



1ST INTERNATIONAL CONGRESS
ON
ADDITIVE MANUFACTURING
BOOK OF ABSTRACTS

IWAM 22



SEPTEMBER 30, 2022

1ST INTERNATIONAL CONGRESS

ON

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IWAM 22

Bragança - Portugal

September 2022



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Instituto Politécnico de Bragança 2022

Campus de Santa Apolónia

5300-253 Bragança - Portugal

ISBN: 978-972-745-310-8

<http://hdl.handle.net/10198/23947>

Book cover: Jorge Santos, Instituto Politécnico de Bragança

Technical Support: Clarisse Pais, Instituto Politécnico de Bragança

WELCOME

Additive manufacturing technologies are playing a decisive role in the laboratory environment, making a significant difference in STEAM education. Students use additive manufacturing to create physical models, topographic maps, biology artifacts, artwork, all types of engineering prototypes and solving mathematics challenges. By bringing additive manufacturing capabilities to the classroom, educators can raise interest in STEAM, introduce new concepts and capabilities, and help set the future for more skilled STEAM professionals.

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Capillarity assessment of 18Ni300 maraging steel cellular structures manufactured by Selective Laser Melting

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ABSTRACT

The progress of additive manufacturing (AM) technologies is allowing to push the barriers to complex metal structures manufacturing. Lattice structures are effectively manufactured by powder bed fusion (PBF) technologies like Selective Laser Melting (SLM), allowing a high freedom in the design in order to attain a required property or performance. The interaction of these structures with fluids is of interest to different fields, from biomedical to injection molding industry. In this study, cellular structures having cubic architecture were designed and manufactured by SLM, having five different open-cell sizes. These structures capillarity was assessed through mass variation when in contact with water. Results show that by controlling these structures dimensions and geometric details it is possible to significantly influence their capillarity and this knowledge can be used in the design phase to tailor this effect.

INTRODUCTION

Lattice structures are periodic entities, build from a one-unit cell that is continuously repeated in three dimensions [1]. These structures are being increasingly explored due to the advancements of additive manufacturing (AM) technologies, that allow to break with previous constraints regarding manufacturability. Furthermore, these allow to reduce the weight of a part, the amount of material used, the fabrication time or the amount of energy used in the manufacturing process [1]. Another goal is to optimize the mechanical proprieties of the structure, with relevant improvements on specific strength [1].

Lattice structures can be used in many applications but have been extensively explored in the biomedical field, as in orthopedic implants [2] or meta-implants [3]; in aerospace [4]; in the injection molding industry [5], etc. In the latter, these can be used to take advantage of these structures gas or fluid permeability, capillarity and wettability, allied to suitable mechanical performance [6], for allowing gas escape and/or to control fluids penetration inside these structures.

This type of structures can be manufactured by AM and according to the ISO 17296-2:2015 [7] the AM techniques could be classified in seven categories: VAT photopolymerization, material jetting, binder jetting, sheet lamination, material extrusion, powder bed fusion (PBF) and directed energy deposition [7]. However, one of the most promising technologies for the manufacture of metals and metal alloys are powder bed fusion technologies, that use a layer by layer strategy and powder as raw material. For metal parts manufacturing, PBF include technologies as Selective Laser Melting (SLM), Selective Laser Sintering (SLS), Direct Metal Laser Deposition (DMLS) and Electron Beam Melting (EBM). In these processes, on the build-platform the layer of metal powder that is deposited is sequentially sintered (SLS and DMLS) or melted (SLM and EBM), using a laser (SLM, SLS and DMLS) or an electron beam (EMB) as heat energy source [8]. PBF technologies allow to manufacture parts with controlled and tailored porosity,

having demonstrated huge potential for the fabrication of lattice structures, as seen in several examples available in literature [9-12]. The process starts with the deposition of a first powder layer on the build-platform and then the laser emits radiation with a certain wavelength, part of which is absorbed by the layer of powder, melting the metal [13]. As soon as solidification occurs, which occurs very quickly (estimated speeds for SLM of 10^3 to 10^8 K/s [14]), a new layer of powder is deposited and the process proceeds iteratively.

Aiming to assess the interaction of fluids and their penetration inside these structures, capillarity tests were performed, using an adaptation of the Washburn method (equipment Attension Sigma 700/701). This method is typically used in powders, that are compacted in a vessel and placed on a high sensitivity scale, that allow mass variation detection that allow capillarity calculation [15]. In this study, this method was adapted for structured samples having cubic architecture that were manufactured by SLM, being assessed the water mass variation when in contact with the fluid, for structures having different open cell size (see Table 1).

RESULTS

The selected design for the unit-cell was a cubic structure (CS), as seen in Fig. 1. Five different open cell sizes were defined, giving rise to five experimental groups, as shown in Table 1. The samples were manufactured in a 500Q SLM machine (Renishaw, UK).

Table 1- Manufactured cubic samples and their unit-cell dimensions.

Experimental groups	CAD DIMENSIONS (μm)	
	Wall	Open-cell
CS300	300	300
CS400		400
CS500		500
CS600		600
CS700		700

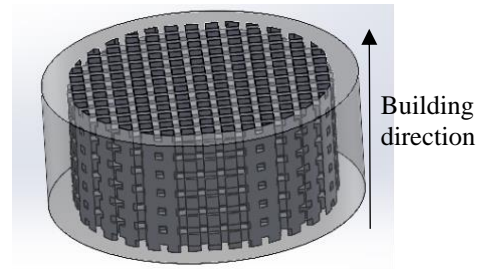


Fig. 1- Cubic sample design (CS500).

The capillarity test was performed to determine the mass gained (Fig. 3) due to capillary action, with five samples tested per group, with Fig. 2 schematically representing the method and apparatus.

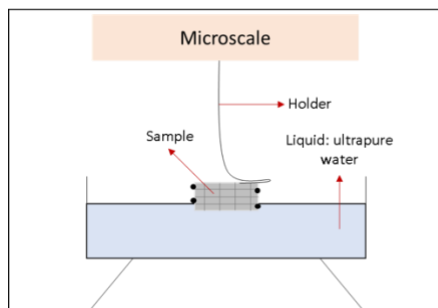


Fig. 2- Schematic representation of the capillarity test.

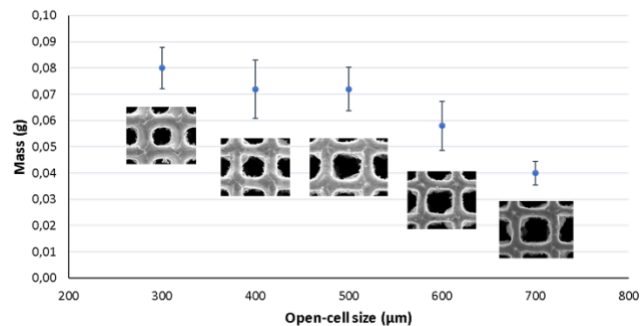


Fig. 3- Capillarity tests results and corresponding images structures surface in contact with water.

The sample surface that was in contact with water was the top (last) surface fabricated by SLM, having a typical roughness, usually lower than lateral faces. From the results presented in Fig. 3, a clear tendency is seen, with the larger the open cell size, leading to lower absorbed mass, indicating a lower capillary effect. As demonstrated by Jurin's law, the smaller the capillary radius, the greater the capillary effect. And although the interconnected porosity on these samples, this effect is in fact confirmed, with higher water absorption by the CS300 group. SEM images in Fig.3 allow an additional conclusion regarding the manufacturing, namely that for smaller open-cell sizes, more rounded shape these open-cells display, thus being closer to a capillary, also promoting a more pronounced effect.

CONCLUSIONS

This study allowed to conclude that the control of SLM lattice structures dimensions allow to regulate their capillarity significantly (twofold increase when comparing CS700 to CS300). This knowledge can be used by engineers during parts design phase to either hamper or conversely avoid the capillary effect. As application example, a mold insert that is cooled by contact with water, but in which the progression of water by capillarity must be avoided.

ACKNOWLEDGMENTS

This work was developed within the scope of the project Nano-SIM 3D and the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020, UIDP/50011/2020 & LA/P/0006/2020, financed by national funds through the FCT/MCTES (PIDDAC). Acknowledgements to Simoldes Aços, Lda. (Oliveira de Azeméis, Portugal) regarding the SLM samples fabrication.

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Influence on heat transfer of the interface contact configuration between two dissimilar steels

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ABSTRACT

In this work, the contact between a 1.2344 steel and a 1.2709 steel obtained by additive manufacturing was studied to simulate the heat transfer exchange between both materials. The contact between the two unbonded materials was compared to the bonded contact created when AM directly deposits disc B on steel disc A using the laser Powder Bed Fusion (LPBF). An experimental analysis of the thermal behavior of both links configurations was performed, where the thermal contact conductance and thermal contact resistance were determined. The information obtained in the heat transfer between both steels is valuable, given that the thermal management of the mold is a critical phase of this manufacturing process.

INTRODUCTION

The thermal management of the mold in the foundry industry is a matter of great relevance on which the final quality of the parts and the production time depend (Hsu 2013). The placement in the molds of inserts printed by additive manufacturing (AM) with high geometric complexity channels (conformal cooling), adapted to the production parts has been shown to increase the quality of the produced parts, furthermore reducing cycle production time (Kurtulus 2021).

However, when they fit each other, the contact between the mold base steel and the insert steel introduces a new interface. Irregularities in the mold and insert surfaces reduce the contact area between them, which affects the heat flow across the interface and introduces a thermal resistance at the junction of the two surfaces, known as thermal contact resistance (Wang 2010). Similar issues are present in other engineering devices, which require a high heat transfer rate, making it difficult to accurately manage the heating and cooling performance of many applications (aeronautics, cryogenics, nuclear industry, space vehicles, among others) (Ren 2021).

This work aims to study the effect of heat transfer in the interface mold (produced by machining)/insert (produced by AM). The experimental thermal tests of the assembly were performed in steady-state mode, using a contact pressure of 50 bar both for unbonded and bonded conditions.

RESULTS

The influence of the contact interface between steel discs A (1.2344) and B (1.2709) was studied with the aid of the heat transfer experimental setup observed in Figure 1. The experimental setup is composed of a heat source with a sleeve type heating resistor (3) around a copper cylinder (2), which generates a power of 400 W. The copper cylinder (2) is driven hydraulically, ensuring a 50 bar constant contact pressure between the steel discs (sample A (4) and Sample B (5)) during the test. On the other side, a cold source (6) cooled by a constant flow of water (7) was placed. To ensure a heat conduction in steady-

state, the whole set and the two steel discs were thermally insulated by rock wool to minimize heat losses.

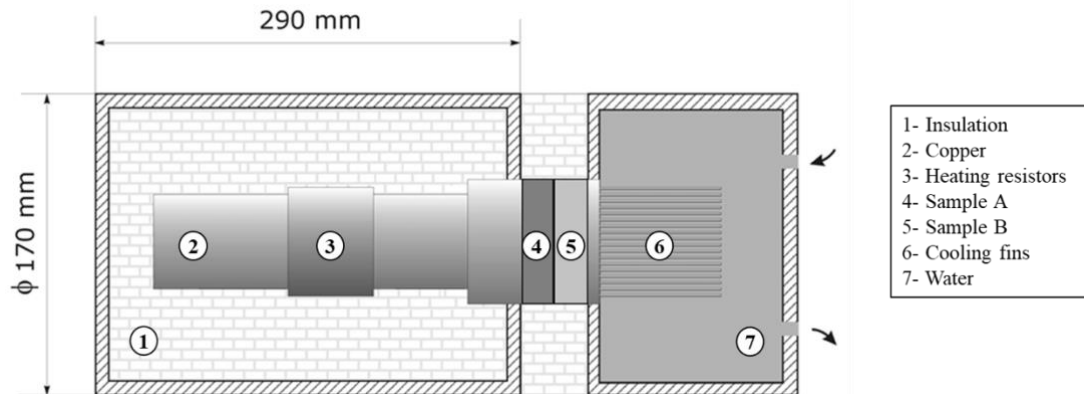


Figure 1 - Heat transfer experimental setup with steel discs samples A and B.

