is assigned by the norm and also by the testing accessories as follow:

- Air/conditioned store room able to keep temperatures ranging from -30° to +75°C,
- heating blanket table to heat airbag module surface up to the temperature of +110°C in 60s,
- rigid fixture , which represented the gripping in the vehicle,
- module gripping simulates the vehicle scene including the reactions toward the near parts,
- for PAB: Passenger Airbag Module it is required, while the door is designed in the way that can meet it while opening. If the doors

are not designed to meet the front glass module, it is not required to use original glass, but it must be supplemented by e.g. acrylic sheet for the purpose of doors contact control,

- control device, that also turns on the measuring device,
- testing horizont with the grate drawn in the place of door,
- high/speed cameras (min. 1000 pictures/s) minimally three views from the backside, from the side from the bisectors. For PAB modules equipped by some function for modification or airbag energy change while passenger position out of standard position there are according to the needs other additional camera views, that enable complete view on the inflating airbag.
- Lights of high intensity,
- Pressure converter that can measure the pressure up to 690 kPa,
- thermometers, that can measure the temperature up to +110°C,
- identification signs (with testing numbers).

Required data (observed values) while testing are conditional temperature in the storeroom, pillow pressure on the door (if required), electrical voltage in accordance with time, views from the high speed cameras. Static test system PAB is done by the temperature of (+75°C), by low temperature (-30°C) and by normal temperature (+23°C).

4TH AIRBAG MODULE TESTING IN VARIOUS ENVIRONMENTS

The main aim is to evaluate module reliability in various environments and in different conditions. Particularly these are: cyclic test of vibrations while temperature changing, test thermal shock, test of humidity resistance, corrosion resistance test and service test.

Cyclic test of vibration while temperature changing.

The main aim is to evaluate vibration and temperature influence on the module reliability.

Testing is done in the air/conditioned storeroom, where the temperature is kept in the range from -30° to +75°C, where the vibration equipment and rigid fixture, that represents module are placed in the vehicle. The testing is done by the vibration 10, 95, 216, 465, 645, 685 a 1000 Hz. Vibrations are applied in the duration of 22 hours in various vehicle axis. Module must meet the testing requirements while vibration thermal testing.

Thermal Shock Test

The main aim is to evaluate the influence of different temperature changes on the module material. Testing is done in the thermal storeroom, which is fast change adjustable and can keep the temperature from -30°C, to +23°C and to +75°C, where the rigid fixture is placed, that represents the module gripping in the vehicle.

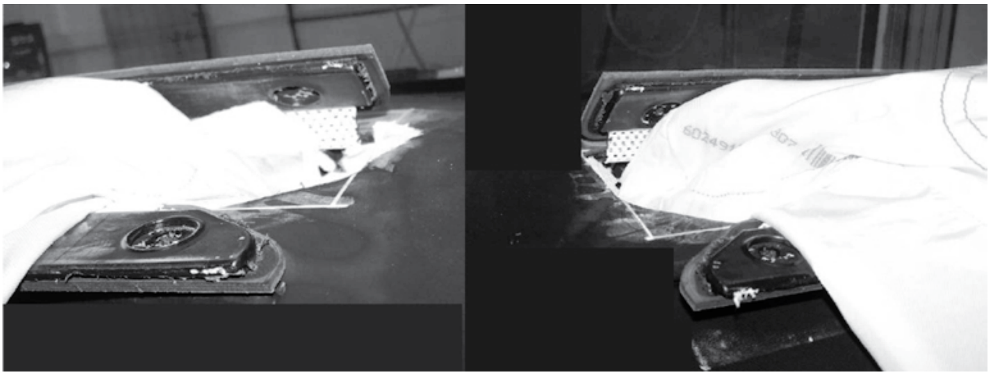
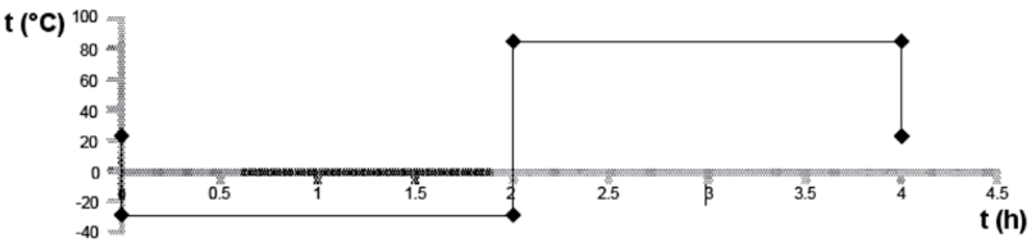


Fig. 1: Detail of left and right door side while airbag blowout

Graph 1: Temperature time relation while vibration testing



Graph 2: Temperature time relation while Thermal shock

60 thermal cycles are applied see (graph 2). One cycle consists of following steps: intense module cooling to -30°C within 30s., intense module heating after two hours to +75°C within of 30s. After another two hours intense cooling to +23°C within 30s. Nonstop monitoring of the current temperature.

Humidity Resistance Testing

The main aim is to evaluate the humidity influence on the module reliability. Testing is done in the thermal storerooms where the temperature is kept from -10 to + 65°C with the humidity of 100%, where the rigid fixture is placed and represents the module gripping in vehicle. Module is heated up to -10, +23 and +65°C while maximum humidity in the storeroom 95% in the following steps. Module is being heated in the time of 2,5 h from 23°C to 65°C humidity of 95%. It is kept on this temperature for 2,5 h and then is slowly cooling up to the temperature +23°C. After it is again heated to the temperature of 65°C. This cycle is being repeated six times. After the 6th cycle module is cooling up within 0,5 h to the temperature of -10°C without humidity check.

Corrosion Resistance Testing

The main aim is to evaluate the influence of corrosion resistance on the module. Module is set for +23°C. 5% of salt brine NaCl is being spread on the module and it works for 24h.

Service Testing

The main aim is to evaluate module endurance while assembling and disassembling. Module is set for +23°C. There are 10 cycles of activities done continuously. Electrical equipment switches are disconnected, module is dismantled out of industry panel, module is mounted back on to industry panel, electrical switches are connected. Module must conform and must show no collision while assembling and disassembling.

Further Testing: refractoriness, gas blowing-through the leakage in the module, module fall from the different heights to the solid surface in the vertical and horizontal position; height 1,2 and 2,5 m, influence of sun radiation, UV radiation resistance, ozone resistance, exhaustion caused by pressure resistance 100±2N by frequency of 1 Hz 4000 cycles by temperature of +23°C.

CONCLUSION

Nowadays, safety of vehicles is on a high level. Vehicle Safety Research is in Europe done by independent organization Euro-NCAP and in United States of America is safety issue covered by NHTSA (National Highway Safety Administration) and by IIHS (Insurance Institute for Highway Safety). These organizations are testing the vehicles through the independent crash tests. On the bases of the results they provide real and independent information focused on the evaluation of vehicles safety.

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SECURITY INTEREST: IDENTIFICATION OF NEW IDEAS FOR FOLLOWING SECURITY RESEARCH IN THE FIELD OF TRANSPORT AND SPECIAL TECHNOLOGY

M. Kelemen, M. Mečár, P. Nečas, V. Krajník, P. Lipták

Abstract

Science, education and professional training of personnel for the transport, special technology and all special support services are in the centre of our interest. The ambition of experts is to contribute to the development of science and education in the field of security management in the transport as the complex adaptive system, in the context of new challenges - safety and special technologies, human factor, energy, environmental and information security, especially personal and property protection within the transport process or the operation and maintenance of special technology.

Key words

security, research, system approach, areas of special security research

Human activities are determined by complexity, diversity and ratio of "intellectual and physical limits" of the key factors in unstable relationship between human, technology and environment".

Interaction and coexistence of these elements is influenced especially by the quality and stability of relationship between human and technologies, considered as a complex adaptive system in terms of transportation, where

- a primary system environment is comprised of transport/special technology performed by particular modes (road, rail, air or water),
- a secondary system environment is comprised of the field of transport/special technology (transport systems, infrastructure, etc.) with synergistic effect of its elements,
- on the background of tertiary system environment, represented by the other spheres of society and nature (security technologies, energy and information security, environmental protection, personal and property protection etc.).

WHAT IS THE OBJECT AND WHAT ARE THE AREAS OF SECURITY RESEARCH IN THE FIELD OF TRANSPORT AND SPECIAL TECHNOLOGY

Aim of the special research in the area of transport safety, personal an property pas a complex multi-dimensional system, is to investigate safety risks in transport, discover new facts and broaden the knowledge of risk and crisis management, consequence management and prevention in specific area such as transport in order to contribute to the theoretical base and through its practical application enhance the safety in this specific sphere of activities which bears on human life, the greatest value for individual and society.

Therefore we are interested in protection of life, health and property of the people, as well as security and property of our inhabitants and wealth of society.

The research is focused on theory and practical safety management in transport within context of respective human activities and multi-dimensional relationships between human, technology and nature in the area of transport, or the transport management in crisis situations.

Study of this specific field of research has an interdisciplinary character.

Security research in the field of transport and special technology could be defined as:

a. object of systematic examination and research primarily in field of transport and closely-related fields of special technology and science (public safety, protection of people and property, special technology security, national and international security),
b. area of research with a set glossary of terms which is continually being developed and updated,
c. area with its own theoretical base and potential of further development,
d. system of collecting, analysing, distribution and exchange of scientific knowledge or practical information and experience in this area (considering the national and multinational dimension),

e. prospective field of education designed for future common PhD. studies, specialized for transport, special technologies and related disciplines concerning the crisis and safety management and avoidance of crisis situations,
f. intellectual source of experts in field of safety and also a laic community,
g. area, which is and will be a valuable source of knowledge and practical application for transport companies, technology suppliers, companies producing the information technologies for transport department, educational and training centres, research centres and laboratories, special medical service, special state and departmental control authorities providing an inspection in transport department and logistics, relevant areas of defence industry, public security, security services, as well as managers at all particular levels of public and business sector management, etc.

