РЕЗЮМЕТА

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на научноизследователските трудове
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Summaries according to indicator B.4 - habilitation work - scientific publications in publications that are referenced and indexed in world-famous databases with scientific information

B.4.1. Spasova D., Radev R., Atanasov N., Yankova R. (2019). Investigation to obtain complex relief MMC with metal matrix Al and Cu reinforcement phase. Advances in Materials and Processing Technologies, ISSN: 2374-068X, 5(3), 394-400. https://www.tandfonline.com/doi/abs/10.1080/2374068X.2019.1616417

The main aim of the present paper is relevant with the research on the possibilities of obtaining of metal matrix composites (MMCs) with uniform and not changing during the process of creating a reinforcement phase. Tests were done for the obtaining of MMC with a metal matrix Al and reinforcement metal phase Cu of type 'in vitro' and 'hybrid'. The method of obtaining the result is similar to 'capillary forming', such as the metal matrix (molten pure aluminium) was infiltrated in the space between the copper blasting grit which is the alternative option of solving similar problem in which the blasting grit (the reinforcement phase) is forcibly implemented into the melts (the metal matrix). From the resulting metal matrix composites (MMCs), areas of reaction between aluminium and the copper powder were established. While finer copper particles dissolve into the aluminium matrix at that temperature, the copper dissolved in aluminium forms α-saturated solution, and as a result a Θ-phase is released ($CuAl_2$). In the slow cooling, the connection between the Θ-phase released and the basic matrix is noncoherent due to the forming of a chemical compound with a concrete crystal lattice.

On the basis of the results obtained, the following conclusions can be drawn:

- The scheme of capillary moulding used allows the building of innovative new multiphase composites in which the liquid metal matrix interacts with the reinforcing phase, being obtained an α- presaturated solid solution of copper in aluminum and separating the Θ-phase ($CuAl_2$).
- The technology used to obtain MMCs leads to obtaining innovative materials with increased mechanical properties.
- Depending on the extent of interaction of the liquid metal matrix and the reinforcement phase, various phases and structures are formed which are not possible to obtain by the conventional methods of casting. Thus, composites are obtained whose synthesis is at temperatures significantly lower than that of the melting temperatures of the elements of the reinforcement phases.

B.4.2. Spasova D. (2019, October). Investigation of the abrasion resistance of stainless-steel composites with Al_2O_3 reinforcement phase produced by using the capillary forming method. In IOP Conference Series: Materials Science and Engineering ISSN:1757-8981 (Vol. 564, No. 1, p. 012035). IOP Publishing. https://iopscience.iop.org/article/10.1088/1757-899X/564/1/012035/pdf

The present paper is relevant with the production and investigation of abrasion resistance of MMCs (Metal Matrix Composites) with metal matrix AISI 304 stainless steel and Al2O3 reinforcement phase. Composites of Fe-C alloys, reinforced with ceramic particles such as carbides and oxides, are widely used to make tools, also used in the mining industry, wear-resistant and corrosion resistant products The purpose of the conducted tests was to determine the abrasion wear resistance of the MMC (metal matrix AISI 304 stainless steel and Al2O3 reinforcement phase), obtained in cement expendable moulds by innovative technology based on the capillary moulding method where the metal matrix (AISI 304) was forcedly infiltrated in the space between the reinforcement phase (Al2O3) particles by vacuuming the space between reinforcement particles. A weighting method is used to determine the wear resistance by radial load in liquid and dry friction mode. For a more accurate wear assessment, the following criteria were analysed: structural changes, wear kinematics, alteration in the size and shape, and weight alteration. The dynamics of mass variation in the wear process and the wear intensity are determined.
The following conclusions can be drawn from the conducted research:

- The methodology developed for the preparation of complex-relief MMCs using single blanks implementing conventional methods for mould production (in expendable cement mould), provides good results in relation to the infiltration of the melt (AISI 304 stainless steel) in the capillary cavities formed among the reinforcement phase particles (Al2O3), and as a result the composite has a dense structure.
- The microhardness measured has revealed an increase in the hardness in the matrix area of the obtained MMC and of the reference sample (AISI 304 alloy) after the abrasion wear, approximately 100 – 180HV units, due to the mechanical reinforcement (cold hardening).
- The experimentally obtained values for the wear parameters (E = 12500, Er = 2500, class of wear resistance (n) - 4), show that the hardness of stainless steels can be greatly increased by the addition of hard ceramic particles, making them the preferred wear-resistant and corrosion-resistant materials.

B.4.3. Spasova D., Argirov Y., Mechkarova T. (2021). Comparative Analysis of the Mechanical Properties of Polymer Matrix Composites Reinforced with Fiberglass Fabric. TEM Journal, ISSN: 2217-8309 2021, 10(4), pp. 1745–175035, https://doi.org/10.18421/TEM104-35

The composites materials are increasingly displacing the traditional ones and are the most widely used of all groups of engineering materials. Polymer matrix composites have the greatest application and they are used for equipment operating in the sea-water environment and polymer pipes. They have very good strength, corrosion resistance, light weight, they are easy to operate and install and they has a long life cycle, which exceeds 30 year. In this article, the mechanical properties of six types of polymer matrix composites reinforced with fiberglass fabric are considered and analysed. Two types of resin were used for the matrix – polyester resin and vinyl ester resin. The both types of matrices are reinforced with three different fiberglass fabric- monoaxial, biaxial and triaxial fiberglass and an intermediate layer of glass mat. The investigated composites are obtained by mechanical pressing in the form of six layer panels. A comparative analysis of tensile strength and banding strength of the six types investigated composites was made. A macro fractographic analysis of the structure was also performed.

After the comparative analysis conducted we can conclude:

- In the comparative analysis, it was found that for all the composites studied, vinyl ester resin used as a matrix material showed better mechanical strength properties than polyester resin, especially regarding of bending strength.
- The reinforcement phase has a significantly greater impact on the mechanical properties, with the monoaxial-reinforced samples featuring the highest mechanical characteristics (Rm_{per} = 330MPa, Rm_{ver} = 350MPa and Rmb_{per} = 265 MPa , Rmb_{ver} = 397 MPa, irrespective of the matrix material.
- The lowest mechanical strength properties are associated with biaxial fiberglass reinforced PMC, but related to the highest vertical displacement i.e., they have higher plasticity.
- Finaly, it can be concluded that depending on the conditions of operation, the constructed six types of composites can find applicability for making equipment working in the marine environment and pipe structures, taking into account the load that will be subjected

B.4.4. Spasova D., Argirov Y., Mechkarova T., Atanasov N. (2021, February). Investigation of the suitability of fiber reinforced polymer matrix composites for facilities operating in marine environment. In IOP Conference Series: Materials Science and Engineering ISSN:1757-8981 (Vol. 1037, No. 1, p. 012029). IOP Publishing. https://iopscience.iop.org/article/10.1088/1757-899X/1037/1/012029/pdf

The objective of the present work is to determine the strength of the Polymer Matrix Composites (PMCs) materials studied in order to assess their suitability for manufacturing facilities and equipment operating in marine environment. There is a wide variety of PMCs used in this field due to the possibility of combining different types of reinforcing fabrics. To achieve the objectives of the study, two types of net shaped glass-fiber reinforced PMCs were created and tensile strength, bending strength and specific gravity were determined. One of the studied composites features a polyester resin matrix and a reinforcement phase of six layers of fiberglass (PMC 1), and the second has a vinyl ester resin matrix and a reinforcement phase of a combination of three layers of fiberglass and three layers of biaxial fiberglass 450 g / sm^2 (PMC 2).