Three thermocouples were placed in each sample for temperature recording purposes, making a total of 6 thermocouples, spaced 6.5 mm apart from the hot side to the cold side of the setup. Bonded and unbonded steel discs were tested under the same conditions. Figure 2 shows the temperature profiles in a steady state with a contact pressure of 50 bar, for the two types of contact studied.

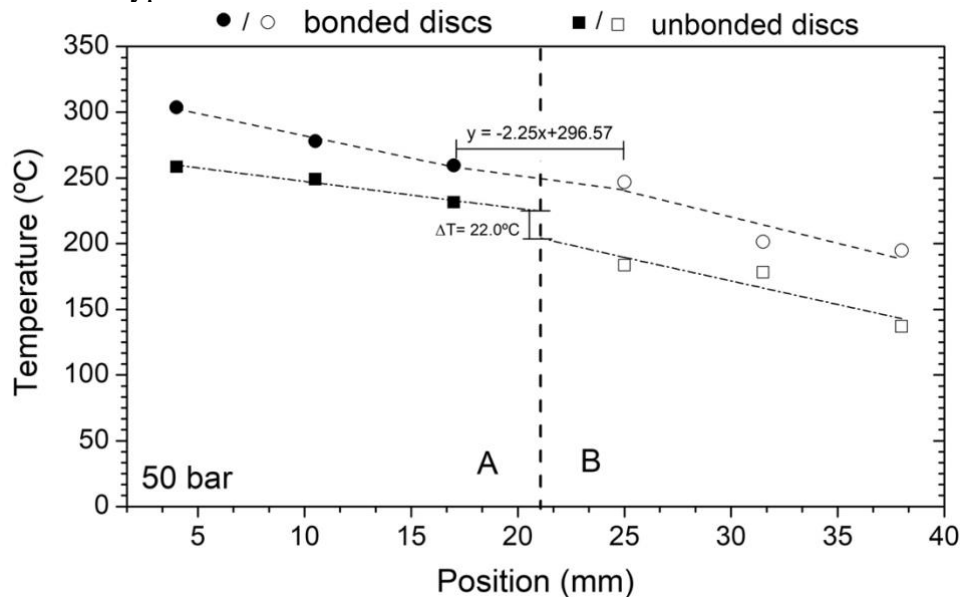


Figure 2- Temperature profiles of the unbonded and bonded steel interfaces in a steady state with a 50 bar contact pressure.

As results of the experimental tests for the two assembly configurations, Table 1 presents the calculated interfacial conductance between the two steel discs (h_c) and their thermal contact resistance (TCR).

Table 1 - Thermal tests results for the unbonded and bonded with contact pressures of 50 bar.

	h_c (W/m ² .°C)	TCR (m ² .K/W)
Unbonded	4574	2.19×10^{-4}
Bonded	21417	-

For the same test conditions ($Q = 400 \text{ W}$ and $P = 50 \text{ bar}$), the temperature profile of bonded steel discs is always higher than that of unbonded discs (Figure 2), indicating a higher level of heat transfer capacity in this system.

Table 1 corroborate results of Figure 2, showing that the contact zone in bonded steels has an interfacial conductance (h_c) five times greater than for unbonded steels, which have a thermal contact resistance of $2.19 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}$. However, while a temperature step is observed in the unbonded assembly interface, in bonded steel discs, the temperatures close to the interface are practically kept constant on both sides of the steel's transition zone. This indicates a localized reduction of the thermal diffusion rate in this zone.

CONCLUSIONS

Combining mold and insert in a bonded configuration can significantly reduce the interface resistance. This way, it is possible to optimize thermal management by heat transfer, bonding the two parts.

ACKNOWLEDGMENTS

This work has been financially supported by project PRIDOP (POCI-01-0247-FEDER-040271), co-financed by the European Community Fund FEDER through POCI - Programa Operacional Competitividade e Internacionalização.

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Cooling performance of an acrylic serpentine with a rectangular cross section

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ABSTRACT

In recent years, photovoltaic panels have established as one of the main sources of electricity considered to be clean. Its efficiency and lifetime are greatly influenced by the operating temperature. Active cooling using cylindrical copper serpentes is one of the most common methods for many systems. However, due to the cylindrical geometry of the tubes, the contact with the plate is a point and its area tends to zero. In this way, serpentes that provide a bigger contact area between the heat removal system and the solar panel board are desired. Serpentes manufactured by machining acrylic plates in CNC milling machines allow the construction of a channel with rectangular cross section with a considerable area of contact between the channel and the plate. The obtained results show that there was a significant improvement of the heat exchange between the plate and the thermofluid when the acrylic serpentine with rectangular section was used.

INTRODUCTION

Solar panels have a paradox that they need sunlight to heat and generate energy, but high temperatures end up decreasing their performance. The use of active cooling systems can increase the efficiency of the system by up to 22%, with the material of the tubes used having a great influence on the heat exchange (Hasanuzzaman et al., 2016; Marinić-Kragić et al., 2020). The lifespan of solar panels is about 25-30 years and can be extended to up to 48 years if there is an efficient cooling system (Nižetić et al., 2016).

RESULTS

From an 8 mm thick acrylic plate, 5x5 mm channels were made in the Mini-milling machine CNC ROLAND SRM-20 according to the figure 1. A 2 mm thick steel plate was used in place of the solar panel.

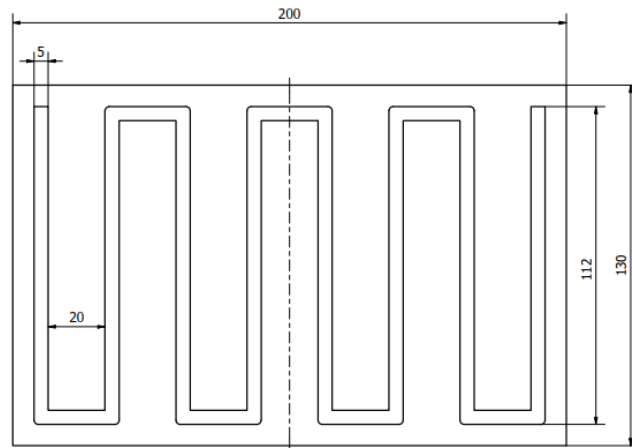


Figure 1: Main dimensions of the proposed serpentine.

For comparison level, a copper serpentine was used, following the same route counted with the same hydraulic diameter (5 mm). A 400 W Halogen spotlight was used as a heat source and thermocouple sensors were used on the surface of the plate and on the inlet and outlet of the fluid figure 2.

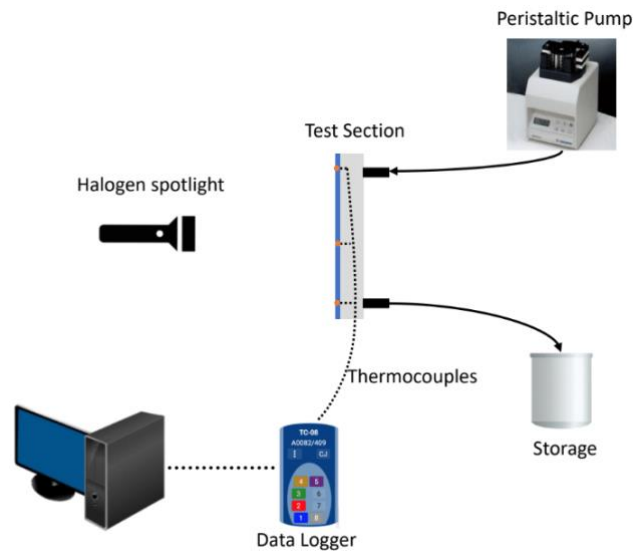


Figure 2: Experimental setup.

The results of the difference between the plate temperature and the fluid inlet temperature are shown in figure 3.

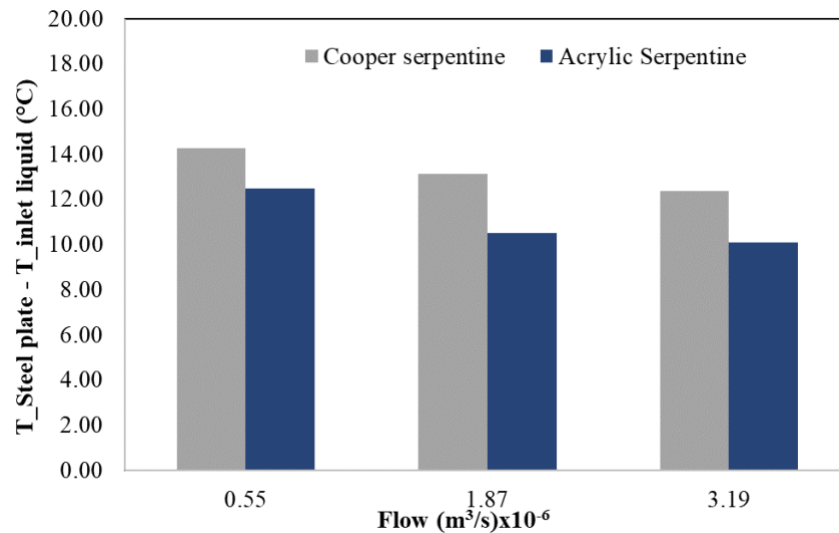


Figure 3: Temperature difference between the plate surface and the inlet fluid according to each flow rate.

CONCLUSIONS

The obtained results show a higher efficiency of the serpentine with rectangular geometry made in acrylic. This is due to the fact that the contact surface between the fluid and the acrylic plate is superior to the copper serpentine, where the contact area is only at the tangent between the tube and the plate and, therefore, tends to zero. New studies should be carried out in a more controlled temperature environment in order to increase the reliability of the preliminary tests.

ACKNOWLEDGMENTS

This work has been partially funded through national funds FCT/MCTES (PIDDAC) from the following research units: UIDB/00532/2020, UIDB/04077/2020, UIDP/04436/2020, UIDB/00690/2020 and UIDP/00690/2020. The authors are also grateful for FCT funding through PTDC/EMETED/7801/2020, NORTE-01-0145-FEDER-030171 funded by COMPETE2020, NORTE2020, PORTUGAL2020, and FEDER. National funding by FCT, Foundation for Science and Technology, through the individual research grant PRT/BD/153088/2021 of Glauco Tapijara Vallicelli Nobrega.

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Development of a modular thermal management system for CBRN equipment by additive manufacturing using stereolithography

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ABSTRACT

The present study is part of a wider project addressing the development of a thermal management system for chemical, biological, radiological and nuclear – CBRN equipment. The solution being developed is modular, to adapt to the different requirements in terms of ergonomic characteristics and cooling needs, from different body parts. The work presented here is focused on the development of the module adapted to the forearm, which was performed by Mechanical Military Engineering students at the Portuguese Military Academy, during their training in the curricular unit of Integrated Project of Mechanical Military Engineering.

After establishing requirements, limitations and developing the various steps towards project development, a microchannel based heat sink design was proposed. The prototype was made by additive manufacturing, more specifically by stereolithography in Elastic 50A. The material was chosen, amongst those available, due to its good thermal properties, assuring high heat flux dissipation. The prototype shows good mechanical characteristics and adequate ergonomics. Preliminary studies confirm good performance of the devised heat sink, to be further validated in experimental tests, in future work.

INTRODUCTION

Chemical, biological, radiological and nuclear (CBRN) equipment is known to be used under harsh environmental conditions, which require it to work as an isolated system, in terms of heat and mass transfer. Consequently, humidity regulation and thermal management are very difficult to achieve in this kind of equipment [1] ultimately leading to thermal stress, hyperthermia and metabolic modifications. The literature review shows that despite of the effort performed so far, there is still no effective solution allowing for the use of a comfortable, light, and safe equipment. Recent solutions, introduced for instance by Tokizawa et al. [1] address a complex tubes system for a liquid cooling system. However, the tubes have large dimensions, thus requiring significant pumping power. Hence, large elements such as pumps, valves and other auxiliary systems are required, which may increase the weight of the equipment up to 10kg. In this context, the work introduced here addresses a multidisciplinary approach in which a detailed analysis to the skin and internal temperatures during equipment operation are monitored (together with several other biometric parameters) to identify the relevant working temperature range and target body regions to be cooled. Then, the cooling system to use is modular to tackle these target points, making use of small heat sinks, based on microchannels. Given the complexity of the system to be developed, the work presented is focused on the module developed to cool the forearm. Although most of the heat load required to cool the body of the user under extreme activity (220W) is taken from the torso (nearly 35%) [2], rapid cooling of the forearm may be very effective under urgent situations, being able to remove between 20-25W [2].