Objectives of the research in area of traffic and special technology safety accords with the core of knowledge of the transport, special technology and related security departments, particularly:

- legislation and specific environment in area of the transport safety or special technology
  - international environment,
  - local environment, of:
    - road transport,
    - rail transport,
    - aviation,
    - ship transport,
    - ,,energy key sources" pipeline transport of the country, S operational and support services,
    - construction, operation and maintenance of special technology etc;
- situation management (SITMAN) as apart of safety management in transport and special technology management
  - ,,human and technology" in transport - complex adaptive system,
  - system perception of safety in the area of transport and special technology,
  - risk management, crisis management,
  - methodology of situational management within the safety management in the area of transport:
    - of subject providing the transport,
    - of security service,
    - in security education of personnel provided by educational and training centres,
    - during crisis situation in transport or special technology operation and maintenance.
    - within crisis planning , crisis management of transport or special technology,
    - with use of modelling and simulation technologies,
    - in context of public and national security, etc.;
- human factor in transport or operation and maintenance of special technology and human performance
  - psychology and pedagogy designed for the personnel of transport department, department of special technology,
    - psychological and pedagogical aspects of leaders and managers workload at organizations providing the transport,
    - psychological and pedagogical aspects of transport specialist's (ground and flight instructors, air traffic control service instructors, security service staff, crisis management specialists, etc..) workload,
    - critical thinking and a teamwork in transport,
    - appropriate psychological selection and evaluation of personnel to be selected for the transport professions,
    - mental hygiene of a transport department staff, etc.,

- psycho-physiological specifics of performing the tasks related to the professions in transportation and transportation safety management;
- accident and incident investigation - accident prevention
    - classification of transport accidents and incidents,
    - investigation teams,
    - stages and structure of accident and incident investigation,
    - multimedial technical support of investigation,
    - new trends in accident and incident investigation,
    - mass-medial communication during the investigation, post-conflict measures, etc.;
    - forms and methods of accident prevention,
    - modern methods and tools of education and training of personnel,
    - case studies and analyses of transport accidents and incidents,
    - new trends in prevention of accidents, etc;
- technologies applied to the transportation department and transport safety
    - vehicle, train, aircraft and watercraft-board technologies,
    - satellite technologies in transport, transport safety, protection of people and property, security and property of a country and society,
    - ground and operational service technologies,
    - ports and airports security and safety technologies,
    - information technologies security in transport, etc..
- transportation, special technology and protection of the environment
- development of Centres of excellence
- European Defence Agency projects
- NATO/RTO projects
- security and defence projects at national level,
- common PhD. studies of universities (academies) etc.

CONCLUSION

We are convinced that the safety management in transport primarily means an cognitive understanding and situation awareness given by competences of the vehicle or aircraft personnel, air traffic controller (or operating personnel, crew), service engineer, security manager, etc. achieved through training and practice in a complex process of professional education and training suitable for the staff in particular positions. Regulation of transport specialists' competence development determinates the competence in the process of solving problems concerning the safety issues as it constricts and modifies existing conceptions of situational gaps when the vehicle operating staff during the transportation, operation or maintenance, air traffic controller, shipman, engine-driver or service engineer could fail. Inadequate decision making and mistakes may endanger the safety of passengers and freight, environment as well as the other spheres of social life.

Scientific cognition, research and complex education in field of safety management within the multi-dimensional relation ,,Human - Technology - Environment" in transport operation and maintenance of special technology, considered as a complex adaptive system in context of available sources, represents the creative activities and research in the area of security, standard and effectiveness of educational process of personnel and also providing the services or development of special technology.

Our knowledge is based on the empiric experience in the former academic and research work which is presented also in the last project completed for the Ministry of Defence of the Slovak Republic "Koncepcia na dokoncenie transformacie vojenskeho skolstva aintegraciu Akademie ozbrojenych sil generala Milana Rastislava Stefanika a Narodnej akademie obrany marsala Andreja Hadika" and in our proposal of common PhD. study programme of three higher education institutions in the field 8.4.4 National and international security, that is still in accreditation process. The next common PhD. study programme will be followed.

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WEAPONRY VECTORING METHODS AT TARGETS DESTROYING

P. Lipták

Abstract

The article deals with methods of missile vectoring at AAM complexes. There are analyzed equations describing particular methods of vectoring. There are described advantages and disadvantages of those methods as well as possibilities of their application at AAM complexes assigned for destroying of all kind of targets.

Key words

vectoring method, anti-aircraft guided missile, three-dot method, method of constant heading, method of half heading, two-dot method of vectoring

A purpose of firing on an air target is to get its extermination. To shoot down the air target it is necessary on the first place to reach approximation of the missile and target with needed accuracy, on the second place to initiate the missile charge in the direction of the target destruction.

To get high precision of missile vectoring on the target it is necessary to change the course continuously in dependency on the target during the whole operation; it means use of anti-aircraft guided missiles to fire on air-targets. Approximation of the missile and target constantly changing position is provided by the air controll system.

GENERAL CHARACTERIZATION OF TECHNIQUES OF MISSILE VECTORING

There are more approximation trajectories of the missile and target. From all of them it is necessary to select the most optimal trajectory from the tactical and technical point of view. Required approximation trajectory is given by structural equations that define the missile motion according to target coordinates. Character of the structure of equations depends on the vectoring method.

The principle how the missile approaches the target is given by the vectoring method.

Basic requests for vectoring methods of anti-aircraft guided missiles to fire on air-targets are:

1. The vectoring method should provide lowest curves at kinematic trajectories at all segments of flight, especially in zone of encounter.
2. The vectoring method should provide encountering of the missile and target in the whole range of parameters of its motion.
3. The vectoring method should provide required precision of approximation of the missile and target under various condition of shooting.
4. Vectoring method should be out of simple technical realisation.

To three-point method belongs:

- Three-dot method
- Method of constant heading
- Method of half heading
- Method of full heading
- Vectoring method with variable coefficient.

To two-point method belongs:

- Method of catching up
- Vectoring method with steady angle og heading
- Method of parallel approximation.

THREE-POINT METHOD OF VECTORING

Using the three-dot method means that the missile has to be on a line connecting the station and target all of the time (pic. 1). Basic equations of this method are:

$$\begin{aligned} \beta_k &= \beta_c \\ \varepsilon_k &= \varepsilon_c \end{aligned} \tag{1}$$

where:

β_k, ε_k is azimuth and positional angle of kinematic trajectory point of PLRR,

β_c, ε_c is azimuth and positional angle of target.

Control parameters in position a in azimuth h_ε h_β are:

$$h_\varepsilon = r_r \cdot \Delta\varepsilon$$
$$h_\beta = r_r \cdot \Delta\beta \tag{2}$$

where: r_r - is diagonal distance of missile

$$\Delta\varepsilon = \varepsilon_c - \varepsilon_r$$
$$\Delta\beta = \beta_c - \beta_r \tag{3}$$

Three-dot method is simple, loaded by small fluctuation errors. Its kinematics has large curving and have big request for normal overcharge of missile. Is useful for shoot at slow moving targets and for shoot at targets where is impossible to meter diameter distance. Therefore is appropriate besides shooting for slow moving targets and for targets using strong activ interference jamming.

From three-dot heading methods, most of used are method of constant heading and method of half heading. Abduced heading methods reduce required normal overburden of missile during move by kinematic trajectory, thereby reduce request for steer of missile.

Method of constant heading has during whole time of flight of missile to target constant heading. Method is described by equations:

$$\varepsilon_k = \varepsilon_c + C_\varepsilon \cdot \Delta r$$
$$\beta_k = \beta_c + C_\beta \cdot \Delta r \tag{4}$$

where C_ε and C_β are heading coefficients.

