materials

Article

Optimization of Wire Arc Additive Manufacturing (WAAM) Process for the Production of Mechanical Components Using a CNC Machine

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Abstract: The paper presents a CNC component manufacturing process using the WAAM process. The study depicts all the execution steps of a component from the CAD drawing, deposition procedure (technological parameters, times, layers, etc.), examination, and economic calculation. The manufacturing of this component using WAAM is more advantageous given the fact that the execution time and delivery are significantly shorter, mainly when a single piece is required and also when discussing the raw material used, usually expensive titanium alloys. For example, for Ti-6AI-V used in the aircraft industry, for which the material price is about 90 Euro/kg, the costs for obtaining a given component using the WAAM process will be about 497 Euro/piece compared to 1657 Euro/piece when using another manufacturing process, as it is shown in this paper. In conclusion, additive manufacturing can easily become a feasible solution for several industrial applications when it replaces a classic manufacturing process of a single component or replacement products, even simple-shaped.

Keywords: additive manufacturing; automotive; manufacturing costs; wire arc additive manufacturing

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1. Introduction

Additive manufacturing (AM) is a production method based on the addition of layered material, thus obtaining functional products. Additive fabrication or 3D printing is very popular nowadays because it covers a series of processes designed to produce parts or assemblies from different types of materials. Basically, 3D printing turns a three-dimensional design into a physical object. The common element of all 3D printing technologies is the way of obtaining these components—overlapping layers of material that lead to the final shape of the printed object [1].

In 3D-printing processes, several materials can be used, some of which we expect—plastic, metals, ceramics, or even concrete, but also surprisingly paper or edible materials such as chocolate. Regarding the 3D printing of metals, in 1926, Ralph Baker (USA) patented the use of the electric arc as a heat source to generate 3D objects by layer by layer-by-layer deposition [2–4].

As shown in Figure 1, the WAAM—Wire Arc Additive Manufacturing—process offers advantages over other processes in terms of the mechanical properties obtained, the dimensions that can be achieved, the deposition rate, and low costs. The disadvantages of this process are the limitations related to the complexity of the shapes that can be achieved as well as the low accuracy that involves further machining [5].

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Article

Optimisation of the Heterogeneous Joining Process of AlMg3 and X2CrNiMo17-12-2 Alloy by FSW Method

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Abstract: This paper presents experimental investigations on the solid-state joint of 3 mm sheets of AlMg3 alloy with X2CrNiMo17-12-2 stainless steel. The study presents a dissimilar joint that was made in a solid state using a modified milling cutter. The study highlights the possibility of using this type of joint in a naval field. The paper presents all the steps of the joining process, from the technological parameters to the examination and numerical validation of the obtained specimens. A numerical model was defined in Abaqus, considering a Static analysis, and the results demonstrated a good similarity with a small discrepancy observed in the elastic range of the specimen behaviour. In the conclusions, this study will provide some recommendations for the optimisation of this joint and proposals for future studies; the idea for this study started from the dissimilar joints used in the naval field. The article also briefly presents some dissimilar joints made on the same milling machine and in the same laboratory.

Keywords: dissimilar joint; FSW process; milling machine; solid-state joining

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1. Introduction

In the early 1990s, a new joining technology called friction stir welding (FSW) was invented and patented by TWI Cambridge [1]. The procedure was first applied at an industrial level in Sweden, in the year 1995 [1]. Due to its qualities, this procedure brought interest to some economically powerful countries such as USA and Japan.

In 2015, Lucian A. Blaga and his team had developed a special process on Friction Riveting (FricRiveting) as a new joining technique in GFRP lightweight bridge construction; through this process, it has been possible to make joints from different materials for emergency bridges [1].

A current concern in society is the compromise between the benefits of using lightweight materials and how to integrate these into larger multi-material designs projects. The wider the range of possible joining technologies to perform dissimilar joints, the less compromising or restricted might be the usage of these materials [1]. The more traditional and well-established methods to perform connections between different material classes are known as mechanical fastening, but most recently, the FSW process and FSW-derived processes solved a lot of situations. The recent research on this process demonstrated that it can also be applied in civil engineering, namely bridge construction [2].