RESULTS

Preliminary work, including literature review, addressed several steps such as identification of requirements, restrictions, selection of the materials to use, among others. A detailed functional analysis was also performed, identifying the system, sub-systems, and respective functions and possible system failures.

The material chosen to fabricate the first prototype was Celanese CoolPoly E5101 due to its good thermal properties. The working fluid was distilled water, as it is a common fluid, non-toxic, non-abrasive and with quite good thermal properties.

As for the dimensioning of the heat sink mode, the total dimensions were firstly taken as 100mmx40mm, to be adapted to an adult forearm, with dimensions of the order of 250mmx300mm [3]. A geometry of straight microchannels was chosen, as it is shown in the literature and in previous work from the authors, to be very effective in removing high heat loads [4]. The channels are square, 800 μ m wide (cross sectional area) due to limitations in the accuracy of the 3D printer available (Form3+ from FormLabs). Then, a simplified optimization analysis was performed, to determine the exact dimensions of the heat sink and number of channels, which would maximize the heat transfer and minimize the pumping power, which was determined based on the calculated pressure losses.

The printed prototype, once assembled and adapted to the forearm, was too long, so the user would be uncomfortable. The chosen material was also too rigid, so it was not much effective from the ergonomic point of view. Given this restriction, a second prototype was developed, slightly smaller, 120mmx40mm, with channels having a total length of 70mm, as illustrated in Figure 1.

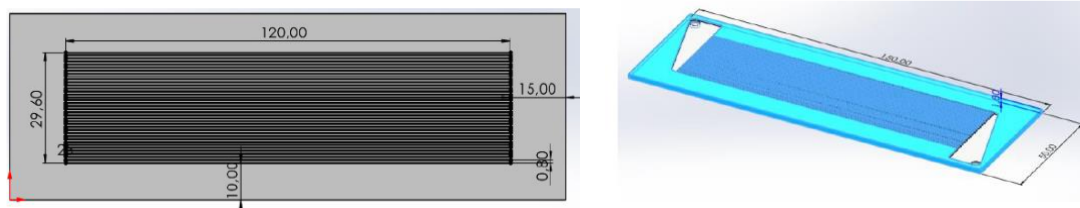


Figure 1 – Schematic of the microchannel based heat sink, with main dimensions.

The material used for this new prototype was Elastic 50A, which has still good thermal properties, and is much more flexible, thus evidencing better ergonomic characteristics. Figure 2 depicts the curves of temperature difference of the refrigerant fluid (between the exit and the entrance of the heat sink) and pumping power, as a function of the refrigerant fluid flow rate.

The figure shows that the heat flux dissipation (which is proportional to the temperature difference) requirements are satisfied under very low pumping power requirements, for low flow rates (of the order of $1.24 \times 10^{-5} \text{m}^3/\text{s}$).

The assembled prototype is much more flexible, being easily adapted to be forearm. The closed loop entire system must now be devised, but the low pumping requirements allow the use of small and lightweight auxiliary systems, such as a micropump.

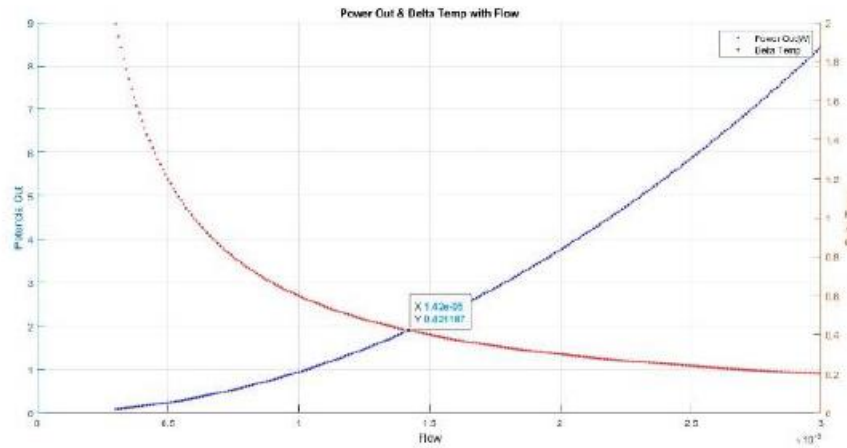


Figure 2 – Temperature difference of the refrigerant fluid (between the exit and the entrance of the heat sink) - red line and pumping power – blue line, as a function of the refrigerant fluid flow rate.

CONCLUSIONS

The present work reports the development of a thermal management system for CBRN equipment, using stereolithography. A modular solution was developed. The present work is focused on the module used for the forearm. Preliminary results show good mechanical characteristics and adequate ergonomics and confirm good performance of the devised module, based on microchannels, and made from Elastic 50A.

ACKNOWLEDGMENTS

Authors acknowledge the support of the Portuguese Army – Defense Ministry, for financing project CINAMIL - Development of thermal management and climatization systems for CBRN equipment.

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Development of a low cost personal protective mask by stereolithography

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ABSTRACT

The present work is part of a broader project that considers the development of IPE – Individual Protective Equipment, respiratory, modular, and low-cost. This seeks to respond to the problem of the shortage of respiratory personal protective equipment (IPE's) that occurred, for example, during the Covid-19 pandemic. The equipment, manufactured by stereolithography, has the characteristics of being reusable, multifunctional, and comfortable to use, presenting modular variants of quick and adjustable replacement, in order to respond to atypical situations with speed. This equipment also has the advantages of having been developed thinking about the particularities of the reality of the Security and National Defense sector. The work was developed by students of the Degree in Military Mechanical Engineering, at the Military Academy, within the curricular unit of Integrating Project in Military Mechanical Engineering, thus demonstrating the possibility of developing quality research work during STEM teaching.

INTRODUCTION

Over the years, there have been multiple situations that demonstrate the importance of personal protective equipment (PPE) and that reveal how essential it is that the whole of society is protected if any event of this nature occurs. Examples are the anthrax attacks in 2001 in the United States, the Fukushima nuclear accident in 2011, or the risk of infection with the Ebola virus (EVD) between 2013 and 2016. With the arrival of the Covid-19 pandemic, other needs emerged. The Sars Cov 2 virus had a large and rapid transmission throughout the population, which, in order to seek protection, began to use personal respiratory protective equipment. Since the needs increased significantly and abruptly, the existing stocks of this equipment were not enough to meet the demand, the supply chains proved to be fragile and there was even a lack of masks on the market. On the other hand, the price of masks was quite inflated and the suppliers were essentially foreigners, so Portugal was not self-sufficient in the production and distribution of equipment. In order to avoid these situations in the future, it is necessary to keep up with technological developments to allow the rapid and low cost production of protective equipment. On the other hand, we cannot neglect the need for this equipment in adverse military scenarios, so it is necessary to take into account some factors different from those usual in civilian use, such as:

- Allow quick donning of the mask that must always be readily available.
- Experiencing relatively low pressure gradients during breathing.
- Be an ergonomic, light and adaptable equipment to different physiognomies.
- Be easy to place even for untrained personnel.
- Ensure it is comfortable to wear for long periods (including while sleeping).

- Respect military standards of protection.

Currently, on the market, there is no equipment that fully meets all these needs. On the other hand, masks that are usually found in the military, although they guarantee very high protection for the user, are considered too complex, since an integral mask (occupies the entire face) can cause unnecessary discomfort in uses where it is not such comprehensive protection is needed. This equipment are also expensive to produce and are typically heavy and bulky. These characteristics can affect the user, restricting their vision, generating stress and excessive moisture on the skin, aspects that make it difficult for the military to fulfill their mission [1]. Another factor to take into account is the portability of the mask, as it has to be easily transportable and collapsible.

In order to respond to the needs and characteristics mentioned above, this project has as main objective to develop a respiratory PPE that can respond to abnormal situations with relative speed.

RESULTS

To develop this project, a functional analysis of the equipment to be developed was first carried out. In this analysis, the main groups and subgroups of the mask were identified in order to facilitate later the development and modeling of the product. To each group and subgroup we assign a role, a possible failure to take into account in the development of the product, and a possible cause that is at the origin of this failure. Then, the different groups and subgroups of our mask were designed in CAD (computer-aided design). It should be noted that the mask measurements were based on the average face size of an adult in Portugal [2].

The exhaust system, particularly relevant in this project, was based on the NATO standard for a 40 mm thread. This reference aimed to standardize the filtration and exhaust system, so both systems are coupled to the mask through the same screw mechanism.

After all the groups and subgroups of the mask were modeled, they were printed by stereolithography, using the Form3+ printer (FormLabs). The mask was manufactured using Elastic 50-A resin, as it has elastic properties that would more easily adapt to the user's facial ergonomics. The exhaust valve and its components, such as the thread, were printed using Rigid 4000 resin, as it is rigid and provides the high strength and robustness required for these elements. Printing was performed to an accuracy of 0.1 mm. It should be noted that the exhalation valve has an opening and closing system that works through 2 parts each with an opening that rotate one over the other. When the openings are aligned, they allow air to circulate, when they are not, the air does not circulate.

After having all the parts printed, the final prototype was assembled, which was tested. The designs and images of the mask cannot be shown for reasons of industrial property protection.

Despite being simple and very preliminary, the tests show that the mask has good ergonomics and a high degree of comfort. The functioning of the exhalation valve was also tested, and it was verified that it is performing its function effectively, that is, when the valve is open, the air flow that circulates is unidirectional, from the inside to the outside, thus forcing the all the air that enters the mask is just the air that passes through the filter.

In the future, it will be important to test the mechanical properties of the mask further, such as elasticity, resistance to tension or high temperatures. It will also naturally be relevant to test the PPE in a relevant military environment.

CONCLUSIONS

This work is part of a broader project that considers the development of IPE – Individual Protective Equipment, respiratory modular and low-cost. The project presented here shows the development of a first prototype of a mask manufactured by stereolithography. Preliminary tests show good mechanical response of the mask. The mask has good ergonomics and a high degree of comfort. The project presents an innovative design of an exhalation valve that in the prototype produced proved to be functional.

ACKNOWLEDGMENTS

Os autores agradecem o apoio do Exército Português e do Ministério da Defesa, no financiamento através do CINAMIL do projeto BQProtect - Desenvolvimento de EPI respiratório modular de baixo custo. C. M. Machado agradece ainda à Fundação para a Ciência e a Tecnologia (FCT-MCTES) o suporte financeiro concedido no âmbito do projeto UIDB/00667/2020 (UNIDEMI).

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Submerged energy harvesting device fabricated by a desktop 3D printer

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ABSTRACT

The 3D printing technology allows researchers to produce low-cost models and test concepts allowing rectifying some possible anomalies that may arise before making the final model. The use of submerged devices with electronic circuits represents a big challenge as the entire system must be adequate to the surrounding environmental conditions. The present work proposes an underwater energy harvesting device fabricated by a desktop 3D printer using polylactic acid (PLA). The device will be submerged in a depth between 3 to 10 meters and has the objective of increasing the operating time of the monitoring sensors stations, such as pH, turbidity and salinity

INTRODUCTION

Currently, desktop 3D printing, such as the Fused Deposition Modelling (FDM) process and stereolithography, is gaining widespread attention from academic research and the industrial community to produce devices and prototypes at an extremely low cost (Faria et al 2018). During the last decade, successful 3D printer applications can be found in biotechnology (Gross et al 2014), pharmaceutical industry (Khaled et al 2014) and biomedical engineering (Souza et al 2020). However, 3D printing devices to be used in the ocean to produce energy are still scarce.

