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UNIVERZITY

FACULTY OF MECHANICAL ENGINEERING

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Unique Activities of Mechanical Engineering Faculty in the Slovak Republic

The Faculty of Mechanical Engineering, University of Žilina, carries out its activities in the environment of other Slovak faculties based on mechanical and production engineering.

The Faculty deals with standard disciplines (such as measurement, automation, industrial engineering, technological engineering, mechanic and strength, design and machine elements) and with specific engineering disciplines (such as machinery maintenance engineering; railway vehicles; engines and lifting equipment; heat and hydraulic machines). The specific engineering disciplines are unique for Slovak faculties. Transport technology and transport engineering are characteristic for the Faculty.

The Faculty solves at present a great number of institutional tasks and projects given by the Ministry of Educational (GAV commission). The faculty is also involved in international research teams in framework of international projects such as COPERNICUS, CEEPUS, TEMPUS and Austria-Slovakia cooperation, NATO, 5th FP EU. Extent and number of projects is characteristic only for faculties with good experienced teachers and scientific staff.

Our faculty is also involved in the 5th Framework Programme of EU. This gives very considerable status among other Slovak faculties.

The geographic location of Žilina is suitable for cooperation with foreign universities near the border (so-called border collaboration). Another unique feature of the Faculty is its participation in the Fraunhofer Society (Germany). The first branch office of the Fraunhofer Society within Central European Countries was established by a professor from our faculty.

The great number of solved projects for engineering enterprises is also typical feature of the faculty. This is a very good way to obtain additional funding for educational and scientific process in the faculty.

Other areas such as number of students, quality control system, interest in study, international collaboration are comparable with other faculties in the Slovak Republic.

Study at the Mechanical Engineering Faculty, University of Žilina

The Faculty is accredited to educate students in a number of study fields of mechanical engineering. There are more than 1,400 students at the Faculty in daily courses, 45 PhD. daily students and 120 PhD. students studying externally.

The Mechanical Engineering Faculty of the University of Žilina, offers a university technical education and its graduates are experts who are able to solve complicated technical problems with respect to social, ethical, economic, ecological and cultural areas.

The Faculty has the following forms of study:

Bachelor Study Programme (Bc.) /2 study fields/
- *Technology of mechanical engineering*
- *Environmental technique*

Master Study Programme (Ing.) /7 study fields/
- *Applied mechanics*
- *Transport and manipulation technique*
- *Material Engineering*
- *Management of industrial engineering*
- *Technology of mechanical engineering*
- *Environmental technique*
- *Device, regulation and automation technique*

Doctoral Study Program (PhD.) /7 scientific fields/
- *Applied mechanics*
- *Machine elements and mechanisms*

- *Transport and manipulation technique*
- *Management of industrial engineering*
- *Material engineering*
- *Technology of mechanical engineering*
- *Environmental technique*

Research and scientific areas of Manufacturing Engineering Faculty

The main research interests of Faculty of Mechanical Engineering are especially in the following topical areas:

- *Development of science for **transport means, mobile working machines, lifting, handling, and power devices design** is orientated to improvement of a transportation system technical basis, including machines for transport infrastructure building and repairing and material handling in transport, industry, power industry, civil engineering, forestry and so on. This process is determined by the goal of reaching a high level of transport means and working machines, drives, lifting, manipulation, power and ecological devices and so on.*
- *Development of science for **maintenance and operating of transport** together with development of transportation systems in Slovakia and its integration to transportation system of Euro-Asia. The activity of faculty is orientated to improvement of systems for operation and maintenance of transport means and devices connected with conventional and non-conventional approaches to transport system, to safety of the system and environment.*
- *Development of science on **design materials and manufacturing technologies** connected with development of technical basis of transport means, machines, tools and constructions. The material and technology theories are orientated to improvement of technical basis services. The current methods for evaluating of technological and functional features are developed.*
- *Development of **enterprise management, manufacturing, manufacturing machines, transport and handling equipment** including the integrated enterprise philosophy. This process is orientated to production systems design, decision processes design, marketing, modelling and simulation, products quality control while respecting the specific features of human beings, nature and economics. The computer systems are a basis for the control systems in production, transportation machines and equipment, devices, m automation and control technology in engineering practice..*

The research units solve at present 29 institutional tasks and 19 scientific grant tasks given by the GAV SR (Scientific Grant Agency of the Ministry of Education of the Slovak Republic and Slovak Academy of Sciences). The faculty cooperates with various foreign universities from Austria, France, Germany, Hungary, Italy, the Netherlands, Poland, UK, Russia, Slovenia, etc., mainly under the scheme of programmes such as 5th FP EU, Copernicus, Ceepus, Tempus, Leonardo, Socrates, NATO as well as the Austria-Slovakia Action.