Analysing, as an example, the case of emergency bridges [1,2], where joints from different materials were proposed, the joint studied in this work is suitable for certain construction areas.

The schematic illustration of friction stir welding is presented in Figure 1 for a butt joint configuration. Friction stir welding (FSW) is a solid-state process, which means that the objects are joined without reaching the melting point. In friction stir welding (FSW), a

processes

Article

Process Transferability of Friction Riveting of AA2024-T351/Polyetherimide (PEI) Joints Using Hand-Driven, Low-Cost Drilling Equipment

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Abstract: The present work deals with the transferability of Friction Riveting joining technology from laboratory equipment to adapted in-house, low-cost machinery. A G13 drilling machine was modified for the requirements of the selected joining technique, and joints were performed using polyethermide plates and AA2024 aluminum alloy rivets of 6 mm diameter. This diameter was not previously reported for Friction Riveting. The produced joints were mechanically tested under tensile loading (pullout tests) with ultimate tensile forces of 9500 ± 900 N. All tested specimens failed through full-rivet pullout, which is the weakest reported joint in Friction Riveting. In order to understand this behavior, FE models were created and analyzed. The models produced were in agreement with the experimental results, with failure initiated within the polymer under stress concentrations in the polymeric material above the deformed metallic anchor at an ultimate value of the stress of 878 MPa at the surface of the joint. Stresses decreased to less than half of the maximum value around the anchoring zone while the rivet was removed and towards the surface. The paper thus demonstrates the potential ease of applying and reproducing Friction Riveting with simple machinery, while contributing to an understanding of the mechanical behavior (initialization of failure) of joints.

Keywords: Friction Riveting; metal-polymer hybrid joints; friction-based multi-material connections; anchoring FE modelling; rivet failure modes

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1. Introduction

The continuously increasing demand for cost reduction, together with high performance product requirements, is leading to substantial research and engineering developments in new materials and tailored joining technologies [1]. The outcomes of these efforts are mixed and hybrid structures in which the properties and performance of products are improved through combining the properties and behaviors of each specific material [2]. Hybrid polymer–metal structures are used in such way in a several engineering applications, as exemplified in Figure 1.

Due to strong dissimilarities in physical-chemical properties, hybrid joints between metals and polymers are challenging, more so because of geometrical and design considerations [2]. To overcome some of the limitations of the current state of the art in hybrid joining, Friction Riveting (FricRiveting) has been developed at the Helmholtz-Zentrum Geesthacht (now Helmholtz Zentrum Hereon) in Germany as a process for joining metallic bolts (rivets) with polymeric plates [3]. This research studies the material combination of aluminum AA204 with polyetherimide (PEI) to be joined via Friction Riveting. The feasibility of this combination has already been proven, and the joints have been characterized and

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Virtual reality in the automotive field in industry 4.0

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A B S T R A C T

Virtual Reality (VR) and Augmented Reality (AR) are the new computer technologies to create a simulated environment in the field of automotive. Virtual Reality can create for its users an experience that simulates the real environment in the field of automotive and creates a 3D image. Instead of having a screen in front of them, users interact with 3D world. By using VR and AR many senses can be stimulated, such as vision, hearing, touch, even smell and noise, the computer being transformed into a gatekeeper to this 3D artificial world.

The paper will present a state of art on the needs of the Virtual Reality and Augmented Reality devices used in the automotive field and two case studies related to some applications of Virtual Reality in the automotive field in Romania.

Selection and peer-review under responsibility of the scientific committee of the 8th International Conference on Advanced Materials and Structures - AMS 2020.

1. Introduction

Virtual development started in early 1970′s, at first with a CAD software in the design field.

At the beginning of 1990 the first public demonstrations of Virtual Reality (VR) started to take place in exhibitions and the outlook was quite promising for some of the observers from industry which started their own experiments.

Volkswagen began to acknowledge the importance of Virtual Reality (VR) and Augmented Reality (AR) in 1994, after a visit at the New York Virtual Reality exhibition and Silicon Valley Virtual Reality exhibition. First, they have made a research regarding some software and hardware. For software, they started a cooperation with the Fraunhofer Institute in Darmstadt with Prof. Encarnacao. The next step was to buy a Silicon Graphics computer and some other devices, including space mouse, data glove and HMD, but nowadays the field of VR is very strong developed [12].