Due to the ocean's aggressive environment, 3D printing can offer a few advantages such as low-cost, fast-fabrication and easy components replacement. To manufacture an energy harvesting prototype, it is necessary to be aware of some details, such as the prototype geometry, layer thickness, material, dimensions that allow placing a linear electromagnetic generator and the necessary percentage of the filling material to achieve a good enough buoyancy of the prototype.

To increase the prototype's robustness and efficiency for operating underwater, it is necessary to avoid moving parts, due to the biofouling. Additionally, it is needed to consider the velocity and heights of waves to optimize the energy production through oscillation (Faria et al. 2022). Electromagnetic linear generator (LEG) can be used within the prototype to operate submerges between 3 to 10 meters, since the utilization of photovoltaic cells or thermoelectric modules at these depths will not be efficient. In addition, piezoelectric energy was not a viable option as they need larger impact areas of water and moving parts (Zurkinden et al. 2017). The present work proposes an energy harvesting device able to operate under the sea and fabricated by a desktop 3d printer. The device was made with polylactic acid (PLA) as it is a biodegradable material.

MATERIALS AND METHODS

The selected material to manufacture the prototype was PLA because is a well-established filament for 3D printers (ensuring good reproducibility), is biodegradable and is harmless if hydrolyzed, facilitating its final disposal.

To manufacture the prototype, a 3D Ultimaker 2 + printer was used to fabricate the main components. In addition, a 3d pen was used to join all the parts that constitute the prototype. The 3D printer used to make the prototype, uses Fusion Deposit Material (FDM) technology (Faria et al 2018). Our fully assembled prototype is larger than the Ultimaker 2+ printing area and as a result, it was necessary to divide our prototype into several parts. Hence, the main body was divided into 6 parts (figure 1). For small components such as the blades, the dimension was not a problem for the printer working area.



Figure 1. (a) Division of the prototype into 6 different parts (1-6), (b): Upper view.

The main properties of the prototype used in the simulation are presented in table 1.

Table 1 – Main properties of the prototype.

Volume (mm ³)	Area (mm ²)	Weight (gr)	The bounding box of model (mm)			The density of PLA Material (gr/cm ³)
			Length	Width	Height	
5.01x10 ⁶	1.85x10 ⁶	1.4810 ³	304.72	304.72	280.00	1.25

All the drawing parts were converted into STL file format by using a drawing software. In addition, the STL files were converted into a gcode through the Cura software.

RESULTS AND DISCUSSION

Figure 2 shows an overview of all the steps used to manufacture the prototype. Note that, all the infill parts were filled with polyurethane.

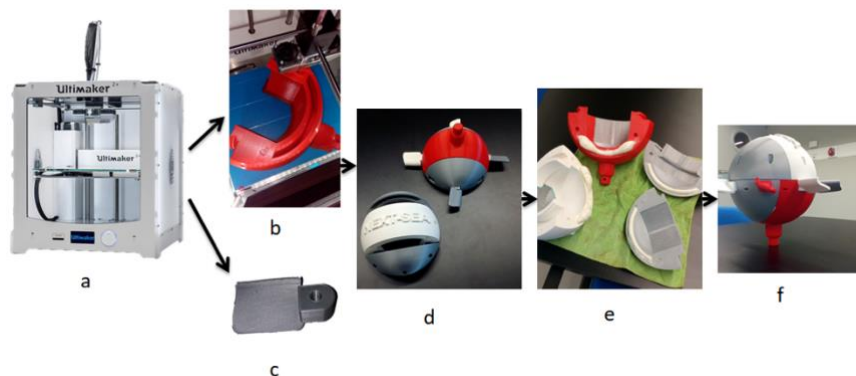


Figure 2. (a) 3d Printer with files to print; (b) fabrication (c) check if the parts fit ; (e) preparation of a set of parts; (f) assemble all parts.

To assemble all the individual parts of the prototype it was used a 3D pen. After connecting all parts, the prototype was polished to remove any excess material placed with the 3D pen. All parts were coated, inside and outside by using a special resin XTC-3D from Smooth-On. The fully assembled prototype is composed of two main parts. The bottom part is a body composed of blades and one support to assemble the upper part. M6 screws were used to assembly the lower and upper parts. An o-ring was used between the screws and nuts.

To test the prototype for water penetration, a waterproof test was performed in a tri-axial chamber with water pressure up to 4 bar. After performing this test, it was observed a small amount of water inside it. As a result, the entire structure was checked and it was observed that the leakage has happened in the region of the bolt/nut. This leakage appeared due to the force applied to the bolt and nut, which promoted the formation of a small crack within the structure. The crack was repaired with the 3D pen and resin. After this reparation, the prototype was tested once again and no water was observed inside it. Hence, this result suggests that it is possible to use this fabrication process to produce submersible devices, with the advantage of being a fast and low-cost process to test concepts. However, due to the selected material (PLA) and the 3D print fill option care should be taken into account regarding the applied force on the bolt/nut. In future prototypes, it is recommended to change the fixation mode and to do it outside the prototype, as it is possible to immediately see the problem and no cracking is formed in the interior structure. Although the proposed prototype needs a few improvements, overall the waterproof tests suggest that our prototype can operate submersed down to a deep of 40 meters.

ACKNOWLEDGMENTS

C.L. Faria thanks FCT grant SFRH/BD/137121/2018. The authors also acknowledge the strategic grants by the projects UIDB/04436/2020, UIDB/00532/2020 and UIDB/04077/2020 from FCT.

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Evaluation of mechanical properties of lattice structures for sandwich panels

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ABSTRACT

One of the main purposes in structural design is to attain the lightest possible load-carrying capability with high stiffness and strength. Recently, several researchers have developed lattice structures that may compete with cellular honeycombs. Lattice structures are defined as periodic structures, composed by continuously repeating unit cells that inter-connect each other in three dimensions [1,2].

The main purpose of this study is to investigate the effect of the lattice topology on the flexural behaviour of the sandwich panels. Five lattice geometries were studied, namely body centred (BC), body centred with struts in z-axis (BCZ), body face centred with struts in z-axis (BFCZ), face centred with struts in z-axis (FCZ) and parallelepiped simple (PS). The relative density, which was kept the same for all the lattices, was taken as 0.3, which is one of the commonly used values of regular hexagonal honeycombs. The mechanical properties were evaluated by the three-point bending test in both numerical and experimental approaches. The numerical analysis was undertaken with the finite element software, Siemens NX. Fused deposition modelling (FDM) was used to print polylactic acid samples with the configurations mentioned. The sandwich samples, which are composed of a lattice core and two thin plates, were manufactured all together. Among the lattices experimentally studied, lattice BCZ exhibits the higher strength, while BC shows higher stiffness and BFCZ achieves the highest energy absorption. The higher values obtained by these lattices are comparable to the ones obtained with a cellular two-dimensional hexagonal structure with the same relative density. Consequently, some of the structures studied may be alternatives to conventional ones in the design process of composite materials.

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A simple method to modify the wettability of the PDMS surface for biomedical applications

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ABSTRACT

One of the most popular materials for manufacturing microfluidic devices is polydimethylsiloxane (PDMS). Organs-on-a-chip (OoC) are a novel class of devices that combine microfluidic devices and cell cultures. To make it simple to study both healthy and diseased conditions, these devices duplicate the microphysiological characteristics that can be found in the human body. Due to its mechanical and chemical characteristics, as well as the fact that it is a biocompatible and inert substance, PDMS is one of the materials of choice for the production of OoC. The hydrophobic properties of PDMS, however, cause the adsorption of non-specific molecules, which can impede the attachment and growth of cell cultures and reduce the specificity of several biochemical tests. The fluid flow inside microchannels of microfluidic devices can be affected by the hydrophobicity of the materials, leading to the need of external sources for flow control, such as syringe pumps. Applying an oxygen plasma treatment is a popular method for enhancing the PDMS surface's wettability. This method, though, only works for a short while. Another tactic is to add components like surfactants during the manufacturing process to change the bulk of PDMS. In this study, PDMS was mixed with different surfactants in concentrations of 1 wt.%. The wettability changes were analysed on the day the samples were made and a week later. One week following fabrication, two surfactants continued to improve the wettability of the PDMS surface to a hydrophilic behavior.

INTRODUCTION

The organic polymer polydimethylsiloxane (PDMS) is frequently employed in the biomedical industry due to its physicochemical and mechanical characteristics, such as optical transparency, gas permeability, nontoxicity, and biocompatibility. Additionally, fabrication is a quick and inexpensive procedure. (Gokaltun et al., 2017) Microfluidic devices for the assessment and research of blood phenomena, such as the behavior of red blood cells or formation of aneurysms, are one of its applications (Miranda et al., 2021; Pinho et al., 2020).

Additionally, PDMS has been employed in the manufacture of organ-on-a-chip and lab-on-a-chip technology (Carvalho et al., 2021; Gonçalves, Carvalho, et al., 2022; Gonçalves, Rodrigues, et al., 2022; Miranda et al., 2021; Vlassov et al., 2018). The

polymer is hydrophobic, with a contact angle with water of about $108^\circ \pm 7^\circ$ (Gokaltun et al., 2017; Klasner et al., 2009), which helps the demolding of the material, but it can be disadvantageous for medicinal applications since it leads to unintended non-specific protein and small molecule adsorption. This might impact analyte transportation and lessen the sensitivity of the detection (Gokaltun et al., 2017; Han & Lee, 2018). The hydrophobicity of the polymer also makes it challenging to move a fluid through the surface, necessitating external pumping sources for microfluidic experiments (Kim et al., 2010; Litwinowicz et al., 2021).

Various techniques have been researched to improve the wettability of PDMS. These techniques may include surface and bulk changes. (Hu et al., 2020) The oxygen plasma treatment is one frequently utilized method of surface modification (Han & Lee, 2018; Seo & Lee, 2006). However, the hydrophilicity produced by this method is temporary, and the PDMS quickly regains its hydrophobicity (Hu et al., 2020; Kim et al., 2010). The maintenance of the polymer's optical and mechanical properties may be improved via surface changes. However, their processes are frequently challenging. The addition of hydrophilic moieties or surfactants to the polymer surface is another potential tactic. Aqueous solutions spread more widely as a result of surfactants because they lower the surface tension of the material. (Hu et al., 2020; Litwinowicz et al., 2021; Seo & Lee, 2006)

For this study, several surfactants were added to PDMS to change the bulk of the material. The surfaces' wettability was then assessed and compared.

RESULTS

Six different samples were prepared for this work. The manufacture of all samples started by mixing the PDMS curing agent and the pre-polymer in a ratio of 1:10. To the samples, polyethylene glycol (PEG), PDMS-b-ethylene oxide (PDMS-b-PEO), Triton X-100 (TX100), Leophen ML or Leophen BN was added at a concentration of 1 wt%. All samples were placed into a rectangular mold and cured for three hours at 80 °C in the oven. After curing, the samples were taken out of the mold, and the static contact angle between a 5 μ L drop of distilled water and the surface at room temperature was used to assess the wettability of the surfaces. Contact angles were measured on an optical tensiometer THETA (Attension), presented in Figure 1, from processing the images of the profile of the droplet deposited on the surface. 640×480 pixels were analyzed during the acquisition time (corresponding to 240 images per test). The spatial resolution of the system for the current optical configuration is 15.6 μ m/pixel. The images were post-processed by a drop detection algorithm based on Young-Laplace equation (One Attension software). The accuracy of the algorithm is argued to be of the order of $\pm 0.1^\circ$ (Cheng et al., 1990). After one week, the contact angles of the samples were measured again by the same process.