Size of these coefficients is given by equations:

$$C_\varepsilon = \frac{\dot{\varepsilon}_c}{\Delta \dot{r}} \quad , \quad C_\beta = \frac{\dot{\beta}_c}{\Delta \dot{r}} \tag{5}$$

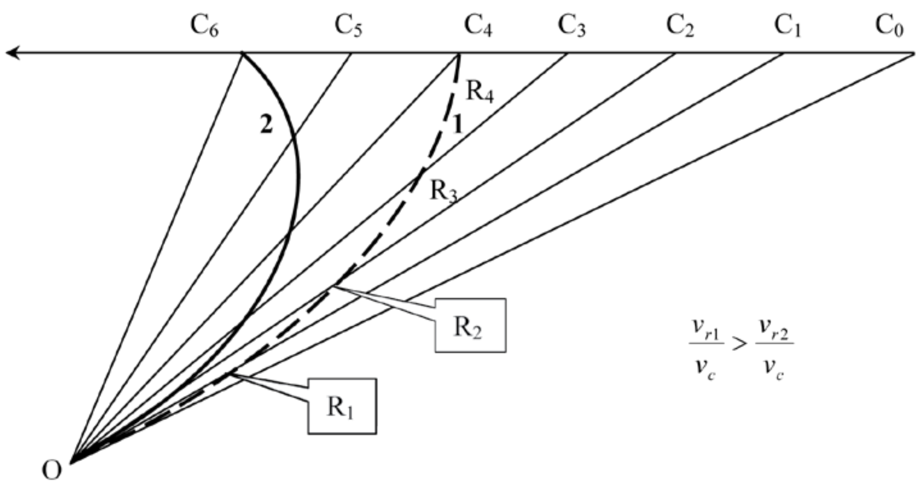
where

$\dot{\varepsilon}_c$, $\dot{\beta}_c$ - is angular speed of target in position and in azimuth

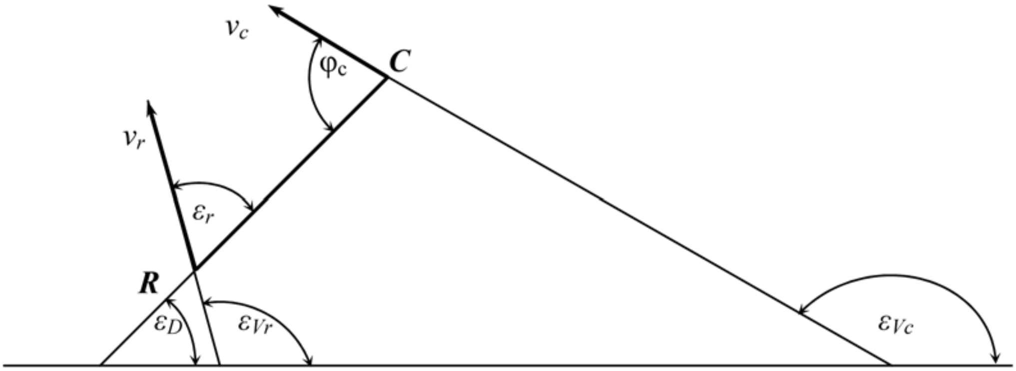
$\Delta_{\dot{r}}$ - speed of approximation of missile with target

Aim of method of constant heading is reduce normal overburden of missile and move up kinematic trajectory after launch of missile, thereby possibility of missile will hit the target during guiding missile to kinematic trajectory is reduced. Method of half heading is described by equations:

$$\varepsilon_k = \varepsilon_c - \frac{\dot{\varepsilon}_c}{2\Delta \dot{r}} \cdot \Delta r$$
$$\beta_k = \beta_c - \frac{\dot{\beta}_c}{2\Delta \dot{r}} \cdot \Delta r \tag{6}$$



Pic.1: Shape of kinematics trajectory by three-dot method



Pic.2: Reciprocal motion of missile and target

Advantages of method of half heading are:

- curvature of kinematic trajectory of missile is half on smaller then in three-dot method, required overburden of PLRR is smaller and therefore also smaller dynamic mistakes of guide, that means guide of missile to target is more precision, most of in shooting on fast flying targets.
- required normal acceleration of missile is not depend on normal acceleration of target, that allow destroy steering targets.

Disadventages of method of half heading:

- for calculation of heading coefficients is necesarry meter diameter distance of target, that means this method is not possible to use during strong active interference racon jamming.
- for implementation of method is necessary more complicated device, thereby fluctuational mistakes in guide to target is growing.

TWO-DOT METHODS OF VECTORING

Location of missile relative to target is determined by distance between missile and target and course join missile-target, tm. by angles ε_D a β_D. Reciprocal motion of two points (missile and target) in one level pictured on pic.2 is described by equations:

$$\begin{aligned} -\dot{D} &= v_c \cdot \cos\varphi + v_r \cdot \cos\varepsilon_r \\ D \cdot \dot{\varepsilon}_D &= v_c \cdot \sin\varphi - v_r \cdot \sin\varepsilon_r \end{aligned} \qquad (7)$$

where

$\dot{D}$ - is speed of changing distance missile-target

$\dot{\varepsilon}_D$- is angular speed of join missile-target

ε_r - is heading angle between vector of speed of missile and join missile-target.

By given parameters moves of target and speed of missile we have to for exact set required trajectory of missile equations top up with one more equation:

$$f(D, \varepsilon_D, \varepsilon_{Vr}) = 0 \qquad (8)$$

Shape of this function determines method of guiding missiles in vertical plane. For different two-dot methods equations (7) will get this shape:

Method of over

$$\begin{aligned} \varepsilon_{Vr} - \varepsilon_D &= 0 \\ \beta_{Vr} - \beta_D &= 0 \end{aligned} \qquad (9)$$

Method of vectoring with constant angle of heading

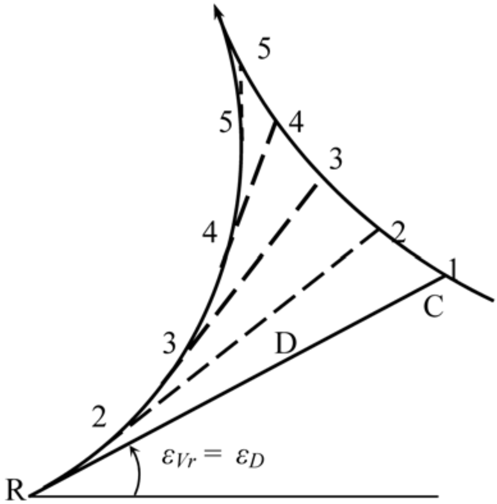
$$\begin{aligned} \varepsilon_{Vr} - \varepsilon_D &= \varepsilon_{ro} = \text{const.} \\ \beta_{Vr} - \beta_D &= \beta_{ro} = \text{const.} \end{aligned} \qquad (10)$$

where ε_{ro} and β_{ro} are gived angles of heading.

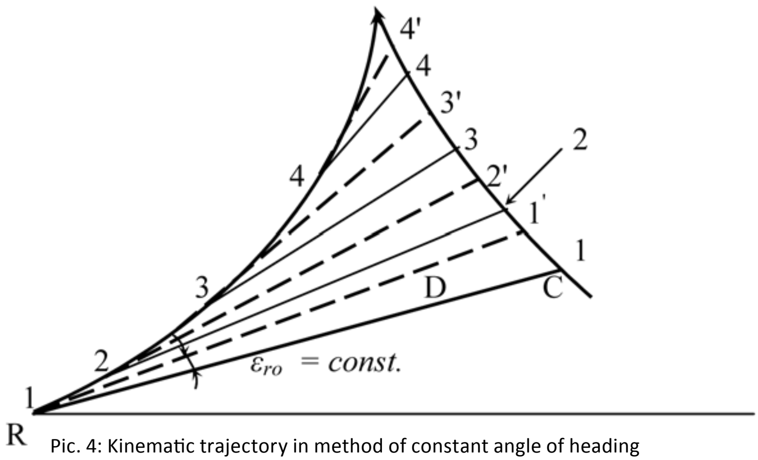
Method of parallel rapprochement:

$$\begin{aligned} \varepsilon_D &= \varepsilon_{Do} \\ \beta_D &= \beta_{Do} \end{aligned} \qquad (11)$$

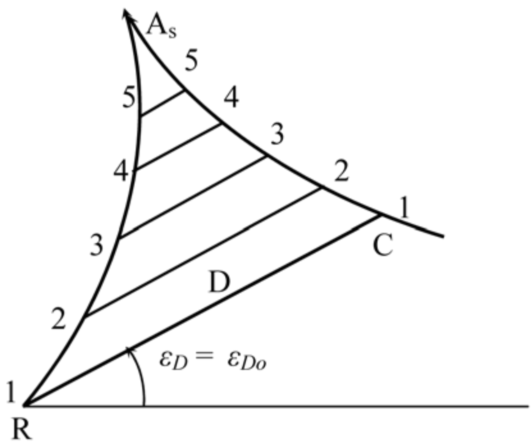
where ε_D, (β_D) - locating angle (azimuth) join missile-target in the moment of start of self-guide.



Pic. 3: Kinematic trajectory in method of overt



Pic. 4: Kinematic trajectory in method of constant angle of heading



Pic. 5: Kinematic trajectory in method of parallel rapprochement

Method of proportional rapprochement

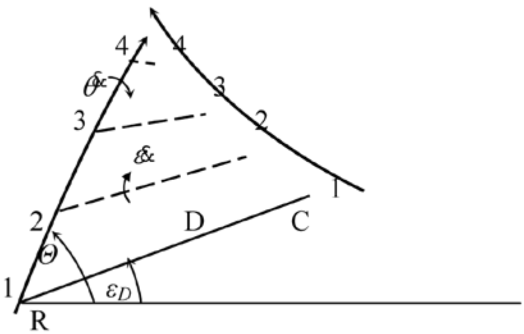
$$\dot{\varepsilon}_{vr} = \alpha_{\varepsilon} \,.\, \dot{\varepsilon}_{D}$$
$$\dot{\theta}_{vr} = \alpha_{\beta} \,.\, \dot{\beta}_{D} \qquad (12)$$

where:

$\dot{\varepsilon}_{vr}$, $\dot{\theta}_{vr}$ - is angular speed of turning vector of speed of missile

$\dot{\varepsilon}_{D}$, $\dot{\beta}_{D}$ - is angular speed of turning course missile-target

α_{ε}, α_{β} - koeficients of proportionality



Pic. 6: Kinematic trajectory in method of proportional rapprochement

Two-dot methods were before used in self-guided anti-aircraft missiles. For their realization were necessary complicated and expencive elektronic devices.

CONCLUSION

The three-point method of vectoring is widely used at anti-aircraft missiles complexes. Looking on character of the air target, its maneuvering speed and method of jamming, there are used three-dot methods, methods with constant heading and methods with half heading.

