Technology transfer for optimizing the mechanical surface treatment of some parts used in the aeronautical industry

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Relevance of the project

Project idea (Purpose and objectives).

The main aim of the project is to optimize the technology of mechanical treatment of the surface of metal parts through the shot-peening technology, applied within the TURBOMECANICA S.A. Bucharest (TMB) for parts intended for the aeronautical industry, in order to streamline this process and increase productivity.

The objectives of the project are:

1. Identifying the process factors that influence the productivity and quality of the shot-peening parts and determining the weak points of the current technology;
2. Optimizing the process parameters of the superficial mechanical treatment technology, in order to increase productivity and surface quality:
3. Advanced analysis of structural and microstructural changes induced in the surface layer of alloys, under the influence of mechanical surface treatment;
4. Industrial validation of the optimized technology.

Considering that the shot-peening process is a component of the major multi-year strategic programs for maintenance and modernization of aeronautical products, the efficiency of this technology is a strategic objective of the company, the achievement of which will significantly contribute to obtaining the level of quality required by the standards in this field , reducing manufacturing/repair cycles and implicitly delivery times, reducing production costs, increasing turnover and strengthening the company's position on the specific market.

The innovative character in relation to the current stage on the national and international level in the field of the project proposal.

Through shot-peening technology, the lifetime of various components can increase by 500-1000%. A series of metallic materials such as steels, nodular (ductile) cast irons, aluminum alloys, nickel or titanium can be subjected to the shot-peening operation. Abroad, the mechanical processing of the surface by shot-peening is not widely used, being a process applied in isolation, to increase the life of some mechanical components subject to wear and fatigue in the aeronautical, automotive and special purpose industries. At the international level, the advanced technologies of superficial mechanical processing by shot-peening are protected, and their acquisition is expensive. In Romania, there is isolated research in this field, and the results are limited to a few types of particles (certain compositions and geometric shapes). At the national level, this technology is applied on a small scale, within a few industrial units (Aerostar Bacau, BMT Aerospace Romania, CONFIND, Rosler Romania, Technics Impex SRL). TMB has been trying for some time to introduce the mechanical treatment of the surface by shot-peening in the production flow of various landmarks in the aeronautical industry. TURBOMECANICA started the modernization of a shot-peening facility, on which to carry out the mechanical treatment operation of the surface of some milestones in its own production (gears, pinions, satellites, etc.), in order to increase the degree of quality of them and the elimination of blockages in the technological flow. However, the technical and technological information relative to this process being limited, it is necessary to carry out own research, in partnership with a research institution, to optimize the currently applied shot-peening technology. The research that will be carried out by TMB together with UPB aims to carry out experiments in which particles of different sizes and hardnesses, both steel and ceramic materials, are used for shot-peening, and the identification of the optimal processing parameters, in order to establish the optimal technology to obtain higher quality products, simultaneously with the reduction of production costs and the increase of productivity and profitability.

The innovative character of the project is supported by the following expected effects: a. the significant improvement of the current shot-peening technology (process innovation) and the transfer of technology to optimize the mechanical surface treatment of some parts used in the aeronautical industry; b. ensuring a better quality of the metal components subjected to ecruzing and obtaining products with an excellent quality/price ratio; c. investments in technological equipment and software necessary for the activity through the development of the existing research and production infrastructure (infrastructure upgrade, computer-aided modeling hardware and software of plastic deformation processes, purchase of new equipment); d. reducing environmental pollution and saving valuable resources by expanding the shot-peening process in as many industrial fields as possible, which increases the quality and duration of the products, thus contributing to the intensification of the long-term competitiveness of the company and the economy, in general ; e. The potential transfer of the project results to the benefit of other domestic/international manufacturers in the aeronautical and automotive industry that apply this technology (this process is intended for practically any potential customer in the aviation or automotive industry).

Knowledge of technological challenges: In order to master the technology of mechanical surface treatment by the shot-peening method, it is necessary to know in detail the influence of various factors/parameters of the process on the results obtained. The most important influencing parameters of the mechanical treatment of the surface by the shot-peening method are: the nature and size of the deforming spheres/bodies (shots); the speed with which they hit the processed surface; the flow rate of the balls, the pressure and the time with which the balls act on the superficial layer subjected to the treatment; the processing angle (the angle between the sphere jet and the processed surface); the density of impacts related to the processed surface unit; the number of passes; the degree of coverage of the surface to be processed, etc., the control of all these parameters raising challenges with effects on the result/quality of the mechanical surface treatment operation. Another limiting factor could be the age of the installation used by TMB for the mechanical treatment by shot-peening. In the conception of the project implementation plan and the content of its activities (section B2.2), all these influencing factors were taken into account.