The investigation of the suitability of Fiber Reinforced Polymer Matrix Composites for the manufacture of facilities operating in marine environment has shown that:

- The density of both materials is approximately the same, lower than that of the traditional metallic materials used for manufacturing equipment operating in marine environment.
- PMC 2 have higher tensile strength and significantly higher bending strength compared to PMC 1, which is mainly due to the fact that its reinforcement phase is composed not only of fiberglass but also of biaxial fabric. This is also confirmed by the macro-fractographic analysis where indicates that in PMC 2 the crack propagation is tangential, unlike PMC 1, where the crack propagation is linear, perpendicular to the tensile load. Tangential crack propagation requires more work of fracture than linear crack propagation.
- Both composite materials are suitable for the construction of equipment and facilities operating in marine environment but taking into consideration that the equipment in the marine environment operating in the marine environment is subjected mainly to bending stresses, BRVMCs would be the more suitable material as compared to FRPMCs.

B.4.5. Spasova D. (2021) Analysis of The Interface Between The Matrix and The Reinforcement Phase In Ceramic-Reinforced MMCs. International Journal of Modern Manufacturing Technologies, ISSN:2067-3604 2021, 13(1), pp. 193–199 https://ijmmt.ro/vol13no12021/21_Daniela_Spasova.pdf

The objective of the present paper is to study the one main problems in the production of MMC – the wettability of the reinforcement particles by the metal matrix. The investigated composites are "invitro" type, with unformed and unchanging reinforcement phase in the process of obtaining and they were obtained using a technology, based on the capillary effect, that is different from the conventional methods known so far. Ceramic particles SiO_2, Al_2O_3 and SiC were used as a reinforcement phase have a complex microrelief that contributes to the consolidation of the mechanical bond, which they form with the metal matrix (Cu, aluminum alloy AlSi12, copper alloy CuZn38Pb2, AISI 304 stainless steel). To obtain a strong mechanical bond, close adhesion-based contact must be established between the liquid matrix and the particles of the reinforcing phase. In the method used to obtain MMC the melt is forcibly infiltrated into the capillary spaces between the ceramic particles of the reinforcement phase, such as helps to overcome the surface tension of the melt and provides good wetting of the particles of the reinforcement phase. A metallographic analysis was performed to investigate the wetting of the reinforcement particles by the metal matrix.

After the analysing of the experiments conducted the, following more important conclusions can be drawn:

- The method under consideration for MMCs production, based on the capillary effect, provides stable mechanical bonding between the matrix and the reinforcement phase, as the forced infiltration of the melt into the capillary spaces, helps to overcome the surface tension of the melt and provides good wetting of the reinforcement phase particles.
- The size of the ceramic particles used does not affect the rate of the wetting, and respectively the mechanical bonding between the elements of the MMC tested. Nor does the melting temperature of the various alloys forming the matrix have an impact on the degree of wetting and the quality of the mechanical bonding obtained.
- The use of surfactants in the MMC formation does not yield good results. Defects are observed from the flux used, which remained between the metal matrix component and the reinforcement phase of

the composite.

B.4.6. Georgiev G., Argirov Y., Mechkarova T., **Spasova D.,** Stoyanova, A. (2021, February). Study of the durability of ferritic-austenitic steel samples after cyclical fatigue impact. In IOP Conference Series, ISSN:1757-8981 Materials Science and Engineering (Vol. 1037, No. 1, p. 012036). IOP Publishing doi:10.1088/1757-899X/1037/1/012036
https://iopscience.iop.org/article/10.1088/1757-899X/1037/1/012036/pdf

The purpose of this article is to investigate the fatigue strength of corrosion resistant ferritic austenitic steels used in marine equipment. Two groups of sheet steel samples were prepared: the first group were reference parts and the second group of samples were welded. The fatigue tests were performed with specially developed vibrating equipment. A simulation study was carried out with the program product Solidworks 3D using the tool - frequency (frequency) and fatigue (fatigue) to establish the limits of the operating modes of the experimental setup (amplitude, frequency, type of signal) and to simulate the durability of the materials consumed. The resonance frequency of the samples in the range of 50-60 Hz was calculated and their durability was simulated. In the simulation analysis performed with a cyclic load of 700 MPa, the durability of the specimen was 4000 cycles and a load of 700 MPa was taken as the maximum for the purposes of the study. The destroyed surfaces were examined by optical microscopy, and the phase composition by X-ray diffraction analysis. Fatigue strength was evaluated by the number of cycles needed for a crack at a certain alternating load. Fatigue tests show how multi-cyclical fatigue affects the formation and development of a fatigue crack, and metallographic and X-ray diffraction analysis shows the phase changes occurring in the structure of SAF 2507 steel.

The following conclusions can be drawn from the research conducted:

- By means of a simulation study with the software product Solidworks 3D, the natural resonance frequency of the tested samples and the approximate number of load cycles were calculated, in order to determine the working mode and their durability in cyclic fatigue tests
- Based on the conducted cyclic fatigue tests, a fatigue curve was compiled for both types of materials, a limit was established below which no crack initiation was observed (for the reference sample 480 MPa, and for the welded 340 MPa).
- An increase in the dislocation density and surface internal stresses of γ-Fe (111) was found from the widening of the X-ray line in the fracture area of the unwelded samples.
- In the weld metal, the X-ray line is identical to that of the unwelded samples while maintaining the ratio between ferrite and austenite as γ - Fe (111) = 60% and α – Fe (110) = 40%.

- The microstructural analysis found that the crack has a zigzag character in the weld metal, and it is rectilinear in the base material, and in both cases its character is transcrystalline.

B.4.7. Georgiev G., Argirov Y., Mechkarova T., **Spasova D.,** Stoyanova A. (2021, February). Investigation of the occurrence and development of fatigue cracks after corrosion of welded samples of ferritic-austenitic steel. In IOP Conference Series: Materials Science and Engineering, ISSN:1757-8981 (Vol. 1037, No. 1, p. 012037). IOP Publishing doi:10.1088/1757-899X/1037/1/012037 https://iopscience.iop.org/article/10.1088/1757-899X/1037/1/012037/pdf

The article treats the occurrence and development of fatigue cracks in welded samples of ferritic - austenitic steel, which were previously subjected to corrosion. For the purposes of the study, two groups of sheet steel samples were prepared: the first group were reference parts, and the second group of samples were welded and then exposed to a corrosive environment. Corrosion tests were performed by immersing the samples in an acidic solution of MACK60 (1,5 ml HNO_3, 8 ml HCl and 2 g NaCl). Both groups of samples were tested with specially developed vibrating equipment for high cycle fatigue with cyclic tests performed in the range of 280 MPa to 470 MPa, and the durability of the specimens in the range of 104 - 107 cycles. The durability of SAF 2507 steel is estimated by the number of cycles until a crack is obtained at a certain alternating load. The damaged surfaces were examined by microstructural analysis to trace the shape and development of the crack in the structure of ferro-austenitic steel SAF 2507 after its welding and corrosion.

The following conclusions can be drawn from the research conducted:

- Severely corroded specimens that formed a concentrator for crack development due to intergranular corrosion were found to withstand significantly less cyclic loading. It was also found that samples with a percentage weight loss of up to 0.25% due to the corrosion effect had no change in durability.
- Based on the conducted cyclic fatigue tests, a fatigue curve was compiled for both types of materials, a limit was established below which no crack initiation was observed (340 MPa for the welded samples and 320 MPa for the corrosive ones).
- After the metallographic analysis, it was established that in the samples subjected to corrosion, the development of the fatigue crack in the areas with a

finely divided fibrous structure, the crack passes through the grains, in the other cases the crack passes transcrystalline.

- It has been established that in welded samples after corrosion, the fatigue crack passes through the seam zone and has a curvilinear character, and subsequently, passing through the alloying zone and entering the base material, it acquires a linear character.