VR and AR technology are very important in Industry 4.0, the combination of these technologies can improve the methods and efficiency of the companies in manufacturing field. The Industry 4.0 brings some new technological challenges in the process that gradually made people adapt and increase the level of the digitalisation.

VR and AR technology are used in the industry, in professional training (military, medical, etc.), in education, simulations, evaluation of designed models, studies related to product ergonomics, rapid prototyping, some example are in Fig. 1.

In the automotive industry, VR and AR technology have proven to be a useful tool also in assisting users in product evaluation processes and certification of the process.

In 1999, BMW started to explore and use VR's ability to analyse products in the design phase. The results demonstrate that VR technology has the potential to reduce the number of required versions of the model. Motorola also developed in 1995 a VR system used to train employees in an assembly line. The conclusion of the experiment showed that VR can be used successfully in professional training, with good results in comparation to classical training.

Boeing, the world's largest aircraft manufacturer, has developed the Virtual Space eXperiment (VSX) based on VR/AR technologies. This product is a demonstration of the usefulness of VR technologies in the aerospace industry and other complex industries involving machine-user interaction, the product can be seen in Fig. 2.

VR and AR in automotive have the potential to reduce the number of screens inside the car and improve their design, production, and maintenance, as well as the driver's experience. This technology has many applications in the automotive industry. One of these is assisting mechanics in their tasks.

AR creates an extension of the three-dimensional environment through virtual objects. This technology can provide important

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Optimization of a dissimilar joint using additive manufacturing

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Keywords: additive manufacturing, automotive, composite, dissimilar joint

Summary: The article will explore a potential Additive Manufacturing approach for combining two distinct thermoplastics, ABS and PMMA. The obtained piece can be produced up of two parts: the lower half is made of ABS, while the upper part is based on PMMA. Given that the assembly is meant to be used on an automobile's exterior, it must be resilient to air and water. Both types of thermopolymers—ABS and PMMA—must be used in a range of lighting applications, including automotive lighting, to lower prices and improve lamp performance. Although PMMA and ABS are different materials, they are compatible and are frequently bonded together.

1. Introduction

Thermopolymers are widely used in almost all economic areas (Figure 1 shows some products). Their widespread use is a result of the desire to minimize the use of natural resources and, in turn, the impact on the environment. Sharp thickness gradients, tiny curvatures, and high-stress deformations are all part of the intricate modelling process that these materials go through. They can be used in procedures including thermoforming, casting, extrusion, and injection moulding. Many different types of plastics are used in the automotive sector, which also benefits from their ability to reduce weight and produce massive components quickly. Nevertheless, these pieces frequently need to be joined with other components during assembly.

Figure 1. Products obtained by vibration welding of lamps in the automotive industry [1]

The requirement to link components arises when manufacturing the entire part in a single production step is problematic due to the use of multiple materials, geometric limits, and complexities.
Parts can be joined by physical bonding (welding), chemical bonding (using adhesives), or mechanical fastening (using nuts and bolts, for example). The material, component size,

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Article

Influence of the Thermal Environment on Occupational Health and Safety in Automotive Industry: A Case Study

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Abstract: Considering thermal environment aspects have a major impact not only on occupational health and safety (OH&S) performance but also on the productivity and satisfaction of the workers, the aim of the case study was to assess the thermal comfort of a group of 33 workers in an automotive industry company, starting with collecting data about the thermal environment from different workplaces, continuing with the analytical determination and interpretation of thermal comfort using the calculation of the Predicted Mean Vote (*PMV*) and Predicted Percentage of Dissatisfied (*PPD*) indices, according to provisions of the standard ISO 7730:2005, and comparing the results with the subjective perception of the workers revealed by applying individual questionnaires. The results of the study represent an important input element for establishing the preventive and protective measures for the analysed workplaces in correlation with the measures addressing other specific risks and, also, could serve as a model for extending and applying to other similar workplaces in future studies. Moreover, the mathematical model and the software instrument used for this study case could be used in further similar studies on larger groups of workers and in any industrial domain.