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- *Scanning electron microscopy*
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- *Fatigue properties especially at high-frequency loading (20 kHz)*
- *Creep tests of materials,*
- *Measurement of internal friction*

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- *Modelling of production planning and control activities*
- *Computer aided design of production systems*
- *TPC – Total Production Control- new concept for simultaneous design, planning, control and improvement of production systems*
- *Analysis and work measurement in production processes and systems*

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- *Computer modelling and design optimisation*
- *Reliability and service life of mechanical parts of vehicles*
- *Theoretical and experimental research of railway wheels and mechanical parts of vehicles brake systems*
- *Railway vehicle dynamics*
- *Emission formation, combustion and engine operation with impact on the environment*
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- *Design of piping systems and pumping stations*
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Peter Palček – Branislav Hadzima – Otakar Bokůvka – Mária Chalupová – František Nový

CORROSION RESISTANCE OF MAGNESIUM AND ITS ALLOYS

1. Introduction

Magnesium and its alloys are perspective materials on the ground of their low specific mass, high ratio strength/weight, good cast properties and machinability and wasteless utilization. Basic mechanical properties of the Mg-alloys at normal temperature are dependent on amount of alloying elements and technology of casting. Very significant property of Mg-alloys is the ability of damping of vibration. Mg and its alloys have very low value of electrochemical stability. For this reason it is inevitable to obtain knowledge about their corrosion behaviour in different environments. In this work were tested three types of Mg – alloys in different corrosion conditions, simulated possible working conditions.

2. Experimental materials

The tested alloys are Mg-alloys AZ91HP, AZ91 and AZ63HP. The experimental materials was made by casting and delivered after heat treatment marked T6 (dissolving annealing and ageing). The microstructures of tested Mg-alloys are in Fig. 1,2. Polyedric grains of the δ-phase, what is solid solution Al in Mg, are formed all alloys. The eutectic $\gamma+\delta$ is segregate in various ratio on grain boundaries. In AZ91 alloy is eutectic segregate in form chain and in AZ63HP alloy in continual form. We can watch the areas of secondary segregate γ-phase in AZ63HP alloy.

3. Experiments and results

The samples of the tested material were immersed to the different environment simulated possible working conditions and after 42 days the weight losses were determined and corrosion rates calculated as it can be seen in the tab. 1.

The potentiodynamic tests were carried out in normal, distilled, river and seawater and the important characteristics of these measurements (corrosion potential, corrosion current density) were compared and are presented in tab. 2.

Corrosion rates [$g.cm^{-2}.s^{-1}$] of Mg-alloys in the various environments after 42 days of the test Tab. 1

Mg-alloy	River water	Normal water	Distilled water
AZ91	$1.217.10^{-9}$	$1.179.10^{-9}$	$7.785.10^{-10}$
AZ91HP	$2.251.10^{-9}$	$6.123.10^{-10}$	$7.788.10^{-10}$
AZ63HP	$9.324.10^{-10}$	$1.180.10^{-9}$	$2.643.10^{-9}$

Corrosion rates were calculated from I_{corr} according to Faraday's law at corrosion potential E_{corr} (tab. 3).

$$v_{corr} = \frac{i_{corr} \cdot M}{n \cdot F}$$

M – grammolecular weight ($24,4 g.mol^{-1}$), n – number of changed electrons (2), F – Faraday's constant ($9,6.10^4$ C)