B.4.8 Spasova D., Argirov Y., Atanasov N., Yankova R. (2022). Analysis of failure causes of S135 drill pipe. Materials Today: Proceedings, E-ISSN:2214-7853, 59, 1719-1725, doi: org/10.1016/j.matpr.2022.04.026 https://www.sciencedirect.com/science/article/pii/S221478532202140X

The task of the study is to investigate the reason for the premature failure of the grade S135 steel drill pipes, used for drilling oil and natural gas, which failure before reaching the permissible load cycles at a depth of about 4500 meters. To prevent accidents from occurring, the drill pipe is to have the required reserve static strength and sufficient fatigue resistance. In the lower zone, where the stress is compressive most frequent occurrence of fatigue cracks in drill pipes. The combination of cyclic loads and corrosion reduces the life of the pipes by several thousand cycles, and for this reason mechanical tests of tensile strength, impact toughness, and fatigue strength were conducted of samples made from the investigated drill pipe. During the drill pipe operation, besides the heavy-load operating mode, an additional impact is made by the corrosive environment, abrasive and pitting wear depending on the ground, therefore macrostructural and microstructural analysis were performed. The obtained data were analyzed and compared with the technical characteristics of S135 steel given by specification. After the analysis, based on the results obtained we can conclude:

- From the conducted microstructural analysis of the investigated drill pipe is established presence of metallurgical defects, which significantly reduces the steel quality and can contribute to the crack source creation. The presence of a microconcentrator (large pore, or group of micropores) is a prerequisite to occur fatigue cracks, which leads to decreased durability of the material.
- After the mechanical tests the presence of macro defects was established in the fracture area caused pitting corrosion due to the interaction of the soil primer and the outer surface layer of the pipe in operational mode, which leads to a decrease in the ultimate strength of the material and also is a prerequisite for premature material failure. The active interaction of the dispersed soil primer with the macropores creates conditions for the development of a crack source on the outer surface and is a main reason for the premature failure of the S135 steel drill pipes.

- For some samples, the mechanical properties are close to those of the steel specification from which we can conclude that the spread of defects is not uniform throughout the pipe volume. This problem can only be solved at the production stage- to be specify the casting technological parameters of billets from which the drill pipes are produced. To be controlled the chemical composition and in particular the chemical elements (Cr, Mn) influencing the deoxidation of the steel melt.

B.4.9. Spasova D., Argirov Y., Petrov P., Mechkarova T. (2023). Study of the Behavior and the Mechanical Properties of Adhesively Bonded Polymer Matrix Composites Under Mechanical Loading. TEM Journal, ISSN: 2217-8309, 12(1). doi: 10.18421/TEM121-05 https://www.temjournal.com/content/121/TEMJournalFebruary2023_36_42.pdf

The main aim set in the present work was reduced to the obtaining of PMCs made by adhesive bonding of two composites with a matrix of different types of resin (vinyl ester and epoxy) and the study of their behavior in determining their mechanical properties. The studies were carried out with four types of adhesively bonded PMCs made in the form of laminates produced from a combination of three types of resin (two types of vinyl ester and one type of epoxy resin) and reinforced with biaxial fiberglass. The aim is to combine the lack of shrinkage of the epoxy resin with the better mechanical properties and better productivity of the vinyl ester resin. An analysis to determine shear strength, under the influence of mechanical load, and given the specificity of the mechanism for the formation and propagation of the crack, tensile strength and bending strength of the investigated composites was made. A macrostructural fractographic analysis to investigate the material behavior under mechanical loads was carried out.

After the studies carried out and based on the results obtained, we can conclude:

- The methodology used for adhesive bonding two types of PMCs with a matrix composed of different (three types of) resins leads to positive results and, accordingly, to increase the complex properties of standard PMCs.
- For all four types of PMCs, almost identical values for tensile strength and bending strength were obtained, similar to the values of tensile strength and bending strength of similar PMCs found in previous studies, indicating that the adhesive bonding area does not affect the mechanical properties of the studied PMCs.
- The results of the mechanical tests and the macrostructural analysis conducted confirmed that a good adhesive bond with high cohesive strength was formed in the adhesive bonding area of the specimens, which did not affect the

overall strength of the adhesively bonded composite, or if there is any influence it is insignificant.

B.4.10. Petrov P., Mincheva D., Atanasov N., **Spasova D.** (2023, August). Analysis of the causes for destruction of mechanically reinforced low-carbon steel strips. In AIP Conference Proceedings (Vol. 2868, No. 1). AIP Publishing. E-ISSN:1551-7616, doi.org/10.1063/5.0165443 https://pubs.aip.org/aip/acp/article-abstract/2868/1/020015/2906492/Analysis-of-the-causes-for-destruction-of?redirectedFrom=PDF

The article analyses the results of technical control of two tipes low-carbon, low-alloyed steel plates with high strength, widely used in the automotive, engineering and construction industries in order to determine the causes of the frequent failure of a series of manufactured plates. The chemical composition control by a spectral spark analyzer/Spark analyzer - SPECTROMAX M07 and comparative mechanical tensile tests (to determine the tensile strength Rm, yield strength Rp0.2, elongation A) has been done. A microstructural analysis was carried out, and the microhardness, surface hardness and surface roughness of the studied samples were measured. The first type has been compared, with the steels used in this area (strips, fasteners and parts and frames of vehicle suspension) by standard, with steel DC01 + C690 (EN 10139: 1997) and 08 ps or 08 kp (GOST 503- 81).The first type are compared, with the steels used in this area (plates, fasteners and parts and frames of vehicle suspensions) by standard, with steel DC01 + C690 (EN 10139: 1997) and 08 ps or 08 kp (GOST 503-81).

After the analysis we can conclude:

- Both structures are ferrite-pearlite highly textured, which indicates that both steels are mechanically hardened, although, according to their chemical composition, strengthening by heat treatment is also possible.
- Although the measured slightly higher hardness, the strength characteristics of steel-2 are about 10% lower in tensile strength and about 15% lower in conventional yield strength than steel-1. The most likely reason for this is the rougher surface of steel-2 (Ra=3.25μm, Rz=17.48μm, Rq=3.9μm) compared to that of steel-1 (Ra=0.40um; Rz=4.22 um; Rq=0.57um), and in support of this, a negative influence of the increased roughness on the fatigue limit and the tensile strength of the steels was found, respectively

- In order to avoid the destruction of the parts made of these steels leading to significant economic losses and labor accidents, manufacturers are recommended to carry out periodic control of the roughness of the produced parts, as it is necessary to experimentally select permissible values, in case of exceeding which actions should be taken to reduce and.

Summaries according to indicator G.7 - scientific publications in publications that are referenced and indexed in world-renowned databases with scientific information

G.7.1. Yankova R., Nikolaeva D., **Spasova D.** (2022). Engineering Software for Calculation of Pre-Insulated Bonded Pipe Systems for Heat Transmission Networks. U.P.B. Sci. Bull., Series C, Vol. 84, Iss. 4, 349-360
https://www.scientificbulletin.upb.ro/rev_docs_arhiva/rez05d_885660.pdf

The article presents a methodology that ensures compliance with the conditions for limit load during operation он pre-insulated bonded pipe systems (PiPS), used in the heat transport industry on the heat transmission network. Their specific construction allows laying directly in the ground and transportation of fluids with high operating temperatures and pressures. Engineering software has been created related to the calculation of stresses and elongations in a certain section, taking into account the change in the length and diameter of the pipe, the depth of laying. It offers the pipeline sizing methodology, which includes an algorithm for the distribution of systems of Pre-insulated connected pipes for heat supply. Based on the methodology, an engineering software based on Design Patterns was created to calculate stresses and strains in Pre-insulated connected pipe systems for heat transfer networks, assuming a change in diameter. Design Patterns that are used in engineering software are 4 for 4 types of functionality: visualization of images and graphics (Abstract Factory), defined data and flight parameters (Fluent Interface), database (Singleton), real-time information input and processing (Data Mapper). In conclusion, it can be said that:

- An engineering software based on DPs has been created for the calculation of stresses and strains in pre-insulated connected pipe systems for heat transfer networks, which, although rudimentary, reduces the design effort by automating data processing.