Project implementation method

Description of the activities necessary to achieve the assumed objectives, with the explicit contribution of the members of the research team from the coordinator, respectively of the partner research team/teams; The deliverables associated with each activity.

Package of activities no.	**1**	**Title**	**Technological requirements and product specifications for parts subjected to mechanical surface treatment, used in the aeronautical industry**			
Partners / Man-month			CO / 2	P1 / 2	**Start month / end month**	1 / 2
Objectives: O1.1. Defining the requirements of the mechanical surface treatment realization technology and the characteristics for the parts subject to the mechanical surface treatment, used in the aeronautical industry. **Description of activities:** **Activity 1.1.** Definition of the technology requirements for the mechanical surface treatment (CO) - The critical analysis of the technology requirements for the mechanical surface treatment using the shot-peening method will be carried out. **Activity 1.2**.Defining product specifications for parts subject to mechanical surface treatment used in the aeronautical industry (CO; P1) - The critical analysis of the requirements for parts processed by mechanical surface treatment by the shot-peening method will be carried out. **Activity 1.3.** Defining the research methodology (processing methods, characterization methods, requirements regarding the samples that will be used, etc.) the mechanical processing of the surface by the shot-peening method, the microstructural and mechanical characterization methods, as well as the requirements for samples used in experimental research. **Associated deliverables: D1.1.** (Month 1) Specifications regarding the technology for performing mechanical surface treatment (CO, P1); D1.2. (Month 2) Requirements regarding parts subjected to mechanical surface treatment (CO, P1); D1.3. (Month 2) Characterization methods (CO, P1); D1.4 (Month 2) Requirements regarding the samples used (quantities, dimensions, characteristics, etc.) (CO, P1).				
Package of activities no.	**2**	**Title**	**Integrated design and experimentation of mechanical surface treatment technology for any aprts used in the aeronautical industry**			
Partners / Man-month			CO / 2	P1 / 2	**Start month / end month**	3 / 13
Objectives: O1.1. Establishing the parameters of the mechanical surface treatment technology for the landmarks used in the aeronautical industry.						

Description of activities:

Activity 2.1. Study of the influence of industrial parameters used in the mechanical treatment of surfaces: the nature and size of the surface processing environment (material/size), treatment pressure, treatment duration (CO) The critical study of the influence of various characteristic parameters of the technologies will be carried out of mechanical surface processing on the microstructural and mechanical characteristics.

Activity 2.2. Design and experimentation of mechanical surface treatment technology, in laboratory conditions (CO; P1) The mechanical surface treatment technology will be designed and experimented in laboratory conditions. In the design of the mechanical surface treatment technology stages, the existing industrial conditions at CO will be taken into account (equipment, technological parameters, specific conditions). During the experiment, the specific parameters will be varied (the nature of the material of the deforming bodies; their size; the application pressure; the degree of surface coverage, etc.) in order to obtain optimal parameters of the mechanical surface treatment process**.**

Activity 2.3. Advanced microstructural and mechanical characterization of processed samples, under laboratory conditions (CO; P1) All processed samples will be analyzed microstructurally (phase structure, morphology, crystal grain size) and mechanically (yield limit, strength limit, elongation at break, microhardness). The data obtained for is a feed-back source for activity 2.2, in order to optimize the parameters of the surface processing technology. Microstructural characterization will be performed by optical microscopy analyzes (Metkon IMM 901 inverted metallographic microscope), SEM electron microscopy (TESCAN Vega II-XMU) and X-ray diffraction (PANalyticalX'Pert PRO diffractometer). The mechanical characterization will be performed by analyzing the stress-strain curves in static mode (universal mechanical testing machine INSTRON 3382) and by micro-hardness tests (Wilson-Woppert 401MVA micro-durometer).

Activity 2.4. Validation of mechanical surface treatment technology, in laboratory conditions (CO; P1) Validation of mechanical surface processing technology in laboratory conditions will be carried out considering the repeatability and reproducibility of the microstructural and mechanical characteristics. For validation, 10 samples processed under identical conditions will be used. Repeatability and reproducibility data will be statistically analyzed for all samples. Based on the statistical data and the standard deviation, the validation report of the surface mechanical processing technology will be made.

Activity 2.5. Advanced microstructural and mechanical characterization of samples processed under laboratory conditions (CO; P1) All samples processed under laboratory conditions will be analyzed microstructurally and mechanically, as in activity 2.3.