The best method among two-dot methods is the method of proportional rapprochement, which is used by anti-aircraft missiles and AAM complexes of new generation. Its advantage is the independence on the missile station, small curve trajectory, possibility of choosing proportionality coefficients by looking of the point of encounter of the missile and target. Because of these advantages it is destined for shooting on fast-flying and maneuvering targets, targets with small efficiency reflection interface, including ground-to-ground missiles as well as targets under various types of jamming.

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POSSIBILITIES OF MODERNIZATION OF ARTILERY AMMUNITION FUZES

P. Lipták, I. Kopecký

Abstract

Artillery fuzes are an indivisible part of artillery ammunition. Their correct function is prerequisite for the quality of artillery ammunition. The paper deals with brief characteristics of artillery ammunition and summarizes an overview of their functional drawbacks as well as possible ways of their upgrading. In conclusion there are presented experiences with some modernization approaches of artillery fuzes.

Key words

artillery ammunition, artillery ammunition fuze, manipulation height, safety mechanism, fuze-lock

In spite of all the discussions that are going on, it can be stated that the quality of artillery weapons and artillery ammunition is one of the basic pillars of a potential armed conflict. Quality of artillery ammunition, e.g. from the view of the required effect of the missile in the target or from the view of chosen target-type, is effected by the right choice of artillery ammunition fuze and its right setting observing safety rules during transportation, before and after firing as well as keeping the specified distance after missile launches from a gun-barrel. Domestic and foreign companies as well as development teams deal and dealt with development of artillery fuzes and missiles with great care. It is also related to the level of development of actual artillery weapons. A very important role in this problematics plays also unification of systems produced and used in Alliance countries [1].

Presented paper summarizes positives and drawbacks of fuzes and tries to outline possible directions of their upgrading.

POSITIVES AND DRAWBACKS OF ARTILLERY FUZES

The Army of the Slovak Republic disposes of the whole range of large caliber artillery systems. The main type of ammunition used with these systems is high explosive ammunition with contact fuzes. These fuzes can be divided into two groups.

To the first group belong fuzes such as models RGM-2, RGM-2P, RGM-2Pu, V429 and V429E. These fuzes were produced in the countries of so-called Eastern block on the basis of the licence contracts and lots of them can be still found in armouries of these countries. Because of their simple construction we talk about the fuzes of war-construction (1940s), so they have the following negatives:

- Low manipulation height of 0,75 m
- Safety mechanism without mask safety (without safety to the defined distance in front of gun-barrel muzzle)
- unlocking of the fuze by effects of physical quantity - force of inertia - applied during firing to the missile in a gun-barrel.

To the second group belong fuzes developed and produced in former ČSSR. These are fuzes such as models KZ-88, KZ-98 and MZ-81, MZ-95. Fuzes KZ-88 and KZ-98 have higher manipulation height of 1,5 m, higher and safer drop height of 5 m and blocking of interrupting element of initiatory chain by two independent mechanisms. The solution is the effect of the same force of inertia which is applied on a missile during firing. Fuzes MZ-81 were series produced in fomer ČSSR and have similar drawbacks. A typical construction feature of both models is their mask safety, but unlocking is based only on the effect of axial force of inertia which is applied on a missile in a gun-barrel during firing. The second block element of other physical quantity is not included in construction.

A positive thing of the above-mentioned constructions was a quite wide unification to so-called "eastern norms", simplicity and wide range of their application. On the other hand, their construction arrangement does not fulfil a basic safety requirement – locking with two safety elements. It is required that function of operating elements is ensured by using two different independent physical quantities. Apart from this, fuzes do not fulfil other requirements such as low manipulation height, low safe drop height, basically no mask safety, to mention the most important.

Low manipulation height does not allow manipulation with ammunition with bolted fuzes in heigher manipulation heights because if it accidentally drops from this height the fuze is unusable for next safe usage. Nowadays this drawback is solved only by special orders in the rules for ammunition usage.

If safe drop height after the missile drops with a fuze from higher manipulation height is low, it is necessary to destroy such missile later or in the place, because it may cause high risks. That is also the reason of limited possibility for loading and unloading them by cranes.

Insufficient or no mask safety causes risk of endangering one's own troops while firing during unfavourable weather conditions (rain, snowing, unbalanced missile or obstacle), because there is a risk of an early missile explosion in insufficient distance from the gun.

Brief analysis mentioned above shows, that it is necessary to modernize all fuzes not upgraded yet and without this modernization their usuage would not be possible.

APPROACHES TO MODERNIZATION OF ARTILLERY AMMUNITION FUZES

Basic task of modernization of artillery fuzes is pre-homologization of these devices to the norms and directives of NATO [5], considering that these devices and technology will still be used in this alliance. In Table 1 there is an overview of alliance norms valid for this area. Accession of Slovak Republic to NATO leads to harmonization of used ammunition with requirements of military directives and norms of this organization.

After preliminary analysis of these directives we can summarize basic requirements for artillery fuze construction of barrel guns:

- fuze-locking with two independent mechanisms, their functionality has to be derived from an effect of two different physical qualities which are applied on the missile (e.g. axial inertial and centrifugal force)
- safe drop height of 12 m
- verifying resistance and safety in accordance with STANAG 4157 or MIL STD 331B.

Table 1: An overview of NATO directives related to development and testing of artillery fuzes

Name	Designation
STANAG 4370	Testing resistance to extraneous influences
STANAG 2916	Profiles of head-fuzes and holes for artillery and mortar missiles
STANAG 4157	Development safety test methods and procedures of unguided missile fuzes of barrel guns
STANAG 4187	Initiatory systems – requirements for construction safety
STANAG 3525	Principles of proposing safety and general criteria of initiatory systems of weapons carried on planes
MIL STD 331B	Fuzes and initiatory components, tests of resistance to extraneous influences
MIL STD 810	Testing methods of extraneous influences
MIL STD 1316D	Fuze construction, safety criteria

As it was already mentioned, fuzes characterized in previous chapters do not fulfil these requirements. So, it is necessary to concentrate on such constructional solutions to fulfil these requirements.

Conception of modernization is based on the fact that original fuzes are disassambled and original safety mechanism is replaced by a newly developed safety mechanism. Fuzes will be consequently tested in accordance with ordered tests STANAG 4157 to find out if they fulfil safety requirements. If we take into account reliability of product function, the required tests will stay without any changes according to the original documentation. Similar tests are done with products used in NATO.

Proposed safety mechanism must be constructionally arranged so, that it can be placed into a loose cylinder volume defined by dimensions of ϕ 26 mm and length 30 mm. These two main construction requirements are a starting point for proposal of safety fuze interrupter allocation and mechanisms which ensure the right operation of fuze safety mechanism.

Safety mechanism must ensure interruption of inititory chain partly while the missile moves in gun-barrel – gun-barrel safety, partly after it leaves the gun-barrel up to the defined distance – mask safety. No accidental action which applies on the missile can produce an early action of the fuze. Basic solution of a problem can be already tested mechanism of mask safety, which is nowadays used in two common arrangements. These are a pyrotechnic mechanism and a clockwork mechanism.

Each of the above mentioned mechanisms has its positives and drawbacks. When we compare safety mechanisms, in case of e.g. fuze DM34 it is evident that used clockwork safety mechanism takes quite a large volume. It follows that it is not usable for fuzes of large volume and it is necessary to look for other solutions or development of a new system.

Using the pyrotechnic principle to ensure mask safety is aimed at adjustment of safety mechanism. Optimization of allocation of a gun-barrel safety two-phase mechanism and a mask safety pyrotechnic mechanism together with incorporation of a centrifugal fuse assumes fulfilment of requirements for a fuze-lock, using mechanisms whose action is based on two different physical quantities.

Another possibility of solving these problems is to apply electronics. Current components base and its dimensions enable to solve safety mechanisms easily, including their allocation to reserved areas where mechanical devices were situated. At the same time it is necessary to solve the question of powering reliability. It is also important to mention that considerable mechanical forces of acceleration – emerging during firing - will be applied on electronic components and they can influnce parametres of used electronic components and a reliable fuze action as well.

CONCLUSION

Analyzing the current situation of artillery fuze technical construction we can observe the necessity of their modernization. As an example of modernization of e.g. fuzes assigned for missiles stabilized by rotation can be the approach of the company Konštrukta – Defence a.s. Trenčín [6]. Comparing constructional parts of a possible fuze modernization and main dimensional characteristics we can confirm the possible conception of artillery head-fuzes modernization by a development of clockwork safety mechanism or electronic timing circuit, potentially pyrotechnic mechanism. Under certain conditions we can preserve used types of detonating devices, fuzes, and cartridges. It will be necessary to solve safety mechanisms of unrotative projectiles, and arrow-stable missiles. From the perspective of utilization of available electronic and optoelectronic components base we can expect gradual replacement of mechanical and electromechanical systems.

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RESIDUAL STRESS MEASUREMENT BENEATH THE MACHINED SURFACE OF HARDENED STEEL

J. Majerík

Abstract

The quality of functional surfaces is significant in terms of endurance and better quality in operating conditions. The investigation of surface layers uses residual stress measurement methods in guality and quantity aspects. In residual stress measurement, the strain in the crystal lattice is measured,

and the residual stress producing the strain is calculated, assuming a linear elastic distortion of the crystal lattice. Although the term stress measurement has come into common usage, stress is an extrinsic property that is not directly measureable. All methods of stress determination require measurement of some intrinsic property, such as strain or force and area, and the calculation of the associated stress. Mechanical methods (dissection techniques) and nonlinear elastic methods (ultrasonic and magnetic techniques) are limited in their applicability to residual stress determination. Mechanical methods are limited by assumptions concerning the nature of the residual stress field and sample geometry. Mechanical methods, being necessarily destructive, cannot be directly checked by repeat measurement. Spatial and depth resolution are orders of magnitude less than those of x-ray diffraction. All nonlinear elastic methods are subject to major error from preferred orientation, cold work, temperature, and grain size. All require stress-free reference samples, which are otherwise identical to the sample under investigation. Nonlinear elastic methods are generally not suitable for routine residual stress determination at their current state of development.