- The contribution in the developed software is related to the expansion of the functionality of the software system by adding: sizing compensators; dimension of linear displacement in tees; sizing the number and length of foam pads; and other calculations.

Summaries under indicator G.8 - scientific publications in non-refereed peer-reviewed journals or in edited collective volumes

G. 8.1. Radev R., Atanasov N., **Spasova D.,** Iliev S., 2002 "Vacuum Impulse Casting of sphere type thin- walled casts", Meet Marind'2002 Proceedings, Varna, Bulgaria, 7-11.11, volume III, p. 163-166

This paper presents a developed methodology for obtaining thin-walled castings of the "sphere" type, based on fusible models of CuSn5Zn5Pb5 brass alloy, by vacuuming the mold, the purpose of which is to solve the problem of producing castings with a small wall thickness (δ = 0, 2 mm). Their main disadvantage is that the melting equipment as well as the mould, into which the metal will be poured, are incorporated in one casing. In the developed methodology, the alloy is melted under atmospheric conditions, and the melt fills the cavity of the casting mold and crystallizes under vacuum conditions. For this purpose, a device has been developed, in which the casting form, made of a liquid-pourable gypsum mixture, is poured under conditions of vacuum in pulses, i.e. the working space is isolated from the atmosphere by a metal membrane, which is placed between the funnel and the mold. The influence of the degree of vacuuming of the cavity of the casting mold and the thickness of the insulating membrane on the filling of the cavity of the casting mold was investigated.

The following conclusions can be drawn from the obtained results:

- The developed technology of vacuum pulse casting allows the production of thin-walled, dense castings with complex relief with significantly reduced production costs, compared to conventional technologies.

- It has been found that the use of insulating membranes with a thickness of 0.05 mm and 0.1 mm and a maximum degree of vacuuming of the mold results in 100% filling of the mold.
- As the thickness of the metal membranes increases, the filling of the mold is significantly reduced. This is generally related to the loss of heat from the metal melt to melt the insulating membranes.

G.8.2. Spasova D., Radev R., Atanasov N., Iliev S., 2003. "Investigation of the use of non-metallic membranes in vacuum pulse casting", Mechanical engineering and technologies, ISSN 1312-0859, Varna, pp. 44-46

The research is carried out with the help of a specially developed device for vacuum pulse casting of non-ferrous alloy castings in fusible patterns, with a small wall thickness. The main point is the use of non-metallic membranes that isolate the mold from the atmosphere and cause a pulsed infiltration of the melt into the cavity of the mold. The object of research are four types of materials of organic origin (polyethylene (colored), polyethylene (colorless), styrofoam, styrofoamin combination with aluminum foil) used for the production of membranes. The investigated parameters to determine the suitability of the membrane material are: the gas-forming ability of the material, the filling of the cavity of the casting mold, determined by the length of the cast helix (thinness test); degree of vacuuming of the mold. The kinetics of gas formation as a result of membrane combustion was determined for each material. Studies have been conducted to determine defects of a gaseous nature.

From the conducted experiments, the following conclusions can be reached:

- A methodology for obtaining thin-walled castings without gas defects, in the conditions of vacuum pulse casting, by pressurizing the forms with several types of membranes, has been developed and studied.
- It has been established that the used membranes allow the mold to be practically maximally pressurized before pouring, in accordance with the capabilities of the equipment used, and during the pouring process it practically does not depressurize.

- The developed methodology for pressurizing the mold and filling it with metal allows to increase the degree of filling of the mold by about two times.
- When using a membrane made of styrofoam, the degree of vacuuming of the mold is slightly smaller compared to the others, but the lower gas-forming ability of styrofoam leads to an increase in the fillability of the mold.
- It was found that the gas-forming ability of the membranes negatively affects the fillability of the mold, but no gas defects are produced in the obtained test bodies, which can be considered as one of the most important results.

G.8.3. Iliev S., Radev R., Atanasov N., **Spasova D.,** 2003 "Electrolytic molding of fusible models", AMTECH', Mechanical engineering and technologies, ISSN 1312-0859, Varna, pp. 40-43, pp. 103- 107

The paper examines the possibilities for obtaining ceramic molds with non-conductive models, made of a wax-paraffin mixture, using the method of electrolytic molding. For this purpose, a methodology has been developed for obtaining a electrically conductive layer on a electrically non-conductive model, so that it is possible to carry out electrolytic molding, by which ceramic molds are obtained. The technological features for preparing the mixture necessary to obtain shell shapes of a certain thickness are presented. The main point is to create an electrically conductive layer by activating the pre-applied ceramic layer with a 4% aqueous solution of HCl. The obtained ceramic shells are dried and fired at 950°C, after which they can be used to make castings. The kinetics for the formation of a ceramic shell under different variants of creating conditions for the electrodeposition of the ceramic suspension on the non-conductive models was investigated.

The main conclusions that can be drawn regarding the quality of the ceramic shells and the suitability of the electrolytic molding method are:

- A methodology has been developed for obtaining a ceramic shell on an electrically non- conductive wax model, which makes it possible to control the thickness of the formed shell, depending on the technological requirements for the casting mold.

- The conducted research proves that the formation of a shell with a thickness of 5 to 6 mm from the investigated ceramic mixtures can be obtained in a period of 5 to 8 minutes.
- Accurate copying from the shell of the model block is achieved due to the chemical method of creating an electrically conductive layer.
- Large porous defects are not observed on the ceramic shell due to the type of slurry used (type of refractory filler and pH).

G.8.4. Yankova R., **Spasova D.**, Petrov P., 2017 "Abrasion of welded layers in dry friction", "Scientific notices" ISSN 1310-3946, Year XXV/ Issue 1 (216), June/June, p.: p. 258-261 https://www.ndt.net/article/NDTDays2017/papers/59.pdf

The article presents a comparative study of the tribological characteristics of welded layers with abrasive wear-resistant electrodes (EH550, OK Weartrode 60T, Abradur 64, Abradur 66) on samples of medium-carbon, low-alloy steel 40X. The aim of the scientific research is to analyze the properties of different types of materials that are used to restore parts subjected to abrasive wear in agricultural and construction machinery, and to determine the influence of the hardness and structure of the welded layer on its wear resistance. Multi-layer welding was performed with preheating of the samples, and the welding mode was in accordance with the manufacturer's instructions. Abrasive wear of the samples is investigated under conditions of dry friction on a surface with firmly attached abrasive particles with a "Thumb Disc" tribotester. Experimental results were obtained for mass wear, wear intensity and wear resistance of the studied samples. The phase composition of the welded layer of the specimen with the highest wear resistance (welded with Abradur 66) was determined before and after abrasive wear by X-ray phase analysis.

Based on the conducted research, the following conclusions can be drawn:

- Welding with abrasive wear-resistant electrodes significantly increases wear resistance. Under the specific wear conditions - dry friction on the surface

with firmly attached abrasive particles, the highest wear resistance is obtained with a welded layer with Abradur 66.

- • From the X-ray structural phase analysis, it was found that an austenitic structure with carbide inclusions was observed in the welded layer before abrasive wear testing, an austenitic structure with carbide inclusions was observed, which were preserved as a metastable structure. As a result of wear, structural changes take place, such as austenite transforms into martensite, as a result of cold- hardening of the material, which favors wear resistance.
- The analysis of the results of abrasive wear allows to take measures to increase the durability of the machine elements by creating improved surface layers that have high operational properties.