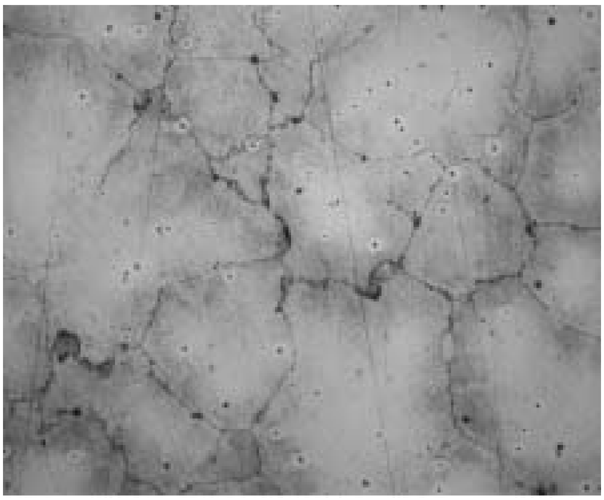

Fig.1 Microstructure of the AZ91, 100x, etch. 0,5 % Nital

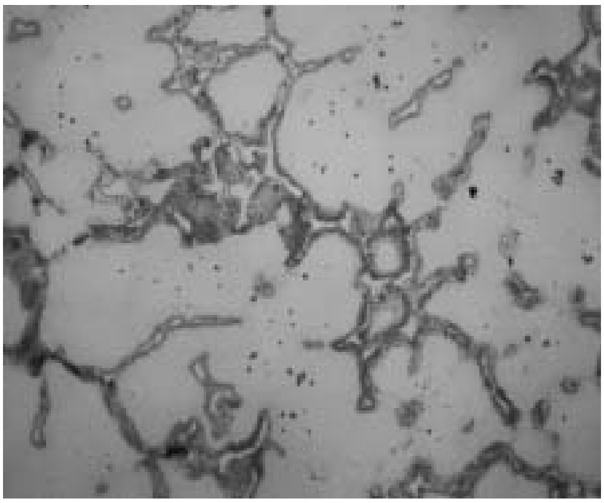

Fig.2 Microstructure of the AZ63HP, 100x, etch. 0,5 % Nital

The average values of I_{corr} [A.cm^{-2}] and E_{corr} [V] measured potentiodynamically Tab. 2

Environment	AZ91		AZ91HP		AZ63HP	
	I_{corr}	E_{corr}	I_{corr}	E_{corr}	I_{corr}	E_{corr}
Distilled water	$5.0600.10^{-7}$	-1.3243	$3.5507.10^{-7}$	-1.2468	$2.5933.10^{-7}$	-1.3305
Normal water	$1.1509.10^{-5}$	-1.4847	$1.2346.10^{-5}$	-1.4480	$2.2800.10^{-5}$	-1.4620
River water	$1.3877.10^{-5}$	-1.4473	$1.4560.10^{-5}$	-1.4233	$1.8910.10^{-5}$	-1.4540
Seawater	$2.0097.10^{-4}$	-1.5245	$1.9547.10^{-4}$	-1.5260	$9.5330.10^{-5}$	-1.5390

Corrosion rates v_{corr} [g.cm^{-2}.s^{-1}] at corrosion potential E_{corr} Tab. 3

Environment	AZ91	AZ91HP	AZ63HP
Distilled water	$6.43.10^{-11}$	$4.51.10^{-11}$	$3.30.10^{-11}$
Normal water	$1.46.10^{-9}$	$1.57.10^{-9}$	$2.90.10^{-9}$
River water	$1.76.10^{-9}$	$1.85.10^{-9}$	$2.40.10^{-9}$
Seawater	$2.55.10^{-8}$	$2.48.10^{-8}$	$1.21.10^{-8}$

4. Conclusions

The corrosion attack is different between AZ91 alloy and AZ63HP alloy in distilled water. The reasons for it are structural differences between alloys. The corrosion products on the surface of (phase are on magnesium base (MgO, $Mg(OH)_2$) and they do not feature stability in distilled water. This layer breaks very easily. The anodic reactions are in the posts of film failure and the cathodes reactions are at the surface of corrosion products. The chemical composition of corrosion product is different on the surface of γ-phase ($(MgAl_x)O_y$, $(Al,Mg)_m(OH)_n$). The guard film (MgO, $Mg(OH)_2$) is broken by these products. The reason for structural components drop out of γ-phase is galvanic corrosion on the surface of AZ63HP alloy. The mechanisms of corrosion in normal and river water are the same. On the surface of specimens different products are formed (on the base of chemical composition of water) which can reduce or accelerate corrosion. By comparing results in river and normal water with those in distilled water we can see that corrosion rates are increasing in AZ91HP alloy and decreasing in AZ63HP alloy. The corrosion rate at AZ91HP alloy in river water was very high. The results from previous experiments showed that least resistance in industrial atmosphere have the AZ63HP alloys. This is conformable with results from the tests in river water, because river water was from industrial zone.

We measured the most positive corrosion potential in distilled water at all three alloys by potentiodynamic tests. Corrosion potentials were decreased in river and normal water and most negative potentials were in simulated seawater. The highest corrosion current occured in simulated seawater in case of all three alloys. Aggressive chlorides in seawater create corrosion holes, increased active surfaces and corrosion rates are increased, too. Potentiondynamic tests indicate behaviour of magnesium alloys at the beginning of immersing tests. Potentiodynamic tests cannot record structural changes, which are created during long time immersing tests. Corrosion products are being created during immersing tests. They can increase or decrease corrosion rates.