Key words

residual stresses, surface functionality, x-ray diffraction, friction ratio, friction force, tensile and compressive residual stress, Bragg law, Bragg-Brentano diffractometer

The reason of residual stresses formation beneath the machined surface is existence of the plastic distortion and temperature as the characteristic of the machining process. Therefore the residual stresses originated in the layer of machined surface under the plastic deformation influenced. But the basic fundamentals of residual stresses formation depended on creation and influenceal factors of plastic deformation. The final result is creation and distribution either tensile (+σ) or compression (-σ) residual stresses. The reasons may be existence of the differences between surface layer modification or in the material mould core created by cutting forces during the machining process. Consequently the result of these reasons is the temeprature effect (heating, refrigeration), unstable phasis transformation, the new structural elements segregation and new components absorption into surface layer. But residual stresses may originate by individual machining technologies affection or in combination with previous reasons altogether. Residual stresses influences the precision of machining and machined part functionality. The compression stresses have the effect of increasing the endurance strength and tensile stresses for decreasing. This fact has particular hold in high strength and hardened steels. The endurance strength of these steels depends on the residual stresses distributed.

DISPOSITION OF RESIDUAL STRESSES BENEATH THE SURFACE

We can dividing the residual stresses according to various aspects.

- Residual stresses partition according to activate reason
  a. Compressive stresses (-σ),
  b. Tensile stresses (+σ),
- Residual stresses partition according to cubature

a. Residual stresses of 1st type (macroscopic stresses, the material failures significantly influences the macrogeometry modifications),
b. Residual stresses of 2nd type (only measurable in various grains capability of material structure, the material failures cannot influences the macrogeometry modifications),
c. Residual stresses of 3rd type. (these type of residual stresses have induces only in some interatomic distances and its nonhomogeneous in the smallest areas of material).

In technical engineering praxis under the term residual stress only the first type (macroscopic stress). Residual stresses are designated as technological because their generation and formation is caused by technological processes during machine parts manufacturing.

RESIDUAL STRESSES MEASUREMENT APPROACHES

a. Mechanical sequential drilling method, (destructive method)
b. Sequential deep-etch method, (destructive method)
c. X-ray diffraction, (non destructive method)
d. Neutron diffraction, (non destructive method)
e. Ultrasonic method, (non destructive method)
f. Barkhausen noise method. (non destructive method)

X-RAY DIFFRACTION MEASURING METHOD APPLICATION

The principle of x-ray diffraction consists of homogeneous crystal lattice measurement. The main measuring area is in various oriented directions of each material grain. X-ray beams are measured in definite deep of investigated material and consistently detected surface and subsurface elastic strain from diffraction of x-ray beams. It is possible to apply this method in polycrystalline materials detection. The involved materials have to discharge the Bragg law for reflection and reinforcement of x-ray beams and evaluating by this technique the diffracted lines. Diffraction occurs at an angle 2θ, defined by Bragg's Law:

$$n \,.\, \lambda = 2 \,.\, d \,.\, \sin \theta$$

where

- n - is an integer denoting theorder of diffraction,
- λ - is the x-ray wavelength, d is the lattice spacing of crystal planes,
- θ - is the diffraction angle.

The residual stresses in the basics phase of material are composited of two parts. In the first instance may be the difference between stiffness and different orientation of each grain and it can be explained or used theoretically or by the research determinated elastic diffraction constants. In the second instance it can be caused by differences in the elastic-plastical effect of the next grains.The principle of this method measurement consists of monochromatic x-ray beam diffraction at the high diffraction angle 2θ on the surface of material. The measured specimen is revoluted in direction of the angle ψ. Angle ψ which defined the rotation of surface specimen is angle between vertical line of surface and diffracted planes of specimen crystal lattice. The diffraction occured by the angle 2θ defined by the Braggs law. For residual stress of 1st type by x-ray diffracton determination is possible to get along the changes of stress spacing in the crystal lattice.

RESIDUAL STRESS MEASUREMENT BY VARIOUS CUTTING SPEEDS

For realisation of our experiment we applied two types of cutting tools as CBN (Cubical boron nitride) cutting insert turning knife for hard turning technology application and grinding wheel with dimensions 250x76x10, material electroalumina, ceramic bond). Workstations of experiment: FST TnUAD Trenčín, UTB FT Zlín (Czech republic), Konštrukta Industry Trenčín, MtF STU Trnava. **Measured distance**: from 5 to 10 µm by measured area 2x2 mm. **Measured time**: 90 min (each sample). **Measured range**: Ψ= 0° ÷ 50,77°. **Applied cutting speeds:** (30,45 and 60 m/s).

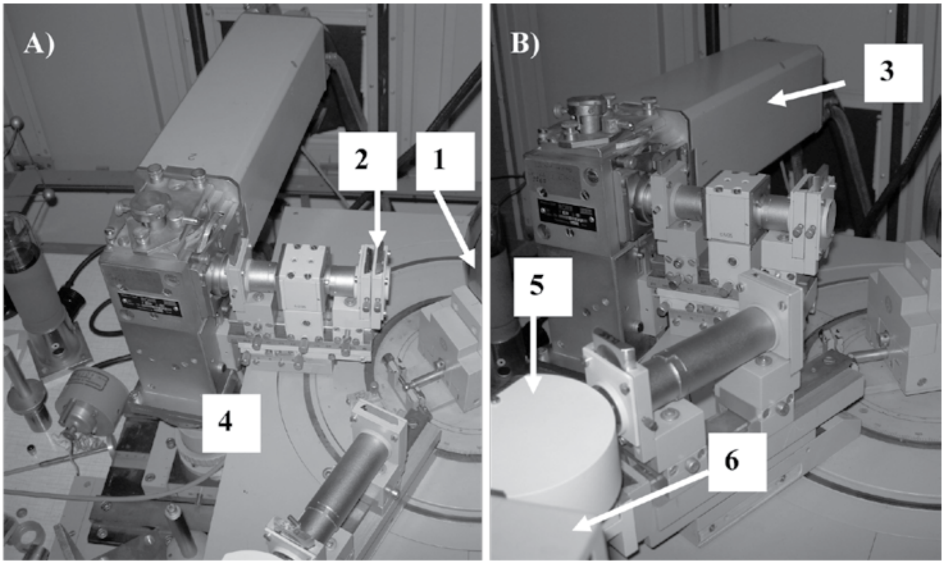

Fig. 1 a, b: Residual stress measurement of hardened steel specimen in X-ray diffractometer by Bragg-Brentano method where 1-specimen, 2-screens, 3-X-ray lamp, 4-Brail detector, 5-monochromator, 6-detector.

PRACTICAL EXAMPLE PROCESSING OF MEASURED VALUES

We can see fundamental residual stress allocation measured on HSS sample on Figure No.2. On axis „x“ is indicated deformation tenseness „$\varepsilon_{\phi\Psi}$“ in the defined direction of angles ϕ and Ψ and on vertical side „y“ is defined as angle „Ψ“.

CONCLUSION

During gradually increasing of cutting speed occures to increase the compressive residual stresses. We can see differences between values of measured stresses from figures 1, 2. From figures 3, 4 resulting in, diffrent aplication of grinding wheels for machining two types of hardened steels according to point 6 from this

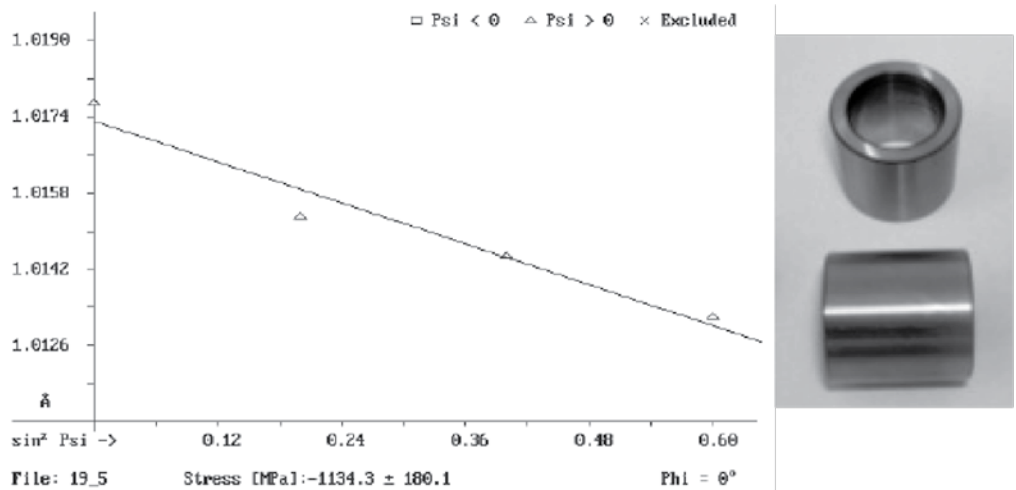

Fig. 2: Measured and processed representations (values) of origin status (compressive stress σ = - 1134 ± 180 MPa) The source status -front surface of sample from hardened HSS. On the right side of Figure is situated measured hard turned and grinded sample.

paper. By both experiments the odds are that by applying grinding wheel A99 80 K13V incomes to compressive residual stresses rise. It is caused by the bigger porosity of this grinding wheel. The result is better heat offtake and chips from the cutting zone. The increase of cutting speed during grinding increases the cutting path of a single grinding grain and decreases the chip volume. The final result is the achievement of higher compressive residual stresses beneath the grinded surface. This fact has influence for machined surface resistance against wear.