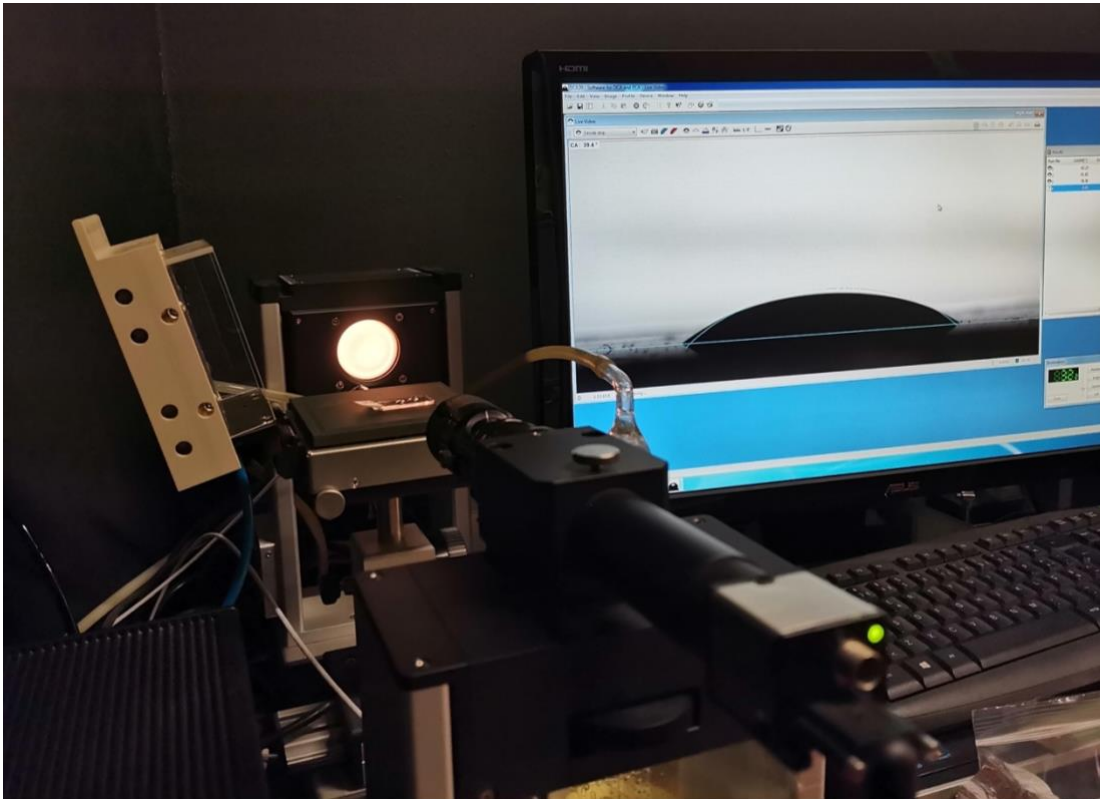


Figure 4 – Optical tensiometer equipment for contact angle measurements.

Unmodified PDMS had an average contact angle of $112^{\circ} \pm 5^{\circ}$, which is consistent with values reported in the literature. In contrast to PDMS alone, the samples containing a surfactant showed a reduction in the average contact angle, as shown in Figure 2. For the samples modified with PEG, Leophen ML and Leophen BN, the average contact angles right after manufacture were $108.23^{\circ} \pm 1.48^{\circ}$, $103.86^{\circ} \pm 3.92^{\circ}$, and $104.55^{\circ} \pm 5.00^{\circ}$, respectively. These values were higher than 90° , demonstrating that the samples still exhibit hydrophobic behavior, even though they were lower than the value obtained for unaltered PDMS. For the samples modified with PDMS-b-PEO and TX-100, the average contact angles obtained after manufacture were $61.35^{\circ} \pm 2.17^{\circ}$ and $84.12^{\circ} \pm 1.56^{\circ}$. These values are less than 90° , demonstrating the hydrophilicity of the samples. The samples kept their hydrophilic behavior one week later, with an average contact angle value that was comparable to the one recorded on the day of manufacturing. When utilizing PDMS-b-PEO, the contact angle value reduction was more noticeable. Since PDMS-b-PEO already had PDMS on its structure, this improved the surfactant's compatibility with the polymer. To provide the desired hydrophilic behavior, more PEG may be needed.

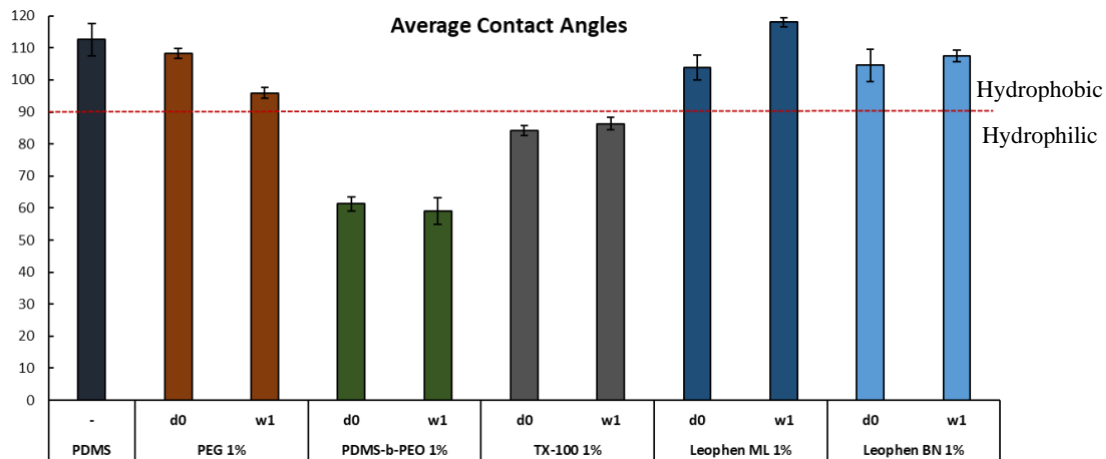


Figure 5 – Contact angle measurements of PDMS and modified PDMS using distilled water.

CONCLUSIONS

Currently the scope of our work is to perform quantitative analysis with different surfactants and hydrophilic solutions, to improve the PDMS wettability. The use of PDMS-b-PEO turned out to be the more effective method for boosting hydrophilicity and preserving transparency. Future research will assess the effects on the flow inside modified PDMS microchannel devices as well as the visualization of particle flow. Additionally, the release of surfactant to the fluid and its impact on cell culture will be assessed, as well as the wettability behavior of the modified PDMS when in prolonged contact with fluid.

ACKNOWLEDGMENTS

I. M. Gonçalves acknowledges FCT for the grant SFRH/BD/08646/2020, supported by national funds from Ministérios da Ciência, Tecnologia e Ensino Superior. This work has been also supported by the projects, EXPL/EMD-EMD/0650/2021 and PTDC/EEI-EEE/2846/2021 through the COMPETE2020, under the PORTUGAL 2020 Partnership Agreement through the European Regional Development Fund (FEDER) and by Fundação para a Ciência e Tecnologia (FCT). The authors acknowledge the partial financial support within the R&D Units Project Scope: UIDB/00690/2020, UIDB/04077/2020, UIDB/04436/2020, UIDB/00532/2020. The authors also acknowledge the financial support (4004) from the Research Center for Biomedical Engineering from Tokyo Medical and Dental University, Japan.

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Control of the dimensional variation adjusting the thermal drying cycle of abrasive composites with incorporated PLA

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ABSTRACT

In composite production, during the thermal drying cycle ($T < 100^{\circ}\text{C}$), size variation of the composite material occurs due to the thermal expansion and water elimination. However, when incorporating PLA components, produced by additive manufacturing, into the abrasive composite, the dimensional variation of the set is very large due to the higher polymer thermal expansion. During this stage, this composite, still in green state, could not have sufficient mechanical strength to withstand dimensional variations. These can result in crack formation. Therefore, the proper thermal cycle is a critical step. To define the convenient heating rate during the drying of composites with a PLA piece, thermomechanical analyzes were conducted. Three different heating ramps were tested, 0.1, 0.5, and 2.0 $^{\circ}\text{C}/\text{min}$ in the most critical phase of dimensional change (up to 60 $^{\circ}\text{C}$), after this temperature the heating continues at 2 $^{\circ}\text{C}/\text{min}$. The results indicate that, the slower is the heating rate, the higher is the absorption of the polymer's expansion by the composite. In the slower heating rate (0.1 $^{\circ}\text{C}/\text{min}$) it was possible to minimize the dimensional variation of the samples in more than 94%.

INTRODUCTION

Abrasive composites are widely used in various industries as a tool to effectively shape and surface metals. Many industries, such as aerospace, automotive, biomedical, or heavy equipment, depend on the precision of these tools to produce increasingly complex parts from the point of view of the geometry and the surface finish (Palmer et al., 2018; Yin et al., 2017), maintaining the properties of the workpiece.

The manufacturing process of abrasive composites involves a thermal drying phase and a sintering phase, after shaping. During thermal drying phase, up to approximately 100 $^{\circ}\text{C}$, the elimination of water occurs progressively, while the densification sintering occurs during sintering at higher temperatures, depending on the type of bonds. During the entire process, the composite is subjected to dimensional variations caused by different mechanisms and reactions, i.e., elimination of water, combustion of organic components, decomposition of mineral precursors and matrix material softening (Capela et al., 2018). However, when incorporating a solid piece produced by additive manufacturing (ex: in PLA), higher dimensional variations occur in the drying step due to the polymer expansion (according to material coefficient of thermal expansion, CTE). These high

variations can compromise the composite, because as green material, it could not have sufficient mechanical strength and so, it is susceptible to crack formation. A priori, this effect can be mitigated with a proper choice of the thermal cycle. The ideal thermal cycle is one that heats up slowly enough to allow the PLA and composite to expand in a slower controlled manner. In order to define the most appropriate heating ramp, the thermal expansion analysis has been performed under 3 different ramps: 0.1, 0.5 and 2.0 °C/min.

RESULTS

The abrasive composite used here has a vitreous bond, with 38% porosity and density of 2.5 g/cm³. The samples have a cylindrical shape with a radius of 2.5 mm and a height of 5 mm. The PLA piece is 1.5 mm thick, with a radius of 2.5 mm (cf. figure 1). The moisture content in the abrasive composite is 2.5 in wt.%.

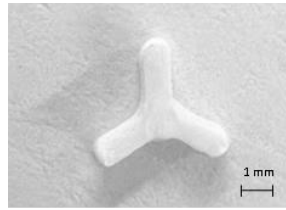


Figure 1- PLA sample before integration in the abrasive composite.

First, a TMA test was carried out with a heating ramp of 2 °C/min up to 75 °C. A high expansion jump (~5%) is detected in the range 40-55°C (figure 2). Then the height of the sample stabilized/decreases about 0.8% up to 75°C. In order to alleviate the problem, the heating rate in the critical zone was reduced (up to 60°C). Two other tests were carried out, with two different heating rates: 0.5 and 0.1 °C/min up to 60 °C followed by a 2 °C/min. heating up to 75 °C. The results of these tests are presented in figures 2a and 2b, as a function of temperature and time, respectively.

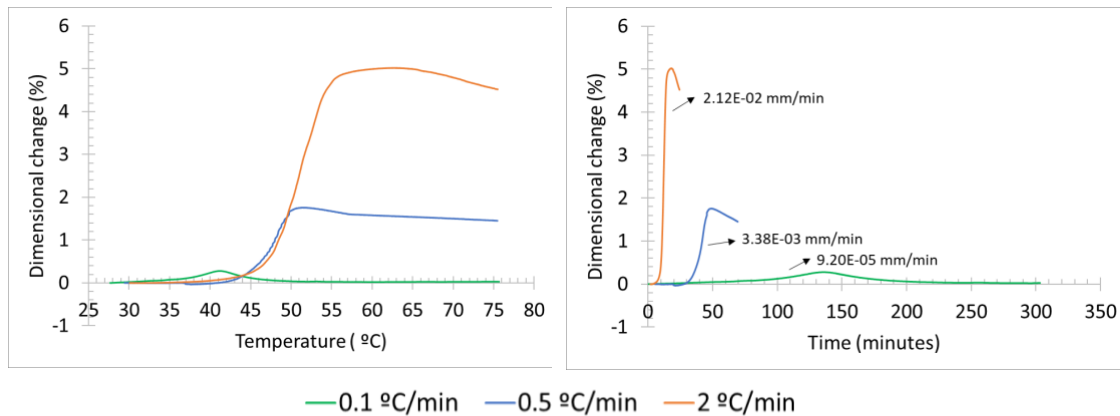


Figure 2- Dimensional variation as a function of temperature a) and time b)

By reducing the heating rate, it was possible to substantially decrease the dimensional change of the samples, especially for the one that was heated at 0.1 °C/min. In this case, the maximum variation recorded was ~0.28%. Compared to the sample heated to 2 °C/min, there was a reduction of more than 94% in the values of dimensional change in the sample with slower heating, and of 64% in the sample heated to 0.5 °C/min.