Keywords: occupational health and safety; ergonomics; thermal environment; human thermal comfort; automotive industry

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1. Introduction

The thermal environment has a major impact on occupational health and safety (OH&S) and also has a great influence on the productivity and satisfaction of workers [1,2]. Occupational thermal stress, determined by an improper thermal environment, could lead to a higher risk of diseases and health problems, reduces employees' work capacity and lowers productivity output [3]. Thermal stress has two components: Heat stress and cold stress, either of which occurs when the core body temperature is no longer maintained at 36–37 °C. Depending on the work environment, the body reacts to maintain its temperature so that the employee can perform optimally. A body adapts to hot temperatures by sweating and increasing skin blood flow to prevent the body temperature from rising, while in cold temperatures, the body shivers and reduces skin blood flow to prevent the body temperature from decreasing [4]. In extreme conditions, the adaptation and maintenance processes are not enough and start to fail, causing the body to undergo thermal stress, defined as the sum of the environmental and metabolic heat load imposed on the individual [4,5].

In recent years, the number of studies on the effects of the indoor thermal environment on human physical and mental health has increased. The studies focused on different

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ORIGINAL RESEARCH ARTICLE

An Investigation of the Effects of Flame Straightening Heating on the High-Strength Structural Steels Microstructure

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Abstract

In this research, the effects of heating cycles that are performed correctly and excessively—well above the limitations given by the steel manufacturer—on flame straightening are assessed and analyzed. The paper focuses on the microstructural changes caused by the overheating during the flame straightening process. To create geometrical changes in a metal construction, a tiny section of the element or structure is heated to the straightening temperature during the flame straightening process. Strenx® 960 is typically produced through a combination of thermomechanical rolling and quenching and tempering, resulting in a fine-grained martensitic or bainitic microstructure. These processes are designed to achieve a balance of high strength and good toughness. The microstructural changes associated with different working conditions in the case of welding include HAZ softening and grain growth. The study aimed to highlight the influence of flame hardening on the microstructure of the material.

Keywords Flame straightening · Heat input · Microstructure · Toughness · Welding heat input

Introduction

The basic idea that metals compress when cooled and expand when heated is the starting point for flame straightening. With precisely defined heating areas, this well-known method allows metal constructions to be flame-straightened up to flame straightening temperature while simultaneously limiting their ability to expand.

To reduce deformation following welding, flame straightening is frequently necessary. The method can lead to notable microstructure changes because of the less concentrated heat source, particularly in high-strength and wear-resistant steels. The effects vary according to the combustible gases (propane, acetylene) because of their varied physicochemical characteristics. The potential of overheating associated with manual technology complicates matters further as it might negatively impact mechanical characteristics.

While flame straightening has long been a common practice in the fabrication of metal structures, minimal has been learned about the effects of heating on the structure of the material, particularly regarding high-strength steel constructions. It is difficult to evaluate the expected influence of the heat source performance, heating time, temperature, extent, etc., without precise knowledge. The established and developed cooling time concept according to EN 1011-2, which may be used to calculate the cooling time from arc energy (heat input) and provide a good estimate of the predicted mechanical characteristics of the joint, cannot be employed with flame straightening procedures.

Two scenarios of flame straightening can be distinguished based on the heating intensity. Partially heating the surface layer (usually up to 30–35% of the entire cross section) in relation to the structure's overall cross section is one often utilized technique. In this instance, the cooling rate is usually high, and the rate of heat input is small in relation to

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TINERI CERCETĂTORI
JUNIOR RESEARCHERS

Aplicații ale procedeul de fabricație aditivă prin depunere cu arc electric (WAAM)

Applications of Wire Arc Additive Manufacturing (WAAM)