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TESTING OF PLASMA AND HEAT SPRAYED LAYERS ON DIES AND FURTHER PARTS WITH LIQUID METAL AT PRESSURE DIE CASTING

J. Ružbarský, E. Ragan

Abstract

Plasma spraying molybdenum and ceramic layers and heat spraying molybdenum layers on samples are described in the contribution. Further theoretical analysis, evaluating adherence and microstructure of the layers together with results of technological tests of plasma sprayed samples on heat fatigue and tests of corrosion and application of tests results are mentioned.

Key words

plasma spraying, heat spraying, molybdenum layer, ceramic layer, adherence of sprayed layers, tests on heat fatigue

In all technologies of thermal deposits possibilities to improvement of deposited layers properties are looked for. These layers as abrasion and heat resisting ones and with low friction coefficient are non-substituted at improvement of parts surface properties.

ANALYSIS OF SPRAYED LAGERS ADHERENCE

The layer of deposited material consists of more partial layer at successive depositing. Owing alternate exerting on pull and pressure splits rise along bounds of layers and perpendicularly to then. By a heat influence the splits can increase.

We can suppose in the beginning the linear dependence between the case of adhesion fracture at the adherence σ_A with the layer thickness x_o and the case of cohesion fracture at the adherence σ_K with the layer thickness x_1 at small interval of layer thickness.

$$\sigma_x = \sigma_A - \frac{\sigma_A - \sigma_K}{x_1 - x_0}(x - x_0) \qquad (1)$$

At coating further layers the smaller influence is present. We can express it by the indirectly proportionate dependence on the layers thickness. Then for the contribution all of differential increase of the split in the distance x from the first layer it applies with the exponent n

$$dl = \frac{k}{x^n}\, dx \qquad (2)$$

where k – constant.

After integration from l_0 up to l and form x_1 up to x for the whole length of the split we obtain

$$l - l_0 = \frac{k}{n-1}\left(\frac{1}{x_1^{n-1}} - \frac{1}{x^{n-1}}\right) \qquad (3)$$

For the adherence σ_K on the whole area S if $\sigma_K{}^*$ is the adherence for connection of areas without fauls and splits

$$\sigma_k = \sigma^*_k \frac{S - k_1 l}{S} \qquad (4)$$

where k_1 - constant

After substitution for l from (3) we obtain

$$\sigma_k = \sigma^*_k \frac{S - \left[c_1 + \frac{c_2}{n-1}\left(\frac{1}{x_1^{n-1}} - \frac{1}{x^{n-1}}\right)\right]}{S} \qquad (4.1)$$

where

$$c_1 = k_1 l_0$$
$$c_2 = k_1 k$$

The exponent n expresses the extent of affecting on development of splits.

After less expressive affecting at n = 0 we get

$$dl = k\, dx \qquad (2.1)$$

After integration from l_0 up to l and form x_1 up to x we have for l

$$l - l_0 = k\,(x - x_1) \qquad (3.1)$$

After substituting into (4)

$$\sigma_k = \sigma^*_k \frac{S - [(c_1 + c_2\,(x - x_1)]}{S} \qquad (4.2)$$

For n = 1 we get:

$$dl = \frac{k}{x}\,dx \qquad (2.2)$$

After integration form l_o up to l and form x_1 up to x for the whole length we obtain for l

$$l - l_0 = k \ln \frac{x}{x_1} \qquad (3.2)$$

After substituting into (4)

$$\sigma_k = \sigma^*_k \, \frac{S - (c_1 + c_2 \ln \frac{x}{x_1})}{S} \qquad (4.3)$$

We can perform analysis of individual functions for various values n in the interval <0, ∞). For n = 0 we obtain the linearly falling function with rising x. In the interval for n (0, 1) we get the falling root function with rising x. For n = 1 we get the logarithmic falling function with rising x and in the interval for n (1, ∞) it is expressively the hyperbolic falling function with rising x.

EXPERIMENTAL RESULTS

The tests of adherence were performed on the samples with the diameter 30 mm according to DIN 50 160 plasma spraying molybdenum layers and ceramic ones Al_2O_3, $ZrSiO_4$ a ZrO_2 + 25 % MgO with the interlayer NiAl and coating form heat spraying molybdenum layers according to figure 1.

Preparation for the tests of adherence resides in sticking the counter-piece on the sample according to DIN 50 160. The strength of glue is larger than the real adherence of coating to the base metal. The tests of adherence were performed on the tensile testing machine ZD 40.

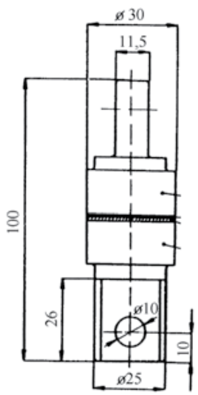

Fig. 1: The shape and sizes of specimens for adherence tests

The measured and calculated dependence of the adherence σ_K on the thickness x of plasma spraying molybdenum layer is in figure 2. The calculated depended is by the relation (4.2), where individual constants are σ_K* = 50 MPa, S = 706,5 mm^2, c_1 = 160 mm^2, c_2 = 44,6 mm^3, n = 2, x_1 = 0,1 mm.

The measured and calculated dependence sK on the thickness x of plasma spraying ceramic layer Al_2O_3 is in figure 3. The calculated depended corresponds to the relation (4.2). The individual constants are σ_K* = 14 MPa, S = 706,5 mm^2, c_1 = 220 mm^2, c_2 = 7,5 mm, x_1 = 0,05 mm.

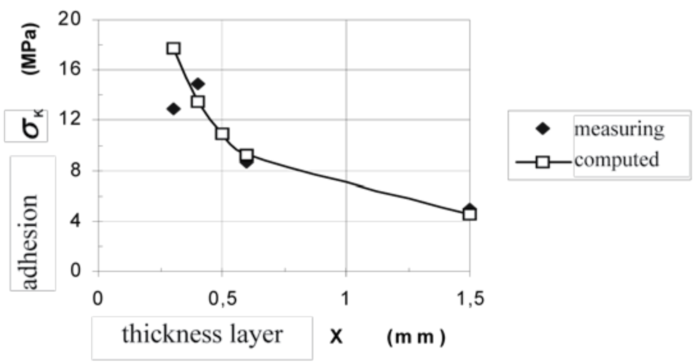

Fig. 2: The graphical course of the measured and calculated values of adherence of plasma molybdenum spraying on steel basic material

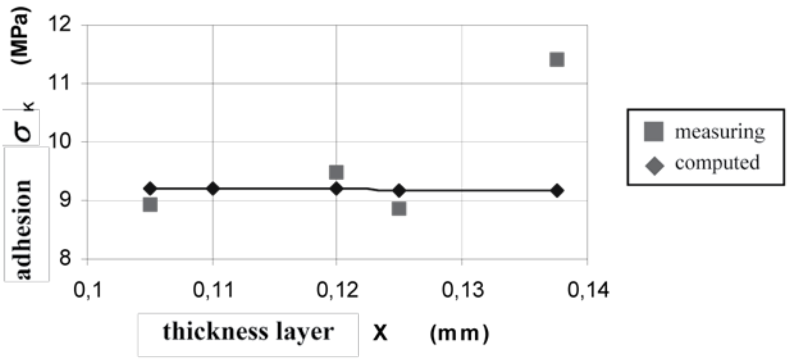

Fig. 3: The graphical course of the measured and calculated values of adherence of plasma ceramic spraying Al2O3 on steel basic material

The measured and calculated dependence of the adherence of plasma spraying ceramic layer Al_2O_3 + 13 % TiO_2 is in figure 4. The calculated depended is by the relation (4.2). Individual constants are σ_K* = 25 MPa, S = 706,5 mm², c_1 = 270 mm², c_2 = 7,5 mm, x_1 = 0,05 mm.

The measured and calculated depended of the adherence σ_K on the thickness x of heat spraying molybdenum layer is in figure 5. The calculated dependence is by the relation (4.3). The individual constants are σ_K* = 80 MPa, S = 706,5 mm², c_1 = 80 mm², c_2 = 53,7 mm², x_1 = 0,4 mm.

It is to see a clear distinguishing of molybdenum slice in figure 6. The structure of the transition interlayer NiAl layer Al_2O_3 after a layer break way. A breach is mainly on bounds of molybdenum lamellas.

Further the samples with ceramic coating were submitted the tests on heat fatigue. Individual samples flat disks were situated in bottom part of iron mould by figure 7, where aluminum was cast. The sturdiest coatings were form Al_2O_3 + 40 % TiO_2 that stand 1160 cycles. The important value was the thickness of the layer.

According to STN 03 8143 the corrosion tests in mist of oxidized natrium chloride the chrome-plated piston the diameter 163 mm with the thickness of layer 0,01 mm. After the tests it is possible to rub the layer and to deposit the coating again and to compensate the chrome-plated layer e.g. on columns for pressure die casting machines. It is the way of lengthening their service life.