Activity 2.6. The design and experimentation of mechanical surface treatment technology, taking into account the industrial conditions for its realization (existing equipment, materials, treatment parameters (CO; P1) The mechanical surface treatment technology will be designed and experimented in industrial conditions. The data obtained from activities 2.2 and 2.4 will be used in the design of thermo-mechanical processing technology in industrial conditions Experiments will be carried out on specific samples.

Activity 2.7. Advanced microstructural and mechanical characterization of samples processed under industrial conditions (CO; P1) All samples processed under industrial conditions will be microstructurally and mechanically analyzed as described in activity 2.3.

Activity 2.8. Validation of the mechanical surface treatment technology applied to the samples, under industrial conditions (CO; P1) The validation of the mechanical surface processing technology under industrial conditions will be carried out considering the repeatability and reproducibility of the microstructural and mechanical characteristics. Specific samples will be used during the tests. For validation, 10 samples processed under identical conditions will be used. Repeatability and reproducibility data will be statistically analyzed for all samples. Based on the statistical data and standard deviation, the surface mechanical processing technology validation report will be made.

Activity 2.9. Advanced microstructural and mechanical characterization of samples processed under industrial conditions (CO; P1) All samples processed under industrial conditions, in order to validate the treatment technology, will be analyzed microstructurally and mechanically, as described in activity 2.3.

Associated deliverables: D1.1 (Month 4) Study of industrial parameters used in the mechanical treatment of surfaces (CO, P1); D1.2 (Month 8) Technological parameters for mechanical surface treatment (CO, P1); D1.3 (Month 8) Samples with mechanically processed surfaces (CO, P1); D1.4 (Month 10) Microstructural and mechanical characterization report of the surfaces (CO, P1).

Package of activities no.	3	Title	Validation of mechanical surface treatment technology for any parts used in the aeronautical industry		
Partners / Man-month		CO / 2	P1 / 2	Start month / end month	14 / 20

Objectives: O1.1. Validation of the functionality of the mechanical surface treatment technology for any parts used in the aeronautical industry.

Description of activities:

Activity 3.1. Optimizing the surface mechanical treatment technology, under industrial conditions (CO; P1) In order to optimize the surface mechanical treatment technology, aeronautical parts will be processed from low-alloy steels, selected from the assortment range of TMB subjected to surface hardening. The data obtained as a result of activities 2.6 and 2.8 will be used in the optimization of the mechanical surface processing technology of some aeronautical parts, under industrial conditions.

Activity 3.2. Advanced microstructural and mechanical characterization of industrially processed landmarks (CO; P1) Samples taken from each type of industrially processed part will be analyzed from the point of view of microstructural and mechanical characteristics, according to the procedure described in activity 2.3. Data obtained will constitute a feed-back source for activity 3.1, in order to optimize the industrial parameters of the surface processing technology.

Activity 3.3. Validation of the mechanical surface treatment technology of aeronautical parts, in industrial conditions (existing equipment, materials, treatment parameters)(CO; P1). Validation of mechanical surface processing technology under industrial conditions for selected parts will be performed considering the repeatability and reproducibility of the data, processing a larger number of landmarks of the same type. During the tests, aeronautical parts will be processed from low-alloy steels, selected from the assortment range of TMB subjected to surface hardening. In order to validate, 10 samples processed under identical conditions will be used for each type of landmark. Repeatability and reproducibility data will be statistically analyzed for all processed samples. Based on the statistical data and standard deviation, the surface mechanical processing technology validation report will be made.

Activity 3.4. Advanced microstructural and mechanical characterization of processed parts, under industrial conditions (CO; P1) - Industrial validation of the mechanical surface processing technology of parts for the aeronautical industry (for selected types of parts), will be performed considering repeatability and reproducibility microstructural and mechanical characteristics. The microstructural and mechanical characterization will be carried out according to the procedure described in activity 2.3. Based on the statistical data and the standard deviation, the technology validation report will be made.

Associated deliverables: D1.1 (Month20) Validation study of the mechanical treatment of the surfaces of mechanically processed landmarks on the surface (CO, P1); D1.2 (Month20) Microstructural and mechanical characterization report of the surfaces of mechanically processed parts on the surface (CO, P1).