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Rezumat

Progresele semnificative în domeniul tehnologiilor de fabricație aditivă (AM), cunoscute sub numele de imprimare 3D, au transformat în ultimul deceniu modalitățile potențiale de proiectare, dezvoltare, fabricare și distribuție a produselor. Pentru industria auto, aceste progrese au favorizat modele noi, produse mai curate, mai ușoare și mai sigure, termene de livrare reduse și costuri de producție mai mici. Lucrarea va prezenta pe etape proiectarea, execuția și controlul calității pentru realizarea unei flanșe de conectare între un strung universal și o masă rotativă WAAM (Wire Arc Additive Manufacturing), produsă în contextul procesului de fabricație aditivă. WAAM este o variantă a tehnologiei de depunere prin sudare și utilizează un proces de sudare cu arc electric pentru a imprima piese metalice 3D. Spre deosebire de cele mai comune procedee AM în care se utilizează pulberi metalice, WAAM funcționează prin topirea sârmei electrod folosind un arc electric ca sursă de căldură. Procesul este controlat de un braț robotizat, iar piesa este construită pe un material de bază (o placă sau o țeavă suport); după depunere piesa poate fi tăiată când este finalizată. Sârma este topită și depusă sub forma unui rând de sudură pe materialul de bază; pe măsură ce sârma este depusă, aceasta creează un strat de material metalic. Procesul se repetă strat cu strat, până când piesa metalică este finalizată. Este, așadar, prezentată realizarea prin WAAM a unei piese confecționată în mod uzual prin așchiere. A fost realizat modelul 3D, în baza lui făcându-se depunerile prin sudare. Au fost măsurați timpii de proces și auxiliari implicați, trăgându-se concluzii.

Cuvinte cheie

MAG, fabricație aditivă prin depunere cu arc electric, durata procesului, eficiență

Abstract

Significant advances in additive manufacturing (AM) technologies, commonly known as 3D printing, have transformed in the last decade the potential ways in which products are designed, developed, manufactured and distributed. For the automotive industry, these advances have opened doors for newer models; cleaner, lighter and safer products; reduced delivery times and lower production costs. The paper will present in stages the design, execution and quality control for the realization of a connecting flange between a universal lathe and a rotary table WAAM (Wire Arc Additive Manufacturing) process produced in the context of additive manufacturing. WAAM is a variant of directed energy deposition technology and uses an arc welding process to print 3D metal parts. Unlike most common AM processes where metal powders are used, WAAM works by melting metal wire using an electric arc as a heat source. The process is controlled by a robotic arm and the part is built on a substrate material (a backing plate) from which the part can be cut once finished. The wire, when melted, is deposited as a welded bead on the substrate. As the wire is deposited, it creates a layer of metallic material. The process is then repeated, layer by layer until the metal part is completed. So, it is presented the realization by WAAM of a piece made in the usual way by chipping. The 3D model was made, based on it, the deposits were made by welding. Process times and involved auxiliaries were measured and conclusions drawn.

Keywords

MAG process, wire arc additive manufacturing, process time, efficiency

TINERI CERCETĂTORI
JUNIOR RESEARCHERS

Cercetări privind influența gazului de protecție în corelație cu parametrii de sudare asupra proprietăților mecanice ale îmbinărilor din oțel inoxidabil duplex pentru industria navală

Research on the influence of shielding gas in correlation with welding parameters on the mechanical properties of stainless-steel duplex joints for the shipbuilding industry

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Rezumat

Scopul principal al acestei lucrări a fost analiza efectelor tipului de gaz protector în corelație cu valorile optime ale parametrilor de sudare, în vederea obținerii proprietăților mecanice adecvate ale îmbinărilor sudate fabricate din oțelul S31803. Îmbinarea cap la cap din oțel inoxidabil duplex a fost realizată prin sudare cu sârmă tubulară cu flux rutilic (FCAW), în pozițiile de sudare vertical ascendent (PF) și orizontal pe perete vertical (PC), utilizând gazele de protecție 100% CO2 (codificat C1) și Ar +18% CO2 (codificat M21). Gazele utilizate în acest studiu sunt preferate pentru asigurarea protecției zonei de sudare în industria construcțiilor navale. Principalele teste mecanice prin care s-au determinat proprietăți mecanice ale îmbinărilor sudate au fost cele de impact, tracțiune, îndoire și duritate. Pentru validarea rezultatelor și stabilirea valorilor optime ale parametrilor de sudare s-au prelevat probe metalografice, pe baza cărora s-a analizat evoluția microstructurii sudurilor și a zonelor afectate termic.