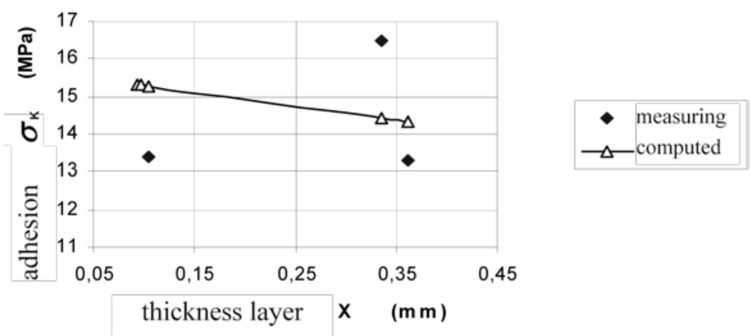

Fig. 4: The graphical course of the measured and calculated values of adherence of plasma ceramic Al_2O_3 + 13 % TiO_2 spraying on steel basic material

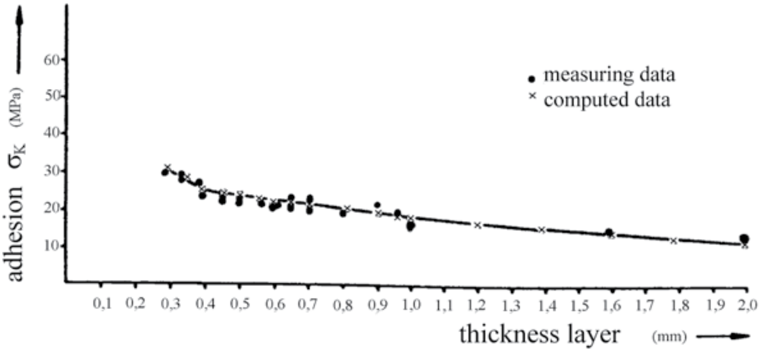

Fig. 5: The graphical course of the measured and calculated values of adherence of heat molybdenum spraying on steel basic material

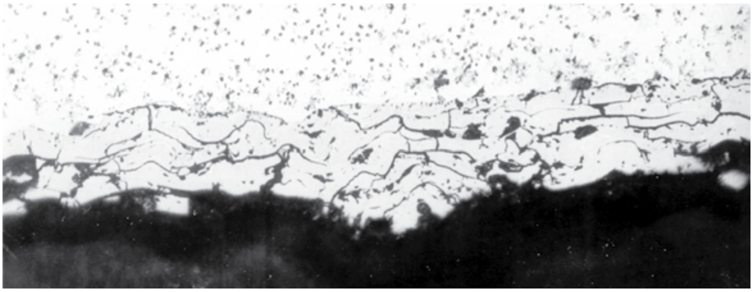

Fig. 6: The clear resolution of interface of molybdenum slices at plasma spraying

CONCLUSION

The tests of the adherence of individual samples and parts after plasma spraying molybdenum and ceramic layers Al_2O_3, $ZrSiO_4$ and ZrO_2 and heat spraying molybdenum were performed. The adherence of spraying layers in dependence on the coating thickness was researched. The derived theoretical courses agree satisfactorily with the measured values.

Further tests on heat fatigue and corrosion tests were researched. Use of spraying coats in practice is for parts that are in contact with liquid metal as dies, tubes for low pressure die casting and other parts.

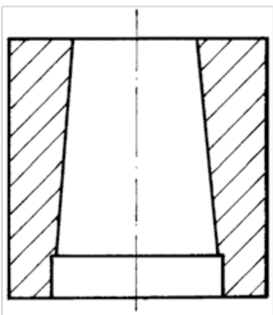

Fig. 7: Test sample placed in chill for tests by heat shock

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AIR POLLUTION THROUGH THE SPECIAL TECHNOLOGY – AEROPLANES AND AUTOMOBILES

I. Kvasnica, P. Kvasnica

Abstract

The content is devoted the authors' experience from contamination of air using special technic – aircraft and automibile transport. The goal is to ensure and make available environmental information on the state of environment and involve the public in decision-making processes. The System contains partial monitoring systems (PMS) installed at selected centres.

Over the recent years, important changes in the Slovakia were introduced by a significant increase in the number of motor vehicles. Computing of emission factor of the aircraft transport is made by eqaution depending on the fuel trade. An important issue is the manner of methods analysis is analytic approache, sophisticated compute in computer system. The quality of environment has influence to the health of people, lower emissions in air is important thence.

Key words

acid rain, oxide, ozone, sources of pollution, concentration, automobile and air transport, emissions

For several decades the air is being polluted by substances that in greater amount destroy the ozone in this layer of atmosphere. It causes depletion of ozone layer or such loss is seen as “ozone hole”. This is caused by accumulation of certain chemicals in atmosphere mainly freons and nitrogen oxides that come to the air as a result of human activities. Information about air pollution is dominant in Quality of environment [3].

Environmental monitoring and information technology are built pursuant to Act No. 261/1995 Coll. on state information technology system, concept depend from the level quality transport and in the year 2000 on the resolution of the Slovak government No. 7/2000 on approved concepts of completion of the complex environmental monitoring information system. This is in line with Act No. 205/2004 Coll. on gathering, maintaining and disseminating information on environment [1].

The System of environmental monitoring is an indispensable tool to know the environment and ensure environmental care. The Information monitoring system with the goal to create a homogeneous, interconnected information unit consisting of partial IMSs. The unit is able to provide most objective report on the actual state of components of environment and due to interconnected databases is generally accessible through the Internet.

AIR POLLUTION – CHEMICAL FACTORS

One of the most important factors of air pollution is emission of gases from producers to the air. This mostly influences the acidity of rains – as a result of air pollution. Sources of the human activities include industry, energetics, transport, municipal sources and incinerators. Table 1 shows percentage of contributions to total amount of emissions according to individual groups of sources [3].

In the Slovak Republic the average acidity of rainwater is pH 3,8 – 4,2. Acid rains cause:

- acidity of the soil,
- washing up of nutrients from the soil and dissolving of impurities settled on the surface – during combustion,
- metals – Al, Cd, Hg – from various metallurgical processes come to the air,
- its penetration to the soil, plants and also to the food chain [2].

Air is mostly polluted by: nitrogen oxide (NO_x), carbon dioxide (CO_2) and carbon monoxide (CO).

Nitrogen oxides (NO_x) – nitrogen creates 5 oxides but only two are important from the perspective of polluting the air: NO – nitric oxide, NO_2 - nitrogen dioxide which are termed as NO_x. They damage health, immune system, bind to the blood, cause swelling of the lungs – death up to 24 hours.

Sources: any combustion – even in transport if the catalytic converters are not used.

Carbon dioxide (CO_2) – was always in the Earth’s atmosphere but its concentration was in balance. Average temperature of Earth’s surface would be approximately -18 °C without CO_2 but natural greenhouse effect increases a temperature of Earth’s surface by approximately 33°C therefore the average temperature of Earth is 15 °C. Main source represents combustion (complete combustion) without regard what we combust.

Table 1: Relative proportional share of sources of pollution to emissions from human activity

Source of pollution	Proportional share of the total one year emissions (%)
Transport	50 – 60
Energetics	10 - 15
Industrial technologies and industrial energetics	15 – 20
Municipal sources	10
Incinerators	5

Table 2: Selected greenhouse gases and their concentration in the atmosphere [3]

	concentration in ppm		relative effect years	lifetime	today's relative contribution
year	1800	1990			
CO_2	280	350	1	50 - 200	55 - 57 %
CH_4	0,8	1,7	30	10	12 - 20 %
N_2O	0,29	0,31	160-300	150	5%
CFC (freons)	0	0,0001	15-25 thousand	70 - 130	15 - 25 %

Carbon monoxide (CO) – is a blood poison also founded in cigarette smoke, binds to haemoglobin and creates carboxyhemoglobin, does not carry oxygen; the blood is not sufficiently oxidized. It is produced during incomplete combustion, operation of automobiles without catalytic converters, in the production of industrial sites – mainly metallurgy and during smoking too.

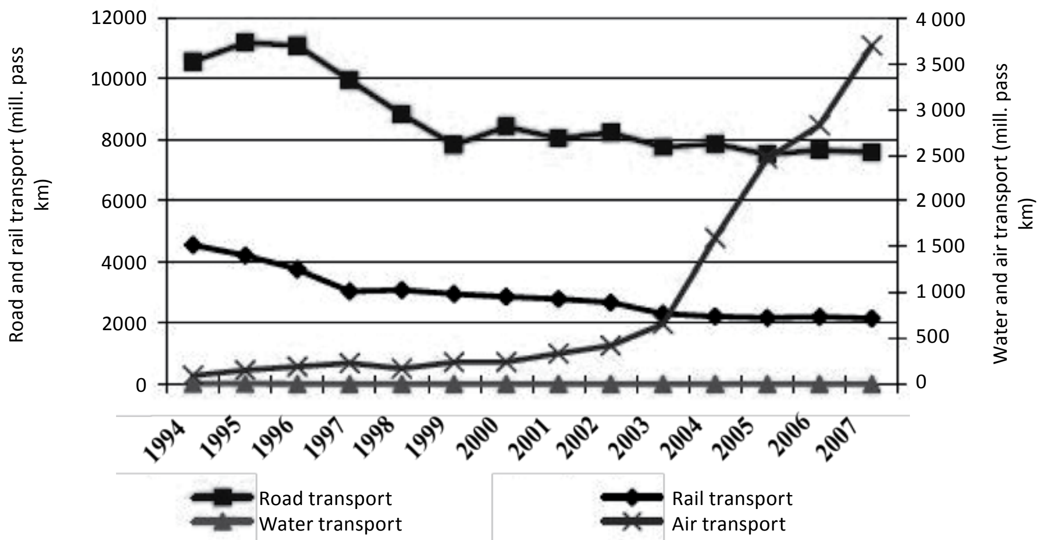
Ozone (O_3) – is about 3 mm thick layer in stratosphere that catches harmful UV radiation of the Sun. We distinguish UVA: 320-400 nm, UVB: 280-320 nm, UVC: 100-280 nm – the last one is the most dangerous; undamaged ozone layer should not transmit the last two types. UV radiation has effects under the water too. Water and snow reflect UV radiation which multiples its effects. It also harmfully affects vegetation, eyes and skin → skin cancer; it speeds up aging process of various materials mainly synthetic → malfunctions.