The results indicate that, with low heating rate, the abrasive composite internal microstructure (namely its open porosity) can absorb or accommodate the polymer's expansion. In figure 2a, it is possible to see that the expansion of the sample happens very quickly, and as the heating rate is reduced, this effect is smoothed. Also, one can note that

the thermal expansion starts at lower temperature (33°C) in the slower thermal cycle, while it starts around 40-42°C using faster cycles. The evolution of expansion rate versus the heating rate is shown in figure 3. A straight correlation is observed between these two items.

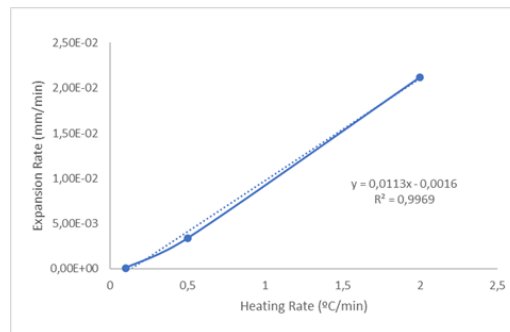


Figure 3 – Expansion rate at the critical zone for different heating rates

Considering dE is the thermal expansion (in mm) the expansion rate is described as:

$$\frac{dE}{dT} \quad (1)$$

The linear behavior observed in fig.3 confirms that dE/dT , i. e. the dimensional thermal expansion in these samples is almost constant. Here, $dE/dT = 0.0113 \text{ mm}/^\circ\text{C}$, in the range 25-60°C. The PLA thermal expansion coefficient (since the thickness of the PLA piece is constant) remains constant inside of the abrasive composite whatever are the heating rates

CONCLUSIONS

By reducing the heating rate during the drying step of abrasive composites with PLA, it was possible to smooth the dimensional change of the composite material and decrease the variation by more than 94 %. Experimental results show that the composite internal structure has capacity to absorb an important part of the external (polymer) thermal expansion during the drying process. A slower heating promotes the absorption of the PLA polymer expansion by changes in the abrasive composite internal microstructure.

ACKNOWLEDGMENTS

This work is supported by FCT national funds, under the national support to R&D units grant, through the reference project UIDB/04436/2020 and UIDP/04436/2020. This work is also within the scope of the Sharlane Costa Ph.D. degree in progress, financially supported by the Portuguese Foundation for Science and Technology (FCT) through the PhD grant reference 2021.07352.BD. The authors are grateful to the Foundation for Science and Technology (FCT, Portugal) for financial support through national funds FCT/MCTES (PIDDAC) to CIMO (UIDB/00690/2020 and UIDP/00690/2020) and SusTEC (LA/P/0007/2020).

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Additive manufacturing techniques for the fabrication of intracranial aneurysm biomodels

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ABSTRACT

The hemodynamics of intracranial aneurysm (IA) involves complex phenomena that influence its growth and rupture. The advancement of additive manufacturing techniques allowed the development of biomodels suitable for *in vitro* experimental tests. Thus, we present in this work the process of manufacturing flow biomodels, using different additive manufacturing techniques and materials. The biomodels obtained through these methods proved to be suitable for experiments using imaging techniques and for validation of numerical studies.

INTRODUCTION

Intracranial aneurysm (IA) is one of the most serious cerebrovascular diseases and it is associated with weakening of the arterial wall, which causes local dilation. This pathology has a mortality rate of 60% after rupture and a dependency rate of 40% (Amenta et al., 2012). The cause of the development and rupture of IAs is still not well understood, being related to simultaneous physical and biological factors (Tromp, Weinsheimer, Ronkainen, & Kuivaniemi, 2014). Therefore, to better understand IAs, it is important to analyze the local hemodynamic, and how it affects the vessel wall (Saqr et al., 2019).

As *in vivo* studies are expensive and difficult to perform, the *in vitro* study using flow biomodels proved to be a reliable method to study IA hemodynamic. In this work, the fabrication of phantom flow biomodels is presented, using two different additive manufacturing techniques: Fused Deposition Modeling (FDM) and Masked Stereolithography Apparatus (MSLA). 3D printing with the FDM technique builds parts layer by layer by depositing the filament (molten material) on a path, while MSLA printers use an LCD screen to project the image as an ultraviolet backlight that is cast as a shadow on the resin. This last technique has the advantage of curing the entire resin layer at once.

RESULTS

The two manufacturing processes of the biomodels (FDM and MSLA) are shown in Figures 1 and 2, respectively.

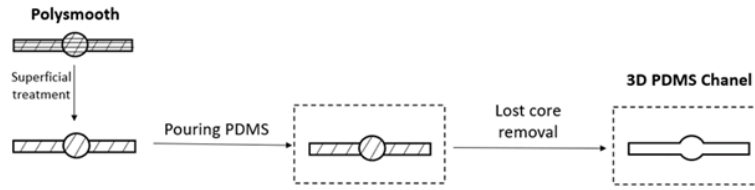


Figure 6: FDM manufacturing process.

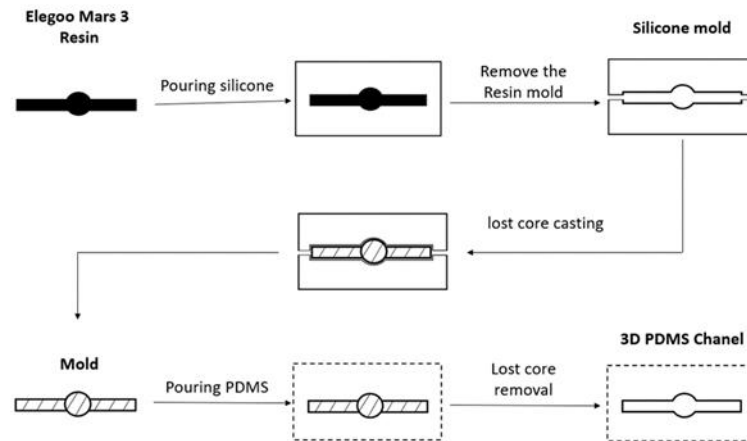


Figure 2: MSLA manufacturing process.

Using the FDM technique, the model used as the lost core was printed on the Ultimaker 3 printer with PolySmooth filament. After obtaining the model, it was positioned in the Polysher machine to perform a surface treatment with isopropyl alcohol. With the surface treatment completed, the model was placed in an acetate box and then the PDMS was poured by gravity over the model. PDMS was prepared in a ratio of 10:1 and its curing process took place in 48 hours. After the PDMS had completely cured, the lost core material was removed with isopropyl alcohol. The final PDMS biomodel is shown in Figure 3 (a).

In the manufacturing process using the MSLA technique, the Elegoo MARS 3 printer was used. Initially, the mold was produced in resin. It was then used for the manufacture of the bipartite silicone mold, which is used to model the lost core material (glycerin-based soap). After obtaining the lost core in glycerin soap, it was placed in the acetate box, and the PDMS was then poured by gravity over the lost core. After PDMS cured, the lost core was removed with water. The final biomodel image is shown in Figure 3 (b).

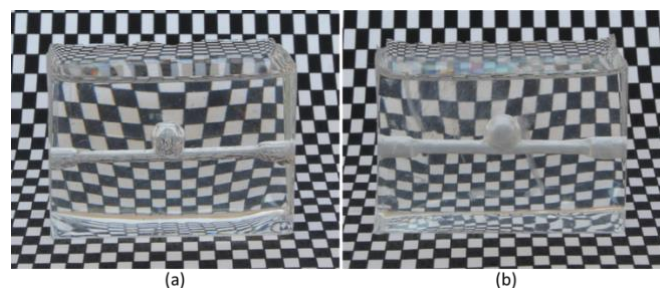


Figure 7: Final biomodels in PDMS, using the MA techniques: (a) FDM and (b) MSLA.

To validate the biomodels, a flow visualization test was performed. The system used was an inverted microscope (IX71, Olympus, Japan), a high-speed camera (Photron

FASTCAM SA3) and an objective lens (ZEISS, 2.5 ×). The fluid used in the tests was a mixture of 61% glycerol and 39% distilled water (w/w) and 0.1% suspended particles of Polymethylmethacrylate (PMMA). Figure 4 shows visualization of the fluid in the biomodel obtained by FMD printing technique.

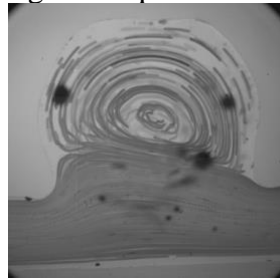


Figura 4: Flow test – 10 ml/min.

CONCLUSIONS

In this study, the results obtained demonstrate that the PolySmooth material using the FDM printing technique proved to be suitable for the manufacture of biomodels, with good dimension accuracy, roughness, good visualization and ease of removal of the material from the lumen. The MSLA technique using resin and glycerin soap, although presenting the same advantages as the previous technique, has the disadvantage of requiring manual work during its manufacturing process.

ACKNOWLEDGMENTS

The authors acknowledge the financial support provided by Fundação para a Ciência e a Tecnologia (FCT), through the projects EXPL/EME-EME/0732/2021, PTDC/EEI-EEE/2846/2021, funded by NORTE 2020, PORTUGAL2020, and FEDER. This work was also supported by Fundação para a Ciência e a Tecnologia (FCT) under the strategic grants UIDB/04077/2020, UIDB/00690/2020, UIDB/04436/2020 and UIDB/00532/2020. Andrews Souza acknowledges the PhD scholarship 2021.07961.BD attributed by FCT. Partial support from the Junta de Extremadura through Grants No. GR21091 and IB20105 (partially financed by FEDER funds) is gratefully acknowledged.

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From kindergarten to fablab - teaching Maker movement and digital fabrication

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Invited speaker

First of all, I want to thank IPB for the invitation. It's good to be home! My name is Alexandra Baltazar and I am the director of education at VIVALab, in Porto. But this was not always my job, in fact when I introduce myself, I like to say that I am a Maker Educator...

To become the maker educator that I feel and call myself today, there was a long path that I would like to share with you.

Academically I am, and always will be, a Kindergarten teacher. And, although it may seem that kindergarten has nothing to do with the world of Digital Fabrication, the Maker Movement and STEAM, in fact they are more connected than it may seem at first glance. I have always been connected to education and I started my path here! At the Higher School of Education. I have worked as a kindergarten teacher for 15 years although I have had some alternative projects along the way. For today what really matters is how an educator ends up in charge of the education department of a fablab.

My curiosity never stopped. I opened V!Va, a summer camp space, which aimed to bring the joy of learning back into children's hearts. To take the weight off assessments and right and wrong for a more explorative stance of what surrounds us. Our audience were children aged 6-15 but the space was organized like a giant preschool room.

In 2015 I took a Lego robotics course. Who doesn't like legos?

Books like Lifelong Kindergarten; Mindstorms; and Invent to Learn brought structure to my ideas and led me to learn to use technology as an urgent thing. Children and teenagers needed to start using technology and stop being used by it. Something that hasn't changed yet. On the contrary, it is increasingly necessary that everyone has an intervening and active attitude towards the technology that is developed daily

I visited FabLab Barcelona and talked to some people there who started to take their first steps in Maker education. I visited a school that had implemented Fab@school until the 12th grade. I came back to Porto with my head buzzing with ideas and inputs. In our Lego after school Classes, we started to feel that it was not enough to follow instructions and build robots. You had to make mistakes! You had to explore! So, we started to add tinkering to legos, waste material and open challenges: "Build something that moves!" and in the end thematic challenges where each group from different schools would develop a project to present on a special day at the end of the year. Tinkering brought with it the process of combining play with investigation; of bringing together familiar materials in unfamiliar ways;

Tinkering also balances autonomy with collaboration and is a comfortable way to deal with the unknown and the "not knowing". In addition, it is super friendly to STEAM as it

merges science, art and technology. In other words, it is a way of being and looking at things to find less obvious solutions and combinations.