G.8.5. Spasova D., Atanasov N., Stoyanov P., Yankova R., 2017 "Quality Evaluation of Complex Relief Metal Matrix Composite Producted by Using The Capillary Forming Method", Scientific Notices" ISSN 1310-3946, Year XXV/ Issue 1 (216), pp.: 251-253 https://www.ndt.net/article/NDTDays2017/papers/57.pdf

The object of research in the presented work is a complex-relief matrix metal composite (MMC), the "in vitro" and "hybrid" type, with a copper alloy matrix (CuZn38Pb2) and a reinforcing iron phase, obtained in one-time casting molds by the "capillary molding" method . The characteristic of the method is that the metal matrix (melt) is forcibly infiltrated into the capillary spaces of the strengthening phase, which is fundamentally a newly developed technology for the production of MMCs. The purpose of the conducted research is to establish whether the method for obtaining MMCs is effective and leads to obtaining solid castings, with a complete filling of the capillary spaces between the elements with the non-reinforcing phase with melt (the matrix). The presence, type, size and location of imperfections (incompleteness) in the resulting composite were examined by means of X-ray radiographic control (with X-ray defectoscope XBM 160/225 YXLON), because with ultrasonic non-destructive testing, defects with a diameter of less than

1 mm cannot be registered. The casting was irradiated in two directions - initially in the "x" direction and subsequently rotated by 90° in the "y" direction.

After the quality control and based on the obtained results, the following more important conclusions can be made:

- From the radiographic control, it was established that the resulting composite has a dense structure, and three groups of pores of insignificant sizes were found in the volume of the composite (the diameter of the largest pore is less than 0.1mm).
- From the evaluation of the casting quality level, according to BDS EN ISO 5579; BDS EN 12681; norm: ASTM E 272; ASTM E310; ASME BPVC Sec. VIII, Div. 2, AM-252.1, it was found that the resulting composite has very few imperfections and meets the set requirement for high casting quality - class A1.
- The high quality of the obtained complex-relief MMC, established by the radiographic control, proves that with the developed methodology for its preparation, the melt successfully infiltrates into the capillary spaces between the particles of the strengthening phase, resulting in a dense structure, without the presence of significant defects.

G.8.6. Spasova D., Atanasov N., Radev R., 2017“Investigation of the interaction between the CuZn38Pb2 matrix and the Fe reinforcement phase during the production of the complex relief MMCs”, Prace Instytutu Odlewnictwa, Vol. 57, no. 4, ISSN: 1899 - 2439 p. 315—319 DOI: 10.7356/iod.2017.31
http://www.prace.iod.krakow.pl/praceio/1517831183de9522074.pdf

The present paper investigates the interaction between the copper alloy metal matrix (CuZn38Pb2) and the reinforcing phase (Fe) during the construction of "hybrid" cast complex-relief metal matrix composites (MMCs). An innovative production method (based on the "capillary forming" method) was used to obtain composites with a controllable geometry of the reinforcing phase and the metal matrix, by spatial vacuuming of the working chamber in three directions and subsequent forced infiltration of the metal matrix into the capillary spaces between the elements of the strengthening phase. An advantage is that single blanks can also be obtained economically, by using conventional methods for making ceramic casting molds on a gypsum or cement base. Given the long high-temperature process of obtaining complex-relief MMCs, diffusion processes leading to interaction between the matrix (CuZn38Pb2) and the strengthening phase (Fe) are expected. In order to clarify the phase composition of MMCs and the ongoing diffusion processes, microstructural and X-ray phase analysis were carried out.

The change in hardness of the newly formed composite phases was also analyzed.

Based on the conducted research, the following conclusions can be drawn:

- The developed methodology for obtaining complex-relief cast composites (MMCs) in one-time casting molds (ceramic, gypsum or cement-based, etc.), leads to obtaining a dense structure in the volume of the composite, such as areas with volumetric defects (pores, unfilled) are minimized.
- From the X-ray structural phase analysis of LMK with matrix brass CuZn38Pb2 and reinforcing phase iron, it was established the presence of diffusion processes leading to the production of a chemical compound Fe_3Zn_{10} (phase Γ), separated along the boundary of the iron particles, as a result of the diffusion of Zn from the saturated zinc α-Cu in the crystal lattice of Fe.
- The measured hardness in the newly obtained structure is significantly higher than the hardness of the starting materials. In the region of the strengthening phase Fe, the measured hardness is on average 150HV, 100 units more than the hardness of pure iron - 50HV, and in the area of the CuZn38Pb2 matrix, the measured hardness is on average 120HV, in contrast to the hardness in the initial state of the alloy-70-80HV, which also proves the diffusion processes during the preparation of the studied MMCs.

G.8.7. Spasova D., (2018) „Production of Metal Matrix Composite With Fibrous Reinforcemt Phase of „In Vitro“ Tipe‘‘, Известия – Варна, 1’2018, ISSN 1310-5833, стр. 24- 30 20

The aim of the present paper is to investigate the possibilities of obtaining cast metal matrix composites (MMCs) and fibrous reinforcing phase type "in vitro". In this case, the studied MMCs are with a metal matrix alloy ZnAl4Cu1 (zamak) and a reinforcing phase of glass fibers. Research on MMCs construction methods has been reduced to the use of various space vacuum schemes for the synthesis of MMCs using the idea of the “capillary molding” method. In the classical method for obtaining cast composites "in vitro", a mechanism of forced introduction of the reinforcing phase into the prepared melt and subsequent homogenization of the composite structure is applied, and in the present case, first the reinforcing phase (glass fibers) is placed in the mold, and then the metal matrix (zamak) in the form of a melt is forcibly infiltrated into the spaces between the elements of the reinforcing phase by vacuuming. The obtained MMCs were tested in impact bending and investigated by means of macro- and microstructural analysis.

After the experiments, based on the obtained results, the following more important conclusions can be summarized:

- The used scheme of capillary molding enables the construction of innovative new cast metal composites (MMCs) with a non-metallic fibrous reinforcing phase (glass fibers) and a ZnAl4Cu1 matrix, through conventional methods for making casting molds (with quick-setting molding compounds), unlike conventional methods where expensive metal gear is used.
- Increased values were reported in the impact toughness test (KCV = 50 J/cm2), compared to those given according to the specification for the alloy (ZnAl4Cu1) building the matrix (KCV = 15÷30 J/cm2), due to the reinforcement and fiber reinforcements elements. This is a prerequisite for the realization of the technology for obtaining MMCs in production.
- The expected higher values for impact toughness were not justified, because during the microstructural analysis, areas with non-wetting of the elements of the strengthening phase were found and intermittent distribution of fibers in the volume of the composite, which is a prerequisite for underestimating the mechanical characteristics. The solution to the problem will be the subject of further research.

G.8.8. Spasova D., Atanasov N., 2018"Investigation of The Production Of „In Vitro" Tipe Metal Matrix Composite with Low Melting Alloys Matrix", XXV International Scientific and Technical Conference, 18-20 April, Pleven, Bulgaria, Year II, ISSUE 1 (2) ISSN 2535-017X (Print), ISSN 2535-0188 (Online), p. 32- 35
https://metalcasting.eu/sbornik/2018.pd

The purpose of the conducted research is to investigate the possibilities of obtaining fundamentally new "in vitro" type multiphase composites with a metal matrix (MMSs), with a low melting temperature - zinc alloy ZnAl4Cu1 and tin (Sn) and strengthening phase Cu,Al2O3, SiC. Two different methods were used to wet the reinforcing phase from the metal matrix in combination with vacuuming the volume of the mold, using the idea of the "capillary molding" method. In the first variant, the mold together with the elements of the strengthening phase (Cu, Al2O3 or SiC) is placed in the device and heated to the temperature of pouring the mold, then it is poured with the molten alloy, which self-pressurizes the system and infiltrates the capillary spaces between the elements of the strengthening phase. In the second option, the metal matrix is built in two stages – first, the elements of the strengthening phase (powder particles Cu,, Al2O3, or SiC) are poured into the cavity of the casting mold. in an amount of about 60% together with metal powder from the matrix material in an amount of about 10%, are placed in the installation and heated to the pour

temperature of the matrix, at which the particles of the matrix material melt and wet the reinforcing phase. The next stage is to pour the already wetted strengthening phase with the previously prepared melt (30%) of the matrix material, as a result of which there is the additional pressing of the composite being built by the melt and subsequent infiltration of the same into the unfilled spaces between the elements of the strengthening phase. The following conclusions can be drawn from the metallographic analysis of MMCs:

- The used methodology for obtaining MMCs makes it possible to build dense composites with a matrix of alloys with a relatively low melting temperature, which can be used to obtain sliding bearings operating under specific pressure, static and shock loads, etc.
- From the two methods developed for obtaining MMCs (with and without preliminary mixing of elements of the strengthening phase with metal powder from the matrix, and subsequent pouring with a melt forming the matrix) better wetting of the strengthening phase and, accordingly, a denser structure is obtained in cases where the elements of the strengthening phase are pre-mixed with metal powder from the matrix and heated to complete melting of the latter.
- The MMCs obtained by the studied method are distinguished by a significantly higher content of reinforcing phase than those obtained by forcing the latter into the pre-melted metal matrix.

G.8.9. Spasova D., (2018) „Investigation of the Structural Improvements after Heat Treatment of the Aluminium AlSi7Mg Alloy Wheels“, International Journal “NDT Days”, ISSN: 2603-4018, Volume I / Issue 1 pages 526-531
https://www.ndt.net/article/NDTDays2018/papers/JNDTD-v1-n4-a14.pdf

In this paper, the structural defects determining the mechanical properties of cast aluminum wheels of AlSi7Mg alloy obtained by low pressure casting are investigated. This alloy has very good casting properties, especially in terms of mold filling and minimal shrinkage. The other advantage is that it is thermally toughened, which allows to further increase the strength of the part. To strengthen the cast wheels, the heat treatment standardized as "T6" is used - hardening at a temperature of 515 to 540 ºC and subsequent artificial aging at 170 ºC, with a retention time of 8 hours. The aim of the present work is to investigate the structural changes of cast aluminum wheels of AlSi7Mg alloy, before and after additional heat treatment with mode "T6", with the aim of changes in the structure respectively in the properties of the studied objects. From the above-mentioned castings, test bodies were made for macro- and microstructural analysis in order to establish the changes in the structure. The macrostructural analysis was carried out

on samples in which a tensile test has previously been carried out. From the conducted structural studies, the following more important conclusions can be drawn:

- After the macrostructural analysis, it was found that in the case of the heat-treated sample, the structure is, as expected, finer-grained and with transcrystalline destruction, compared to the original one, and, accordingly, better mechanical properties.
- The size and distribution of the pores in the individual zones in both types of samples is identical, i.e. no increase in pore volume was observed after heat treatment.
- From the conducted microstructural analysis, it can be seen that in the thermally treated samples, part of the Si from the eutectic Ev (α+Si) dissolves in the α solid solution, because upon reheating the α saturated solution, dispersed zones are separated which are coherently connected to the matrix. The eutectic breaks down and the coagulated silicon crystals are arranged along the boundaries of the α solid solution, which is the reason for the hardening of the material.
- The selected mode of heat treatment "T6" of AlSi7Mg alloy aluminum wheels, carried out in order to increase the mechanical properties, does not lead to an increase in the volume of defects (pores), but only an improvement of the structure and, accordingly, of the mechanical properties.

G.8.10. Spasova D., Yordanov K., (2018) „Mathematical model of the heat interaction between the metal matrix and the reinforcement phase during the production of Metal Matrix Composites“, ANNUAL JOURNAL OF TECHNICAL UNIVERSITY OF VARNA, e-ISSN: 2603-316X, BULGARIA, 2(1), June 30, 2018, p. 1 - 8. http://dspace.tu-varna.bg/handle/123456789/55

The present paper is relevant to the establishment on mathematical model of the heat interaction between the metal matrix (liquid phase- Cu) and the reinforcement (solid- Fe) phase, during the production of the Metal Matrix Composites (MMCs) by the method of capillary molding. In this case a heat object is substituted with a mathematical model, drawn up and grounded to investigate the original behavior and properties, clarifies temperature fields in bodies. The established simulation clarifies temperature fields and the causal liaison between the metal matrix and the reinforcement phase in the formation of the macro and microstructure at the time of production of MMCs. Casting process simulation is an approved method for the optimization of the methods of casting technology. The basic opportunities, ideology and structure of the software "MATLAB FEA" (Finite Element Analysis) are

introduced to simulate the casting technology. The possibilities of the product are illustrated by the results, obtained from a computer simulation by the technical process of the production of MMCs. The research process is accompanied by temperature measurement in the working chamber, based on which a mathematical model of the interaction of the metal matrix and the reinforcing phase was created. The temperature of phase transformation from solid to liquid state and the behavior of the two phases relative to each other (the strengthening phase Fe and matrix Cu) are considered. After the analysis, the following conclusions were drawn:

- On the basis of the measured temperatures during the preparation of the complex-relief MMCs, the use of a mesoscale phase field has been demonstrated to create a mathematical model of the behavior of the liquid phase (melt-Cu) in relation to the strengthening phase (Fe).
- A simulation was created, which clarifies the temperature fields and the causal liaison between the matrix and the reinforcement phase at the time of obtaining the complex relief MMC by the capillary molding method.
- The created mathematical model provides an opportunity to clarify the interaction between the liquid and the solid phase, based on the temperature field, thus contributing to clarifying the wetting of the strengthening phase.
- It has been established that the construction of complex relief MMCs, by the "capillary molding" method, emerges as a new technology for the production of a topological complex of metal-composite structures with an ultra-high interfacial region and other unique qualities.

G.8.11. Spasova D. (2019). Investigation of the structure and the properties of 18ХГТ (1.2162) Steel Gear-Wheel Surface Hardened by Vacuum Carburizing. Int. J.“NDTDays”,ISSN: 2603-4018, 2, 569-75. https://www.bg-s-ndt.org/journal/vol2/JNDTD-v2-n5.pdf#page=69

The task of the present study is to specify the technological features of vacuum carburizing of gears made of steel 18XGT (1.2162). For this purpose, the structure of the surface of a gear wheel made of steel 18XGT (1.2162), hardened by vacuum carburizing in industrial conditions, was investigated. The vacuum carburizing technology allows obtaining a non-oxide surface and a homogeneous distribution of the saturation phase. By means of microstructural analysis and X-ray structural phase analysis, the structures of the carbonized surface layer, as well as the structure in depth, were investigated. The microhardness in depth of the hardened layer was also measured.

From the conducted research, the following conclusions can be drawn regarding the technological mode of vacuum cementation:

- The carburizing mode used and the examined structures give us reason to believe that the cementation temperature can be lowered by 10 degrees.
- The intermediate heating times used are increased, especially at higher temperatures, because the heating rate is extremely low.
- It is possible to reduce the carbon potential, in order to reduce the amount of residual austenite in the surface layer, by reducing the number of acetylene (C2H2) injections.
- The chosen mode of vacuum carburizing allows obtaining a non-oxidizing surface, which is proven by the macrostructural analysis, in which no oxidation of the surface is observed.
- In general, it can be concluded that the chosen methodology for vacuum carburizing accelerates the technological process, compared to conventional cementation methods.