Package of activities no.	4	Title	Exploitation of project results (Dissemination of results, Intellectual property rights); project management		
Partners / Man-month		CO / 2	P1 / 2	Start month / end month	1 / 22

Objectives: O4.1. Evaluation of the effectiveness of the obtained research results; Identification and attribution of innovative scientific results of the project; Dissemination and exploitation of scientific results; Assignment of intellectual property rights.Descrierea activităților:

Activity 4.1. Dissemination of results (CO; P1); As a primary objective, dissemination of results with adequate impact on both academic and industrial research is a must. This is achieved by disseminating the project results within the scientific community and by transferring the results to industrial end users. A plan for the exploitation and dissemination of results (PEDR) will be established at the beginning of the project, including a plan of actions and required resources, continuously updated during the implementation of the project. PEDR will summarize the beneficiaries' strategy and the concrete actions related to the protection, dissemination and exploitation of the project results. Both CO - TURBOMECANICA SA Bucharest, and P1 - Politehnica University Bucharest, will contribute to the dissemination of the non-confidential results of the project, through scientific papers published in ISI journals (Journal of Alloys and Compounds; Materials Science and Engineering A; Materials Science and Engineering C; JOM-US; Materials and Corrosion; Metals; Materials, etc.), scientific papers presented in international conferences / workshops (International Conference on Innovative Technologies - IN-TECH; European Congress and Exhibition on Advanced Materials and Processes - EUROMAT; International Conference on Advanced Computational Engineering and Experimentation - ACEX; International Conference on Materials Structure & Micromechanics of Fracture – MS&MF; International Conference on Materials Science and Engineering - BRAMAT; International

Conference on Materials Science and Technologies - ROMAT; etc.), on the Internet **t**hrough pages web; by participating in national and international trade fairs.

Activity 4.2. Intellectual property rights (CO; P1); The PEDR will include an intellectual property rights (IPR) plan, which will provide adequate and effective protection of the knowledge created in the project, with respect to the partners' legitimate interests and their intellectual property rights. Dissemination is subject to restrictions resulting from IPR protection, security regulations or legitimate commercial interests. Ownership of innovative scientific results, together with all resulting rights, will be assigned to the partners involved in obtaining them, in accordance with each contribution. The default regime of joint ownership, transfer of results and licensing of results between partners and to potential end users will be established. For the foreground generated during the project, the following principle applies: IPR for the foreground results is owned by those who generated it.

Activity 4.3. Project management (CO; P1); Careful planning has been carried out regarding the activities and responsibilities of each partner within the consortium. The objective is to ensure the successful completion of the contract by ensuring that all deliverables and milestones are met. The management and implementation of the project will comply with the provisions of the financial contract with the Financing Authority (UEFISCDI), the provisions of the Consortium Agreement (CA), the legal provisions regarding research and development activities, as well as public procurement from the regulations regarding budget funds. The Executive Board (EC), consisting of the Project Director and Project Officer of each partner, will be responsible for technical, financial and administrative management. The CE will be headed by TMB(CO). Project management will include the following activities: legal, contractual, financial and general administrative management of the consortium; organizing the consortium meetings, chairing the consortium meetings, preparing the minutes of the partners' meetings; controlling the development of project objectives; preparation of technical reports; collect Cost Statement from partners and report consolidation information each year; monitor and analyze compliance between partners and obligations; coordinates and stimulates effective communication between project partners; data management; ensure communication with the Funding Agencies. Project management procedures and conflict resolution procedures must be agreed by the partners as soon as possible through the CA.

The scientific management of the project *will be carried out based on the analysis and decisions of the CS (coordinators, partners and key persons). The fulfillment of each work package is the responsibility of the designated partner, who will apply the decisions of the CS to achieve the expected results and to achieve the established intermediate objectives. A risk analysis will be carried out, which can be the basis for introducing the necessary corrections. The implementation of the activities through the development of the project is conditional on the achievement of essential results (milestones), which can guarantee the achievement of the established objectives. At the beginning of the project, an adequate Data Management Plan will be provided. The CO, through the Data Manager, will be responsible for data management.*

Associated deliverables: D4.1. (Month 12) Plan for dissemination and exploitation of results (CO); D4.2. (Month 12) Intellectual Property Rights (IPR) Plan; D4.3. (Month 10, 18) 2 submissions of scientific papers to ISI journals (CO; P1); D4.4 (Month 8, 14, 20) 3 scientific communications within international scientific events (CO; P1).

TURBOMECANICA S.A. (TMB). TMB has gained an important place in the supply chain of the major manufacturers of propulsion systems by permanently demonstrating the ability to ensure the quality of delivered products, to diversify technical capabilities and to efficiently use production capacities, and last but not least, the ability to operation based on flexible needs. TMB's reputation is based on engineering experience, the quality assurance system and special processes approved by NADCAP, together with the high qualification, passion and loyalty of the specialists.