STEAM and the maker movement are two approaches to education that have gone their separate ways although they could be completely merged. Interestingly the only fact that distinguishes them is motivation for their emergence. STEAM emerged from the increasing lack of interest that students had in the exact sciences while the maker movement emerged from the interest and motivation of individual people or groups to make things, to discover, to learn together.

Otherwise, as approaches to teaching, both STEAM and the maker movement have as a starting point the development of socio-emotional skills and abilities. They both seek to solve real problems in real life, they seek interdisciplinarity, the hands-on activities are perhaps more in the maker movement but, STEAM also seeks to develop hands-on activities.

In 2018 me, Tauan, Miguel and João decided to open VIVA lab. Our goal was to create a fablab open to the community, dedicated to design, education and innovation. And, I think I can proudly say that we have been on a very successful path with an impact on the local community.

Regarding education, there are numerous projects that we have developed in these last four years.

The very week we opened in September 2018, we opened with the "Future Maker" camps which have been happening in the different school holidays since then. Even with the pandemic and with quite small groups, we never stopped doing "Future Makers".

The "KitFerraBI" is a project that aims to foster experimentation and the maker spirit in the family, while teaching how to use different tools. Each box is dedicated to a tool and can be rented for a period of one week. The instruction tutorials are available on youtube always with suggestions of what to do but leaving room for each one's creativity. We have only implemented this project in one school in Porto but we can say that it has been a success even after the pandemic.

Also during the pandemic (necessity sharpens the wit) I created a podcast about Maker education, called "5 minutes of Maker education" because I felt there was nothing in Portuguese and it was important to start talking about it. Unfortunately, in the last year I didn't make any episodes but it's not forgotten and I intend to come back to create more content. It already has almost 500 views and the most listened to episode 111.

Obviously, we began to feel that we needed to get the word out about what we were doing, and support teachers to gain confidence in using both maker methodologies and digital fabrication machines and the different technologies and resources available. So, Maker Training for Teachers emerged where we have worked with over 100 teachers, and we want to continue to bring this educational approach to more teachers and schools.

Regarding young people between 15 and 18, we felt that it was difficult to bring them to the FabLab ... because they felt that what we did was for the younger ones or that it was for adults. From this need was born "Making our Future", which we applied to Scale Up and won in 2020. An ideas competition with small workshops in schools to get young people to find solutions to the problems they identified around them. We were in the middle of a pandemic, which made some of the actions we had in mind impossible. Still, we did online sessions and we had 20 applicants and we did a physical prototyping day with the proper restrictions.

Meanwhile, within the precious plastic project, we created a workshop called "Plastic Play", which aims to take the precious plastic machines to schools and, through a hands-on activity, raise awareness about the problem of plastics by teaching the different types of plastic and making a piece that everyone can take home. The target audience of this activity is young people from 15 to 18 and with the support of Lipor, we have already been to 8 schools and worked with over 500 kids.

This year we also entered the European project horizon 2020 "Shemakes" which aims to bring girls into science and technology through the textile world. We have developed several workshops within the curiosity path for girls from 8 to 18 years of e-textiles, sewing, laser cutting, etc. and we are now entering the second year of the project.

The "Laboratorio VIVA" is our extracurricular activity where we decided to divide the groups by "DO", "MAKE" and "CREATE

Finally, the course of educational technologies of ESE which I will tell you more specifically ... in this course last year I taught two subjects: Fabrication 1 and 2 (subject of 1st year) and Project (subject of 2nd year).

In fabrication 1 and 2 the idea was for students to get an overview of what the maker movement and maker philosophy is; experience the creative learning process and how to implement it in a classroom; what tools and materials are and how we can take advantage of both; what open source is and the need to document; how to implement project based learning; and finally, within the maker movement and fablabs the idea was to create workshops so students could experiment with different materials and different tools. Mainly because most people, unfortunately, these days, have no contact whatsoever with tools.

Astrid Poot, a Dutch maker, has created a flyer for children to record as they use tools. In the flyer she identifies 50 tools that every child should try until the age of 12 years old but most of the adults in the room have probably never used some of them either.

<https://forms.gle/mxsS3HL1nKrvSUt8>

It was curious to notice that the exploration of materials and tools and the willingness to learn new things they didn't know showed a clear division in the group. There are people who are predisposed to experience the New and even look at it with curiosity and then, the discomfort that the new brought to the other half of the group. The new exposure puts us in a position of discomfort, nevertheless, some liked the possibility to experiment and felt safe to make mistakes (the educator's attitude is very important).

So to create the largest and most varied number of experiences for the students, we did paper workshops, textile workshops, wood workshops, stop motion workshops, toy upcycling and some more science related workshops. Manufacturing 2 was more dedicated really to manufacturing and digital manufacturing machines and so we worked on 3D modeling, 3D printing, 2D drawing and using the laser cutter. A curiosity, when we surveyed the students about how important the subjects were, the most common answer was "learning to share ideas and communicate" which is one of the 4c's of skills for the 21st century. The second answer was the ability to make mistakes and not be afraid of making mistakes and resilience, i.e. being able to start again. The third was

creativity, so in an empirical way, the students identified this educational approach as something that helps develop skills for the 21st century.

In the project subject, of the course in ESE the aim is to take a little further what on a small scale they have done in fabrication one and two with the Creative Learning Process, applying the maker mindset. The Creative Learning Process has as guiding principles the 4 p's : Projects, Pairs, Passion, Play. The learning process does not happen in a linear way, but follows a spiral where we imagine what we would like to create, build something, play with materials and ideas and in this process, we share our creations and reflect on the "how" and "what" we learned, coming back to imagine again. The steps of the spiral itself do not have to follow this pre-defined sequence; we can jump to one or the other as we go along with our projects. As we move through the creative learning spiral, we delve deeper into relevant themes and skills, and exercise our ability to conceive, design, and implement ideas that are meaningful to us and our communities. According to Resnick, in his book *Lifelong Kindergarten: Cultivating Creativity through Projects, Passion, Peers, and Play*, "kindergarten-style based learning is exactly what is needed to help people of all ages develop the creative skills needed to thrive in today's ever-changing society." Unlike the other common education systems in academic life that follow the transmission model of teaching, during kindergarten learning is acquired through active conduct of the child by interacting and connecting with the world, something that does mainly when there are fun and engaging proposals and possibilities.

These students didn't have their first year fabrication subjects with me, so they were quite 'stuck'. It was hard to have a brainstorm session!

It was a very difficult subject for the students. Breaking free from what they are used to doing, fulfilling school assignments and moving to a maker mindset and project development in one semester was a battle! We followed a Product/design thinking project development approach

We did this in small steps with the help of Trello so they could get into the spirit but with step-by-step instructions. The research was the first obstacle. Three or four "researches" and that was it! When I started insisting for similar research, contextualization on the subject, and the possibility to research with the target groups... it seemed I had ideas coming from Mars! Then came the struggle with prototypes, from sketch to dirty prototype it seemed nothing made sense. Communicating, Sharing, Reflecting and Accepting Error are all skills that need continued work and it wasn't until the end of the year that this class began to understand the importance of the different steps in developing a project. They wanted to start making the final product right away and got super angry when I wouldn't let them and said that we were going to prototype with waste material. Or that we would switch projects to test and get feedback from colleagues. Anyway, although this subject was a bit like a battlefield between two countries that spoke different languages I feel that, little by little, they were able to participate and understand the need for these steps. And, I firmly believe that if we work with these educational approaches such as STEAM and the Maker Movement we will certainly have students who are better prepared for the future. Autonomous, able to communicate, with critical thinking, creative and above all curious!

Promote learning through knowledge sharing between higher education courses with interconnection to the business context

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ABSTRACT

In the 2018/2019 academic year, the teachers of the Mechanical Technology I/Manufacturing Processes I and Safety and Environment course units of Bachelor and Higher Professional Technical (CTeSP) courses, respectively, designed a pedagogical proposal for teaching these course units in an interconnected way. For that purpose, two study visits to companies in the metal-mechanical area were carried out with both courses. An exchange of knowledge between the students was also promoted, once communication sessions between both courses were implemented. In general terms, CTeSP students recognized that the communication sessions held by their Bachelor colleagues were useful for the acquisition of knowledge in the field of mechanics. Similarly, the Bachelor students considered that the information transmitted by the CTeSP students alerted them to some safety precautions they should take when working in laboratories or, in the future, in industrial environments.

INTRODUCTION

Collaborative work between teachers with different backgrounds, by promoting debate on teaching and assessment practices, can boost the implementation of some practices that are more student-centered and in different learning contexts. In this sense, the exchange of knowledge between students, combined with the importance of the link to the business context, was the basis of the ideology of a teaching experience that took place with students from the courses of Mechanical Engineering and Technology and Industrial Management and the Higher Professional Technician (CTeSP) in Mechanical Technology and Vehicles, of a Polytechnic Higher Institution in the Northeast of Portugal (*see* Silva, Barros & Ribeiro, 2021). More specifically, the experiment carried out had as main objectives: (1) promote the improvement of student learning; (2) guide the classes so that the student has a more active role in their learning; (3) motivate students to engage in the construction of their knowledge; (4) contribute to CTeSP students having a more informed view on aspects related to the practice of the Mechanical Engineering degree; (5) to establish a greater connection between the courses and the business world/professional context; (6) to promote a more contextualized learning of contents and (7) to promote the development of transversal competences, such as organization and communication, teamwork, critical thinking and sharing with peers. In the following we present some of the opinions/perceptions of the teachers and students involved in the experience, analyzing their contribution to improving students' learning.

RESULTS

Most of the Bachelor students (86.5%) believe that presenting their work in front of a different audience allowed them to work on communication skills. The most significant difficulty highlighted by 48.6% of the students was the fact that they had to simplify the presentation so that their CTeSP colleagues would understand. Similarly, 83.3% of the CTeSP students who represented their colleagues in the presentation session considered that it allowed them to improve their communication skills and 66.7% that it was more rewarding to do it for their colleagues on the degree course than just for their classmates. In general terms, it can be considered that the CTeSP students' presentations on safety at work aspects were enriching for the Bachelor students. It should be noted that 89.2% of the Bachelor students consider that the information transmitted alerted them to some precautions they should take regarding safety at work in laboratories or, in the future, in industrial environments. In general, CTeSP students recognize the usefulness of the communication sessions held by their colleagues from the Bachelor courses for the acquisition of new knowledge in the field of mechanics.

Regarding the study visits, both Bachelor and CTeSP students had a very favorable opinion about their contribution to their learning, since more than 65% of the students agree or totally agree that: (i) It helped them to better understand the work of a mechanical engineer and (ii) It allowed them to observe aspects related to the topic of safety in the workplace. Furthermore, more than 65% agree or totally agree that these: (iii) Met their expectations; (iv) Contributed to enriching their knowledge, and (v) Helped them to better understand industrial practices.

CONCLUSIONS

The experience developed had an important contribution to the student's learning at various levels. The presentation to other audiences and all the logistics related to its preparation promoted the development of transversal skills, such as the ability to work in a team, select materials and synthesize information, communicate, and deepen the knowledge of technological means. However, as the sessions delivered by university students cover very specific knowledge of a certain area, the communication process for the target audience can become more complex. The study visits were an added value for the deepening of the student's knowledge, as they allowed them to come into contact with the working methods of companies linked to the mechanical sector and to observe the manufacturing processes in a real context. They also had the opportunity to observe the hazards and risks underlying certain activities in a business context.

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The Importance of Smart Cities and Urban Policies for the Interior of the Country

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ABSTRACT

Smart cities are an emerging concept around the world, a smart city is a city that mobilizes and uses resources, namely social, cultural, financial, natural, information and technology, to efficiently improve the quality of life of its inhabitants, workers, students and other visitors.