G.8.12. Spasova D., Argirov Y., MECHKAROVA T. (2020) Investigation of The Strength and Elastic Characteristics of Elastic Rope Used in Safety Equipment. International Journal "NDT Days", ISSN: 2603-4018, Volume III, Issue 5, ISSN: 2603-4018, p. 569- 575 https://www.ndt.net/article/NDTDays2020/papers/JNDTD-v3-n5-a07.pdf

The paper investigates the suitability of an elastic rope used to make safety equipment in the shipping industry. The researched object - an elastic rope with a round cross-section of 25.5 mm, a product of the German company JUMBO-Textil, is made using an innovative technology, different from the one known so far. The rope consists of a rubber core consisting of 300 rubber fibers and two outer braided sheaths of polyamide fabric, the purpose of which is to protect the rubber fibers

from external influence. The peculiarity of making this type of wrap is that the threads are not intertwined at right angles to each other, but cross to each other. For the purposes of the study, a tensile test was conducted, and the mechanical characteristics of the examined elastic rope were determined, to determine the load it will withstand when used in rescue equipment. Macrostructural analysis was also performed.

The following conclusions can be drawn from the conducted research:

- The researched elastic rope object is made using an innovative technology, different from the one known so far, because is made of a rubber core and a double outer shell of high-quality polyamide fabric, with high strength and elastic characteristics.
- The first shell loses its maximum resource at a load of 2800 N, and relative elongation reaches values A = 867% (Lo = 70 mm, Lu = 677 mm). Failure of the second shell begins at a load of Fm = 2850 N, and the value of the relative elongation doubles A = 1738 % (Lo = 40 mm, Lu = 735 mm). This circumstance proves that this type of elastic rope has double protection, which in turn enables timely intervention in the event of an accident, even if there is a tear in the outer layer, and guarantees safety, because the second layer has higher mechanical characteristics.
- From the conducted research, it was established that the research object - an elastic rope product of the German company JUMBO-Textil, is suitable for use in the production of rescue equipment used in the shipping industry.

G.8.13. Tatyana MECHKAROVA, Yaroslav ARGIROV, Nikolay ATANASOV, **Daniela SPASOVA**, (2021). Technology and Equipment for Annealing on a Welded Strip from GS- 50CrV4, International Journal "NDT Days", ISSN: 2603-4018, Volume IV, Issue 4, p. 238- 242 https://www.bg-s-ndt.org/journal/vol4/JNDTD-v4-n4-a04.pdf

The present paper investigates the repair-restoration activity of GS50CrV4 spring steel strip with dimensions: width 50mm, length 150000mm and thickness 3mm, subjected to highly variable tensile stresses. The strong tensile load and high temperatures (between 100 and 200 degrees), in the mode of operation of the studied parts, lead to their periodic destruction. The aim of the research is to create

an economical and reliable technology for repair restoration of these details in workshop conditions, without having to completely replace it or transport it to an outside repair company. Most often, the repair activity consists of welding activities with portable equipment or metal cutting operations. The parts that are subjected to welding activities have a chemical composition that requires mandatory heat treatment, due to the fact that it must meet certain set mechanical characteristics (hardness, strength, etc.). Control of the technological process is carried out by measuring hardness in the different areas of the part.

The results of the research can be summarized in the following conclusions:

- A technology has been developed for repair and restoration activity in a working environment of GS50CrV4 spring steel strip in the following sequence: 1- Tungsten Inert Gas (TIG) Welding in the destroyed area, with filler material; 2- Next gas flame tempering with a specially made copper burner, with heating up to 980°C; 3- Rapid cooling between aluminum plates with water; 4- Annealing at 200°C in an electric resistance furnace specially made according to the working conditions;
- The performed control proves that the developed technology for repair and restoration activity in a working environment, on GS-50CrV4 (SEW 835) spring steel strip, leads to positive results, and at the same time it is also economically expedient (saving time and expenditure of funds).

G.8.14. Daniela SPASOVA, Yaroslav ARGIROV, Radostina YANKOVA, Nikolai ATANASOV, (2021). Study of Tensile Strength and Cyclic Fatigue of Polymer Matrix Composite Materials. International Journal "NDT Days", ISSN: 2603-4018, Volume IV, Issue 2, p. 140- 147 https://www.bg-s-ndt.org/journal/vol4/JNDTD-v4-n2-a10.pdf

The present paper is related with the investigation of some strength characteristics of fiberglass reinforced polymer matrix composite (PMCs), suitable as materials used in equipment operating in marine environment. The working environment requires these composites to have high strength properties, especially regarding fatigue strength. Fatigue is the most common cause of failure, because

the loads are obtained as dynamic due to the oscillation frequencies that the motors and screws generate during operation. This fact determined the purpose of the present work namely, to determine the tensile strength and cyclic fatigue strength of the studied composite materials, to assess their suitability for production facilities and equipment operating in marine environments. A macrostructural analysis was also carried out in the failure zone of the samples. The investigated materials are four-layer polymer-matrix composites (PMCs), with matrix polyester resin and reinforcing phase glass mat 300 g/sm^3 and fiberglass mesh 145 g/m^2. One of them is with a reinforcing phase glass fiber mat and in the other two the reinforcing phase is composed of fiberglass and fiberglass mesh with different fiber orientation.

The following conclusions can be drawn from the conducted research:

- Better mechanical properties, determined after tensile testing, are observed for PMCs with a glass mat-only reinforcing phase, because the glass fibers are randomly distributed, which in turn leads to isotropic (identical properties regardless of the orientation of the reinforcing phase). Anisotropic properties are observed in the composites with fiberglass mesh reinforcement material, i.e. there is a dependence on the direction of orientation of the fibers in the volume of the composite.
- An increase in plastic properties is observed for the composite with the reinforcing phase fiberglass network oriented at an angle of 45°.
- The maximum stress and the maximum number of cycles for destruction of the considered material were determined simulatively.
- After the fatigue tests performed, it was found that the three composites have approximately the same fatigue strength.

G.8.15. MECHKAROVA T., ARGIROV Y., SPASOV D., STOYANOVA A. (2021). STRUCTURAL CHANGES OF NITROGEN FERRITE AFTER AGING IN TEMPERATURE INTERVAL UP TO 100 C. Annals of the University Dunarea de Jos of Galati: ISSN L 2067-2071, Fascicle IX, Metallurgy & Materials Science, 39(1) https://www.gup.ugal.ro/ugaljournals/index.php/mms/article/view/4319

The research in the presented article aims to determine to what extent the nitrogen- ferrite aging occurs below 100°C, after gas carbonitriding and subsequent quenching of technical pure iron (Armco). The Armco iron samples were pre-

deformed by a tensile testing machine, with a strain rate of ε=16%, and then recrystallization annealed at a temperature of 700°C and a duration of 2 hours, which achieves a coarse-grained ferrite structure with an average size of the ferrite grain Ī=105μm. After gas carbonitriding with low-temperature saturation at t=570˚C and cooling in water, nitrogen- ferrite is obtained. In order to be able to carry out X-ray structural studies of the ferrite phase, the carbonitride zone consisting of ε-carbonitride in the surface layer was removed by electrochemical etching. Aging is carried out in a laboratory chamber oven with a fan for convective heat exchange in the volume of the chamber up to a temperature of 100°C. In order to find out what structural and strength changes the aging process leads to, the microhardness in the individual grain was studied and an X-ray structural analysis was carried out.

In conclusion, it should be noted:

- The supersaturated nitrogen- ferrite formed after low-temperature gas carbonitriding has a tendency to age, being to the greatest extent strengthened in a temperature range of 80-90°C and held at these temperatures for 80 to 100 minutes. The measured units of microhardness are 460-465HV, for comparison the initial hardness in the diffusion zone of nitrogen- ferrite is in the range of 250-320HV.
- In the aging regime, these intervals of optimal temperatures and durations turn out to be too narrow, which is due to the high sensitivity in the coherent interaction between the nitride phase (α") and the ferrite matrix (α).