Cuvinte cheie
Gaz de protecție, parametri de sudare, oțel inoxidabil duplex, procedeu FCAW

Abstract

The main purpose of this practical work was to analyse the effects of the type of shielding gas in correlation with the optimal values of the welding parameters, to obtain the appropriate mechanical properties of welded joints made of S31803 steel. The duplex stainless steel butt joint was made by rutile flux cored wire welding (FCAW) in the vertical upward (PF) and horizontal on vertical wall (PC) welding positions using shielding gases 100% CO2 (coded C1) and Ar +18% CO2 (coded M21). The gases used in this study are preferred for providing weld zone protection in the shipbuilding industry. The main mechanical tests by which the mechanical properties of the welded joints were determined were impact, tensile, bending and hardness. To validate the results and establish the optimal values of the welding parameters, metallographic samples were taken, based on which the evolution of the microstructure of the welds and the heat affected zones were analysed.

Keywords
Shielding gas, welding parameters, duplex stainless steel, FCAW process

1. Introducere

La procedeul de sudare în mediu de gaz protector cu electrod fuzibil, zonele topite și încălzite sunt protejate de acțiunea nocivă a gazelor din atmosferă,

1. Introduction

In the Gas-shielded metal arc welding process, the molten and heated areas are protected from the harmful action of atmospheric gases by a continu-

APLICAȚII INDUSTRIALE-PRACTICIANUL SUDOR
INDUSTRIAL APPLICATION-WELDING PRACTITIONER

Optimizarea unor proceduri de recondiționare cu procedeul WIG a matrițelor utilizate în domeniul auto

Optimization of TIG refurbishing procedures for automotive moulds

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Rezumat
În această lucrare sunt abordate impactul și beneficiile sudării WIG în recondiționarea matrițelor de injecție a polimerilor. Sunt puține procedee de sudare care, utilizate pentru recondiționare, au un raport calitate/preț adecvat. În cadrul unui ciclu de viață al unei matrițe, sunt necesare diferite intervenții de recondiționare, refacere sau revizie. Costul unei componente dintr-o matriță fiind ridicat, înlocuirea componentelor defecte sau uzate cu unele noi nu este eficientă, competitivitatea pe piață scăzând dacă nu se apelează la repararea/recondiționarea lor, în locul schimbării.
Aici intervine sudarea WIG, însă se pune accentul pe specializarea sudorului. Investiția inițială - în echipamentul de sudare, apoi în instruirea sudorului - se amortizează în maxim 2-3 ani. Avantajele sunt evidente, pornind de la costuri, timpi reduși și până la protecția mediului, deoarece la fabricarea unor componente noi sunt folosite cantități mari de energie și rezultă deșeuri metalice din prelucrarea mecanică.

Cuvinte cheie
recondiționare, sudare WIG, matrițe, industria autovehiculelor, cost, duritate

Abstract
This paper covers the impact and benefits of WIG welding in the reconditioning of polymer injection moulds. There are few welding processes that have an adequate quality/price ratio. During a mould life cycle, different refurbishing, rework or reconditioning interventions are required. The cost of a component in a mould is high, replacing defective or used components with new ones is not appropriate. Market competitiveness decreases if components are not repaired/reconditioned.
This is where WIG welding comes in. The focus is on the specialisation of the toolmaker-welder. The initial investment - in the welding source, then in training - amortises in 2-3 years maximum. The advantages are obvious, from cost, reduced time and environmental protection, as a large amount of energy is used in the manufacture of new components and metal waste results from mechanical processing.

Keywords
refurbishment, TIG welding, moulds, automotive industry, cost, hardness

1. Introducere
Recondiționarea matrițelor a devenit o operațiune importantă în industria autovehiculelor, deoarece matrițele sunt componente esențiale ale mașinilor-unelte implicate în fabricație, fiind indispensabile pentru fabricarea diverselor piese din componența structurii de rezistență, a caroseriei autovehiculelor sau a altor subansamble din structura autovehiculelor. Acestea trebuie să fie în stare perfectă geometrico-dimensională și de funcționare pentru a produce piese

1. Introduction
Mould rebuilding became an important operation in the automotive industry, as moulds are essential components of the machine tools involved in manufacturing and are indispensable to produce various parts of the bodywork, bodywork, or other sub-assemblies of the vehicle structure. They must be in perfect geometric-dimensional and functional condition to produce quality parts and to ensure the minimum necessary safety and performance charac-