Milan Sága

CONTRIBUTION TO THE SOLUTION OF ELASTIC-PLASTIC PROBLEMS

1. Description of the mathematical model

Considering ideal elastic-plastic material ($E_T = 0$) for one-dimensional cases, we can write

$$\sigma + B \cdot \|\sigma\|^{n-2} \cdot \left|\sigma \cdot \dot{\epsilon}\right| \cdot \sigma + $$
$$+ C \cdot \|\sigma\|^{n-2} \cdot \sigma \cdot \dot{\epsilon} \cdot \sigma = A \cdot \dot{\epsilon}, \qquad (1)$$

where σ is the axial stress and ϵ is the total strain. The hardening effect is achieved by combination of Bouc – Wen's model with Suzuki – Minai's model, which is

$$\sigma = \alpha \cdot E \cdot + (1 - \alpha) \cdot z,$$
$$\dot{z} = E \cdot \dot{\epsilon} - \frac{E}{2 \cdot \sigma_y^n} \cdot \left|z\right|^{n-1} \cdot \left|\dot{\epsilon}\right| \cdot z + \frac{E}{2 \cdot \sigma_y^n} \cdot \left|z\right|^n \dot{\epsilon}, \qquad (2)$$

where $\alpha = \frac{E_T}{E}$, z s the stress parameter and σ_y is the yield limit.

The program NONDYN for the solution of the mentioned problem was created in the programming language MATLAB. For the solution of non-linear differential equations it is modified by the Crank-Nicolson method to suit our own problem.

Let's solve a simple spatial triple truss (see Fig. 1) excited by harmonic force *F*.

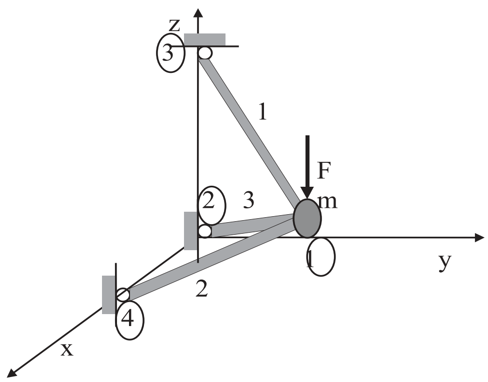

Fig. 1 FE 3-D model

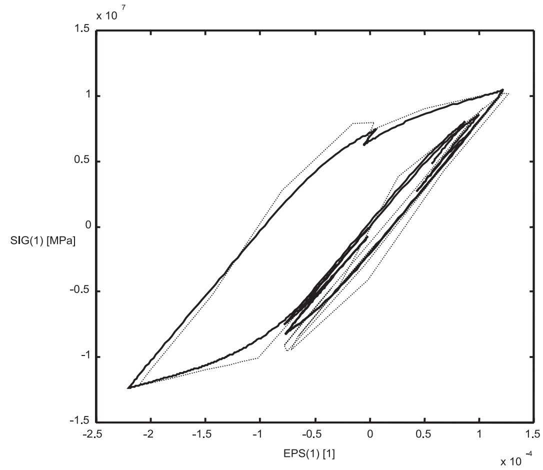

Fig. 2 Stress – strain relationship of the first element

2. References

[1] SÁGA, M., GERMAN, R., GALČÍK, R.: *Solution of elastic-plastic problems in structural engineering,* NMCM 2000, Liptovský Ján, Slovak Republic (CD)

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RELIABILITY CENTRED MAINTENANCE AS A BASE FOR MAINTENANCE SYSTEM ON ŽSR

1. Introduction

In the existing system of railway vehicles periodic repairs carried out in accordance with the valid railway repair regulations, the main indicator for locomotives is the so-called mileage run, for wagons it is a time period. This approach is given by a long historical evolution and in principle by traditional way of using the planned-preventive system. Most of locomotive and wagon depots on ŽSR are defending their existence especially by carrying out all maintenance work. This is often done without real requirements and own technological possibilities on low technical and quality level, but it seems to be cost-effective comparing with price set by railway repair workshops.

Growing importance of maintenance is caused by operational-economical and technological influences. Besides, there are numerous other environmental, health and safety requirements that are expected from maintenance. Growing complexity of production and service systems raises high demands on skills of maintenance workers.

2. Railway vehicles maintenance and maintenance organisation on ŽSR

Organisation of railway vehicle maintenance is being carried out in accordance with ŽSR regulation V25 "Regulations for repairs of electric and diesel locomotives" that underwent long evolution. Principal changes were done in 1967, 1975, 1982 and 1999.