AIR POLLUTION – TRANSPORT

Current trend in transport is mostly influenced by the road passenger and cargo transport that is flexible enough to follow the economic situation at the expense of more environment-friendly ways of transport.

Passenger and freight transport

Transport of goods and modal split in road freight transportation grow continually. Road transport shows the greatest share on modal split by cargo transport – app. 70 %. Modal split by railroad cargo transport dropped by more



Pic. 1: Public transport depending on type. Source: SO SR

than 30 %, compared to 1993, while modal split by aquatic cargo transport in 2007 stayed on the same level as in 1993 [2].

Over the period of 14 years (1993-2007), there was reported a 23.3 % decrease in the number of carried passengers. Compared to 1993, slight growth was recorded only in 1996 (3.3 %) and 1997 (0.3%).

Demand of transport on the utilisation of resources

Final energy consumption in the transport sector over the period of 14 years has more than doubled itself. Overall consumption of liquid fuels (96 %) represents the greatest share of energy consumption in the transport sector on the overall energy consumption, while the share of solid fuels, gaseous fuels and electricity overall consumption remains small. Road transport shows the greatest share on the overall energy consumption in the transport sector (95 %) [2].

Number of vehicles

Total number of motor vehicles in 2007 over the period on 1993-2007 grew by 27 %. Major increase in the number of motor vehicles in 2007 was recorded in the categories of heavy trucks and pickup trucks (grew by 90 %, compared to 1993), and passenger cars (grew by 44 %, compared to 1993). Number of transport vehicles in railroad and water transport types (being the most environmental-friendly transport modes for passengers and goods) dropped by appr. 24 % over the last 12 years.

EMISSIONS FROM TRANSPORT – POLLUTION

Automobile transport contributes to emissions by automobiles' exhaust pipes which contain CO, Pb, Cd, Hg, NO_x, SO_x, formaldehydes, NOx, CO, hydrocarbons considerably contributing to the soil acidification and putrefying of forests. Amount of these emissions caused by automobiles without catalytic converters depends on the speed of the automobiles – importance of limiting the speed [6]. Petrol motor produces much more pollution than oil one – petrol motor produces mainly CO, hydrocarbons, organic oxidized substances – formaldehydes and chemical compounds of lead; oil motor produces mainly NO_x, SO_x, organic oxidized substances – formaldehydes and soot. Emissions NO_x are increased by the speed of a vehicle. CO is at its highest rate during the low speed of a vehicle then it decreases and increases again in the speed above 60 km/h. Hydrocarbons are at the lowest rate at the speed approximately 80 km/h.

Air transport

Air pollution again relates to emissions CO_2, CH_4 a N_2O. Due to the absence of data about number of air transport cycles realized in the air transport, calculation of emissions is made according to the equation 2.7 in GPG - from sold fuel for both categories of civil aviation (Tier 1 method) [3].

In accordance with IPCC Guidelines fuel is divided into consumption for international and domestic air transport. Calculation of emissions is based on the same division.

Emission factor for CO_2 is an invariable taken from EMEP/CORINAIR. Emission factors for CH_4 and N_2O represent average emission factors included in all phases of flight (LTO - climb, cruise, descent). Emission factors CH_4 and N_2O are stated for representative aeroplanes with proper average flight distance in international and domestic air operation.

Emissions from transport

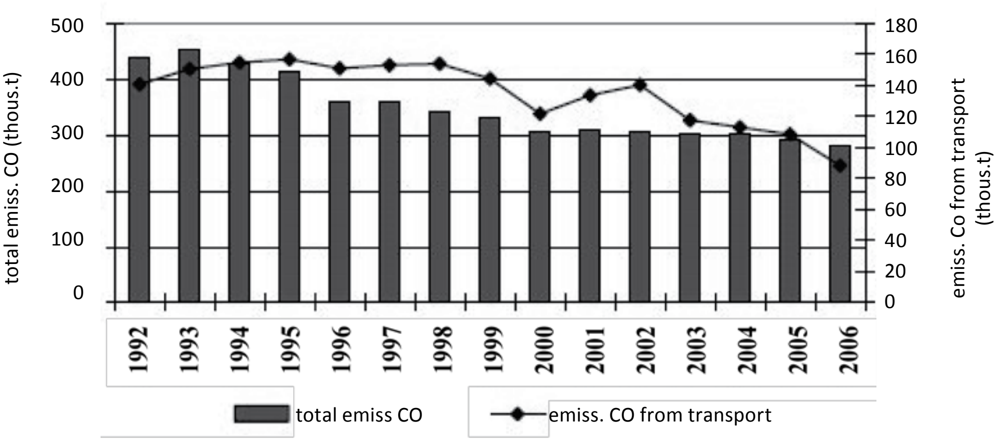
In terms of transport's share on total emissions of the assessed pollutants for 2005, significant is transport's share on CO emissions – 31 %, 39 % in case of NOx and 19 % in case of NM VOC. Solid pollutants represented 20 % of all emissions in 2006, while the SO_2 emissions showed 0.2 %. Transport's share on heavy metal emissions is approximately 2.5 %, with copper showing the greatest hare on heavy metal emissions by transport (6.6 %) followed by zinc (2.4 %), and lead (2.5 %) [2].

Transport's share on total greenhouse gases emissions is approximately 14 %, with the CO_2 share of 17.0 %, and the N_2O share of 5.0 % being among the most dominant. Road transport shows major share on total transport emission production. Share of other types of transport on individual pollutants is very small.

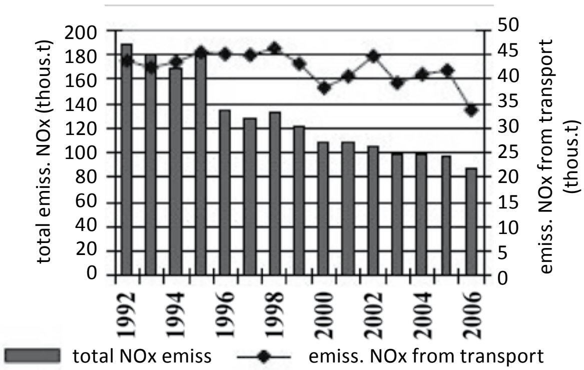
It is seen from graphical dependence on Pic. 2 that absolute amount of CO emissions and proportion of traffic on this amount decreases, however, in the last 7-8 years the number of transported people remains the same. Simultaneously the number of passengers transported by air transport has rapidly increased (see Pic. 1).

It is seen from graphical dependence on Pic. 3 that absolute amount of NO_x emissions decreases, with mild variation to the proportional share of transport. However, in the last 7-8 years number of transported people remains the same. The number of passengers transported by air transport has rapidly increased (see Pic. 1).

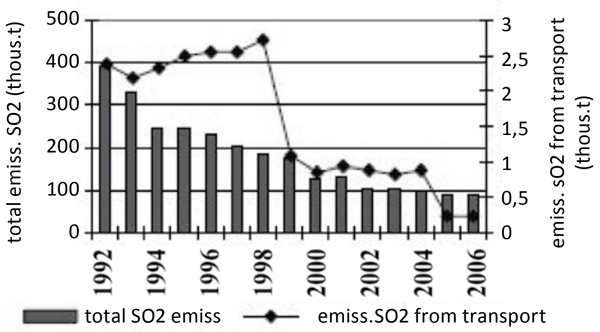
It is seen from graphical dependence on Pic. 4 that absolute number of SO_2 emissions decreases with rapid fall in the years 1998-1999 and 2004-2005. In the last 7-8 years the number of transported people remains the same meanwhile the number of passengers transported by air transport has rapidly increased (see Pic. 1).



Pic. 2: Trend CO emissions in transport in dependence to total CO emissions in the Slovak Republic
Source: SHMI



Pic. 3: Trend NO_x emissions in transport in dependence to total NO_x emissions in the Slovak Republic
Source: SO SR



Pic. 4: Trend SO_2 emissions in transport in dependence to total SO_2 emissions in the Slovak Republic
Source: SO SR

Precautions for decreasing emissions

Based on the monitored indicators there is a positive trend of decreasing emissions related to the total amount of emissions in the Slovak Republic [5]. In order to support this trend is necessary to operate such vehicles, in automobile transport, that comply with emission norms. It is inevitable to decrease energetic demands of air transport by 1-2% which means fuel consumption during the flight. Therefore, from the perspective of fuel consumption, the usage of aeroplanes will be much more effective.

Another possibility to decrease emissions is a training of pilots and aircrews on flight simulators. Use of flight simulator includes many other advantages and security elements [7].

CONCLUSION

In the air transport introducing aeroplanes with effective operation seems to be very effective and useful. In automobile transport is advantageous to use vehicles with new propulsion systems which comply with EURO5 emission standards. It is necessary to confront the results with present status with respect to impact on environment.

If we reduce emissions in the air and also abovementioned energy demands in transport, the number of produced pollutants will be decreased too.

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