G.8.16. Spasova D., (2023), Study of the formation of a surface layer of castings between two liquid phases, Machines Technologies Materials 2023, Volume III, ISSN 2535-0021, p. 295- 299
https://mtmcongress.com/winter/sbornik/3-2023.pdf

The present paper is related to the study of the formation of a surface layer of castings between two liquid phases, i.e. one liquid phase is the melt and the other the coating of the casting mold, with a melting temperature lower than the crystallization temperature of the alloy used. For this purpose, the melt is superheated so that after filling the mold, it remains for some time in a liquid state

before it starts to solidify, to ensure the melting of the coating of the mold, thus forming the surface of the casting between two liquid phases (melt-coating). The temperature field at the moment of interaction of the two liquid phases was analyzed. The influence of different types of low-melting coatings (based on sulphur and low-melting frit) on the surface roughness of aluminum and copper alloy castings is considered. Initially, negative results were obtained related to the formation of mechanical and chemical scorch on the surface of the casting, as well as the presence of gas defects in the volume of the castings. To avoid the formation of mechanical and chemical burn, as well as the formation of gas defects, vacuuming of the casting mold was applied with a low degree of mold vacuuming (- 0.2 ÷ -0.3 Bar). A microstructural analysis was carried out and the roughness of the examined samples was measured according to standard methods - BDS [ISO] 4287/17, ISO 4288.

Based on the conducted research, the following conclusion can be made:

- The created methodology for forming a surface layer of castings between two liquid phases (coating of the casting mold - sawdust) leads to positive results and is suitable for obtaining castings from aluminum and copper alloys. The formed temperature field ensures contact of the melt with the coating while both are in a liquid state, thus a surface of the casting is formed on a liquid phase, providing a lower roughness.
- Coatings with sulphur do not lead to positive results, but coatings based on low-melting frit are particularly suitable for realizing the task.
- The created technology leads to obtaining castings with low roughness corresponding to the 1 degree of accuracy for a casting surface and comparing the resulting roughness with the roughness after machining, the resulting surface of the test castings corresponds to surfaces obtained after fine turning and rough grinding.

G.8.17. Spasova D., (2023), Determining the Simultaneous Influence of Several Factors on Abrasive Wear After Layer Welding, International Conference "NDT Days" 2023 June 12-16, 2023, Sozopol, Bulgaria-

Welding with wear-resistant electrodes is a commonly used method that is used in the restoration of parts operating in contact friction conditions. Steel 40X, one of the commonly used structural steels, is medium- carbon, low- alloy steel and with low wear resistance. Its wear resistance can be increased by welding the contact surface with wear-resistant electrodes. In the present paper, 5 types of

samples were investigated, 4 of them were welded with wear-resistant electrodes (EH550; Abradur 64; Abradur 66; OK Weartrode 60T;), and the fifth sample is a comparison sample made of 40X steel. Tribological studies of the welded samples were carried out in dry friction mode and the influence of the carbon equivalent and the chromium equivalent on the hardness and dimensional stability (change in mass of the specimen) of the welded surfaces was investigated. Macrohardness was measured along the depth of the welded layer and a metallographic structural analysis was carried out.

Based on the conducted research, the following conclusions can be drawn:

- The developed welding technology with abrasive wear-resistant electrodes significantly increases wear resistance in dry friction mode. The highest wear resistance is obtained when welding the base material with the "Abradur 66" electrode, which is complex alloyed with high hardness determined by the high content of carbon and carbide inclusions, and the lowest wear resistance is observed when welding with the "EN 550" electrode, which is due to the lower chromium and carbon content.
- It was found that high hardness does not always lead to high wear resistance, as in the welded specimen with OK Weartrode 60T. Materials with high hardness are brittle and create a prerequisite for the breaking out of particles, which lead to the transition to three-body abrasive wear mode and, accordingly, to a decrease in wear resistance.
- From the interpolated spatial graphical dependencies, between the individual parameters in the dry friction mode, it can be concluded that the wear mass drops significantly at a chromium equivalent value above 10% and a hardness above 500 HV, as well as with a carbon equivalent value above 4% and a hardness above 450 HV.

G.8.18. Spasova D., (2023), Investigation of The Effect of Non-Stick Coatings Based on Corundum, Zircon and Graphite on The Formation of The Surface of Complex Relief Castings in Combination with The "Capillary Molding" Method, International Conference "NDT Days" 2023 June 12-16, 2023, Sozopol, Bulgaria

The present paper is related about investigating the possibility of obtaining complex-relief castings by wax models combined with the "Capillary molding" method and use of coatings guaranteeing low surface roughness. The characteristic of the method is that the preparation of the molding mixture takes place in the casting

box itself and the formation of the necessary layer of binder around the sand grains, i.e. the preparation of the molding mixture takes place without applying mechanical impact on the components. The binder penetrates the capillary spaces between the sand grains, wetting them over their entire surface as a result of vacuuming the mold. Using the “Capillary Molding” method, it has been found that a very good bond is achieved between the coatings used and the mold support over the entire surface. The advantage is that the casting mold is not fired, as it is in the classical technologies for obtaining complex relief castings on fusible models, but is only dried to 150-200 °C. With the created method of capillary molding, a very good connection is made between the coatings used, based on corundum, zircon and graphite, and the supporting part of the form, because carbophen resin and water glass were used as binders in the coatings, as well as in the production of the supporting part of the casting molds.

Based on the conducted research, the following conclusions can be drawn:

- By using the "Capillary Molding" method, a very good connection is made between the coatings used and the support part of the mold over the entire surface.
- In contrast to the conventional method of casting p fusible models, in the method used, the heating of the mold is lowered by several hundred degrees, which leads to a lower energy consumption of the process and also to obtain a mold without cracks.
- The influence of the coatings used (based on corundum, zircon and graphite and water glass binder) on the formation of the surface of complex relief castings is significant, because coated surfaces are obtained with low roughness (Ra = 1.2 ÷ 1.5), corresponding to the roughness of the coating.
- Also, there are no gas defects in the volume of the casting, which indicates that the gases formed as a result of the interaction of the melt seep into the pores of the mold, as a result of its vacuuming.
- When using coatings based on corundum, zircon and graphite and binder carbophen resin, the surface is also obtained with low roughness Ra = 1.8 ÷ 2.2, but gas defects are observed near the surface layer.

G.8.19. Petrov P., Nicolova R. **Spasova D.,** (2023) Effect of gas nitrocarburising on the structure and properties of welded joints of corrosion-resistant steel, International Conference "NDT Days" 2023 June 12-16, 2023, Sozopol, Bulgaria

The present work investigates the possibility of changing the properties of welded joints of steel parts made of austenitic and duplex corrosion-resistant steels by subsequent nitriding/nitrocarburising of the joints. The examined samples are

welding joints of two types of corrosion-resistant steels - austenitic (316L) and duplex (S31803; S32205). After removing the root of the welds and grinding the surfaces (operations performed before the mechanical tests of welded joints or for welded products), the welding joints are subjected to chemical-thermal treatment in an environment of ammonia and carbon dioxide, according to a low-temperature mode of gas carbonitriding, leading to the formation of the "s" phase on the surface. It is believed that the presence of an “s” phase on the surface of steels leads to equal or even better corrosion than that of stainless steels. After the welding of steel sheets from the selected steels and their subsequent chemical-thermal treatment, the variation of hardness by zones was followed and a microstructural analysis was carried out.

Based on the conducted research, the following conclusions can be drawn:

- From the conducted microstructural analysis, it was found that the examined welding joints are of good quality, without the presence of defects such as pores, cracks, undercuts, undercuts.
- Low-temperature gas carbonitriding leading to the formation of an “s”-phase significantly strengthens the individual zones of the welded joint of 316L austenitic steel.
- The maximum degree of strengthening is achieved in the zone of thermal influence, which is a particularly favourable fact, since it is precisely there that deterioration of the mechanical parameters after welding is expected.
- Regarding duplex steel, a revision of the choice of welding electrode should be proposed, as a rather serious difference was found regarding the possibility of saturation of the base material and the weld seam.