Already in the first version of V25 regulation there is a definition: "A purpose of locomotive maintenance is to remove effects of wear on vehicle components and preventively create conditions for failure-free operation between planned inspections and repairs. Basis of maintenance system is based on preventive planned inspections and repairs carried thoroughly and early enough, by which effects of wear are removed and conditions for failure-free and economic operation and for decreasing volume of repairing work are created".

Maintenance of locomotives was basically divided into the following principal elements:

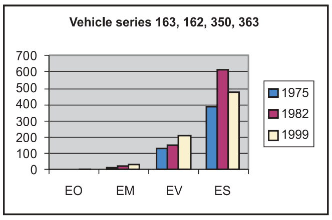
a) Vehicle servicing in operation,
b) Periodical inspections and repairs of vehicles,
c) Unplanned repairs of vehicles.

Preventive maintenance system is based on the principle that periodical inspections and repairs should be carried out in such extent and quality, *so that to ensure failure-free, safe and economical operation between individual inspections and repairs while keeping given performance norm.* So they must be carried out in such an extent and in such quality so that the vehicles work economically in operation between two overhaul repairs as well as between repairs at a lower level.

That means that repair works at lower levels should remove effects of partial wear of vehicle components. Overhaul repairs should be done in such extent so that total vehicle wear would not exceed permitted operational limits.

It is interesting to follow trends in mileage norms for some locomotive series:

	Maintenance category mileage (1000km)			
V25	EO	EM	EV	ES
1975	2,5	16	128	384
1982	0,9	22	154	616
1999	5,5	30	210	480



From the analysis it is evident that either already in 1975 the mileage norms were proposed so optimally that there was no need to make any changes, or there were not sufficient data needed for making changes.

The same trends could be observed also in case of passenger and freight wagons while there are efforts to change periodicity from time periods to mileage as it is in case of locomotives.

3. Maintenance information systems

ŽSR must search for new maintenance strategy. One of possible approaches, besides use of new methods (TPM and RCM) is introduction of suitable maintenance information system for transport means and other facilities.

The Department of machinery maintenance engineering already in the 80-ties had worked out methods for implementation of reliability into the design of maintenance system. But later on we turned to the method of reliability centred maintenance – RCM, as it comprises the proper combination of statistic, historical and a-priori reliability (FMEA, FMECA and FTA).

Maintenance information system should assist in optimisation of extent and content of maintenance activities. In other words – maintenance information system should "force" a company to think about change of maintenance system and gradually focus attention to failure consequences and not to executing planned extent of maintenance works. When a company starts to think about implementation of maintenance information system, the competent managers should first of all think about goals they want to achieve by such a great change in a company. From goals, stated by competent managers, who have sufficient power, authority and ability to pursue new ideas, a project of implementation of new maintenance system should be done.

4. Tasks to be solved for improvement of railway vehicle maintenance

At present ŽSR are in the transformation process, which affects also maintenance system of rolling stock. The basic requirement is to create an effective maintenance system at minimum costs but to ensure high availability of vehicles. The transformation should bring increased reliability by adopting new maintenance system and advanced maintenance management system. This will be based on:

- analysis of needed vehicles in future in accordance with traffic volumes,
- analysis of vehicle parameters and costs for their operation (LCC)
- analysis of role of depots
- determination of structure, functions and activities carried out in depots,
- assessment of work effectiveness carried in depots and outside (outsourcing),
- maintenance costs in depots, their structure, types,
- methodology for making regulations,
- assessment of technological base (existing and required/useless machines and equipment),
- human resources – organisation, work description,
- information flows – analysis of necessary information, information systems,
- assessment of optimum number of railway depots under new situation, analysis of repair and maintenance technological level.

Juraj Uríček –Viera Poppeová – Robert Zahoranský – Martin Chochúľ

THE DEVELOPMENT OF TRAINING ROBOT SLR 1500

1. Introduction

The design of the robot SLR 1500 is angular. It has five degrees of freedom, three of them serve to position the end effector in the space and the remaining two determine its orientation with respect to the object being manipulated.

Fig. 1. The robot simulation

2. The control system and simulation software

The development was oriented on the design of simulation program equipment of robot, computer simulation possibilities – simulation of robot functions, motion and manipulation functions: graphic model of robot (mathematical 3D model, determination of edge visibility, kinematics bindings), the design of simulation algorithms, design of software and verification of correct function. The output of program: it is the control program for the SLR 1500 robot, which may be saved on a disk and inserted into memory again later.

3. Conlusion

The robot presents a complicated mechatronic system with several subsystems. In this time the development is oriented to the robot control system design with applying the artificial intelligence methods, mainly digital image processing and cognitive sensor systems.