Although the concept of smart city is not consensual, there are some aspects that are common to the various definitions, namely, environment, use of information technologies, knowledge and sustainable urban development.

The use of the "smart" concept captures innovative digital transformations driven by new technological capabilities. However, other social factors besides smart technologies are central to smart cities (Smith, 2022).

In Portugal we have cities and towns with very different attitudes and degrees of maturity regarding urban intelligence (Neto, 2022).

There is no direct correlation between urban intelligence and its geographic location. Urban intelligence does not depend on whether the city is located further to the coast or further inland, it depends on the dynamism, creativity and innovation of each city, in the implementation of good solutions.

Urban intelligence is increasingly dependent on the Internet of Things (IoT) and this is the new technological period that will eloquently change the way people, cities and "things" interact (Lopes et al, 2017).

Thus, this work aims to identify possible projects that Municipalities can adopt/implement, so that cities become smarter, which will imply a better quality of life for those who visit them and for those who live there, which can contribute to the development of the interior. from the country.

INTRODUCTION

Defining what smart cities are smart cities and measuring levels of sustainability, quality of life and well-being are topics that are not yet consensual. Despite the various existing indices and rankings, there is still no standardization of indicators that establish what, after all, smart cities are.

However, there are some indicators, most cited and that seem to us to be a decisive area of action:

- Municipal Management;
- Economy;
- Environment;
- Mobility;
- Safety;
- Education and Health.

Urban intelligence as a public policy is an “hat” that involves fields of action, within the different areas of activity, ranging from education (a bet on STEAM education), to energy efficiency (city energy consumption), to the management of water, waste, control and monitoring of road traffic (traffic congestion), pollution levels in the city, noise levels, measurement and regulation of parking lots, control of public lighting, automation and health of public buildings , among other actions.

In Portugal there has been a remarkable number of projects implemented by the Municipalities in recent years, taking technologies to cities. However, for a project to be interesting, it must have a positive impact on society, that is, on citizens.

The Portuguese Municipal phenomenon does not present uniform or common characterization lines to the universality of existing Municipalities. Indeed, Portuguese Municipalities, as local phenomena that are, and a fortiori, the bodies that represent them, end up reflecting the vicissitudes and constraints of the physical and human environment in which they are integrated.

Thus, of the 308 Portuguese Municipalities it can be said that the coastal municipalities assume legal and hierarchical primacy, more than that, due to their population and financial nature. However, also small and medium-sized cities in terms of smart cities are not behind the large ones and have enormous potential to assert themselves in this concept of cities. Living in a city in the interior of the country is without hesitation a “smart” concept.

Inland, with all the obstacles inherent to its location in an area of low population “density”, the resilient way in which these municipalities overcome all these contingencies is remarkable.

RESULTS

Most of the projects already implemented in the cities were the initiative and dynamics of the Municipalities, however, there are more ambitious projects, which can only be achieved with a clear involvement and funding from the State.

Many of the municipalities in the interior of the country, and especially the smaller ones, no matter how much effort they can devote to new projects, without external support, they do not have much room for manoeuvre.

Community funds are a good way to access support. It is essential that these can include initiatives for the development of smart cities in an integrated and explicit way.

Some examples of projects to be implemented according to the area of activity are:

MUNICIPAL MANAGEMENT	ECONOMY
Online services; Management and access to open data; Platforms that integrate various services; Management of donations, for example during a pandemic;	Tourist information platforms, online reservations and city maps; Coworking spaces and actions to encourage startups; Incentives for the development of the creative economy;
ENVIRONMENT	MOBILITY
Programs for waste management;	Smart traffic lights;

Management of energy efficiency in buildings; Public lighting (LED);	Monitoring of carbon dioxide emissions; Real-time information on the location of certain vehicles;
SAFETY	EDUCATION AND HEALTH
Video surveillance and image analysis; Cybersecurity; Technological GPS location systems;	Implement STEAM education at school; Creation of STEAM Labs; Digital platforms: Monitoring of pandemics; clinical material management. Health programs for healthy living; Remote monitoring of the elderly; Real-time information on the concentration of people;

Table 1 - Identification of projects by area

CONCLUSIONS

The degradation of the quality of life of citizens residing in large cities will certainly lead to a utopian return to their cities, towns and villages from which they originate, inverting the direction of migration from the interior to the coast, which occurred in the last century.

Digital transformation starts with transforming the relationship between the back office and the front office. Cities, regardless of their size or region, will be able to find the agents and themes of change that allow this transformation to take place.

This transformation is increasingly being felt and it is clear to see that mayors are more aware of the impact of smart cities on urban life. The search for territorial rebalancing with the bet on new models of development of a city is adapting them to the new challenges (from demographic to environmental) and with the duty to make them smart cities, without losing their identity.

Smart cities are the latest form of urban planning and of great importance for cities in the interior of the country. This transformation could reverse the direction of migration from the interior to the coast and contribute to the much-desired territorial cohesion.

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The importance of STEAM education in schools: literature review

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SUMMARY

Never before has there been so much talk about educational innovation like today! Innovation that translates into a continuous process of improving teaching in our schools, which necessarily involves the human development of each and every student, focusing on areas that also accompany the technological development of recent decades.

The advent of new emerging technologies has led to the emergence of teaching and learning approaches aimed at cultivating the critical thinking needed for the complex and rapidly changing digital age. This trend has contributed to an integrated approach to teaching and learning known as STEAM (Meletiou-Mavrotheris M., 2022).

It is this methodology that we intend to briefly address in this work, given that the topic is emerging and that it should be studied empirically, so that this methodology is implemented in our schools, although the same is not done in this work, limiting itself to a more theoretical approach.

Thus, a literature review was carried out in order to clarify the extent to which STEAM education can contribute to the much-desired educational innovation.

INTRODUCTION

STEAM is known as a pedagogical and educational approach that integrates areas and is based on projects, aiming to train students with different knowledge, so that they develop different knowledge skills.

This methodology emerged in the United States in the 1990s, after students showed a lack of interest in the exact sciences. The acronym STEAM results from the English words Science, Technology, Engineering, Arts, Mathematics.

Although this approach was initially called STEM, today it integrates more the letter “A” of Arts, which is associated with the four initial areas of the exact sciences.

It is understood today that arts education improves academic performance and helps our students to better interpret the world, and that is what the STEAM methodology wants to demonstrate.

In this sense, Arts should be understood as a discipline that brings to the fore themes such as humanities, language, culture, architecture, literature, music, dance, cinema, theater, sculpture, design, painting, animation and photography (Antunes, J.).

Thus, we can say that STEM is about how things are done, while STEAM encourages the discovery of why these things are being done.

METHODOLOGY

The methodology adopted for this research work was done through a brief systematic review of the literature, where some scientific articles present in the Scopus database and Google were selected, according to the topic under study.

The literature review intends to provide a small theoretical contribution, since it brings together recent knowledge in the area of the STEAM approach, also serving to expand knowledge through empirical research carried out.

The process began by searching the Scopus database and Google within “article title, abstract, keywords” with the following keywords related to the theme of this work: STEM education; STEAM approach; STEAM education and STEAM pedagogy. This research had the first filter by restricting the time horizon to the last decade (2012-2022). This choice was due to the fact that this approach is quite current.

RESULTS

The STEAM methodology according to (Antunes, J.) focuses on the development of some essential skills for the 21st century student, such as:

- Creativity, imagination and innovation.
- Critical thinking and problem solving.
- Communication and collaboration.
- Flexibility and adaptability.
- Social and cultural skills.
- Ability to deal with different situations.

In STEAM projects, it is intended that students begin to develop these skills in a more interactive and autonomous way. Build, prototype, create, troubleshoot and interpret your own creations.

For (Noemi, D., 2018) STEAM education is more dynamic, therefore, it favours the learning of students who are not always able to absorb or retain knowledge with the traditional teaching model seen in most schools. Pointing out the following advantages for education:

- Learning and acquisition of interdisciplinary knowledge.
- Applicability of learning.
- Changes in the relationship between teacher and student.
- More preparation for the job market.

Another author (Silvia, I.O., 2017) considers the STEAM methodology as an active methodology, that is, they are interactive processes of knowledge, analysis, studies, research and individual or collective decisions, in order to find solutions to a problem. It is the teaching process in which learning depends on the student himself. The teacher acts as a facilitator or advisor for the student to do research, reflect and decide for himself, what to do to achieve a goal.

In the same line of reasoning, (Hero's Academy) consider that the STEAM approach removes the limitations of traditional teaching and replaces them with logical and interpretive reasoning, criticism, research and innovation. STEAM does not just teach theories or concepts, but develops practical experiences and problem solving that stimulate scientific thinking in an interpretive and reflective way, generating a greater understanding of reality.

CONCLUSION

More than understanding that the world is constantly evolving, we also need to adapt to changes and education is part of this paradigm.

From the literature review we can conclude that the STEAM approach favours learning through experimentation and creation in an interdisciplinary way.

As future work, we propose the analysis of this approach in an empirical way in schools in Portugal, differentiating the schools of Higher Education.

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The power of Additive Manufacturing as a STEAM educational tool

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ABSTRACT

STEAM is an acronym which stands for Science, Technology, Engineering, the Arts and Mathematics and is an educational approach to learning which is very popular nowadays. The reason behind this fame lays in the wide and inclusive approach which is clearly explained by the acronym.

In a society which follows two divergent yet parallel trends, that is following a common model and finding a proper self-identity, science and technology cannot be left behind when it comes to education; however, they need to be coordinated and harmonized together with art to find their full potential.

Additive manufacturing has the potential of meeting all the requirements asked by the STEAM acronym, since the freedom of design that this new fabrication technology takes with itself is very promising for the education of the next generation of creators and technology professionals.

INTRODUCTION

Additive manufacturing (AM), also known as 3D printing, is a very powerful and nowadays popular method to fabricate complex objects, based on the fusion, deposition or sinterization of a raw material (including but not limited to powder, wire, filament, rod or pellet) on a layer-upon-layer fashion. This method overcomes all the drawbacks of conventional production technologies in terms of shape and complexity, allowing also the fabrication of hollow structures and engineered foams, or rather lattice structures with a well defined and optimized periodicity which enables the prediction of the mechanical performance.

The unprecedented freedom of design provided by additive manufacturing technologies and available for different materials (polymers, composites, metals, ceramics, food etc.) and on a wide range of available fabrication volume and 3D printing solutions (from desktop devices to robotic-arm-based systems) and a relative diverse range of prices for these solutions, the choice for an AM technology suitable for a particular purpose can be very flexible and varied. This additional freedom make the availability of this technology possible and safe for students with a variety of ages and potentially not familiar with this fabrication method, that is from first grade to academics.

STEAM is a recent evolution of the well-known STEM education world which is devoted to the inclusion of “arts” in the scientific world, with the purpose of shaping the critical minds of the next generations to be more inclusive, flexible and open to new solutions and to the integration of different subjects which are typically not so bonded together.

RESULTS

As outlined by Sinha et al. (Sinha et al., 2017) “Additive Manufacturing (AM) has played an integral part in the growth of makerspaces as democratization of manufacturing

continues to evolve. AM has also shown potential in enabling the successful amalgamation of art (A) with science, technology, engineering, and math (STEM) disciplines, giving new possibilities to STEAM subjects and its implementation”.

In addition, there are several research papers published which deal with the STEAM education, describing exactly 3D printing as a perfect learning and teaching tool. Indeed, 3D printing devices allow the cooperation of professionals and academics and/or teachers experienced in science and math to design abstract models of their disciplines and to make it real through art and layer-upon-layer fabrication (Belbase et al., 2019; Vanscoder, 2014).

Also, it should be pointed out that the enhanced project-based learning which is strongly encourage and exploited in art and problem-solving education which is typical of science, math and technology, can be combined using 3D printing as a tested method (Deak et al., 2021).

CONCLUSIONS

Results of the present research show how the accessibility and scalability of 3D printing, together with its unique features (freedom of design, as an example) are leveraged in the STEAM educational environment where art and technology are put together to shape the next generation of professionals and educators.

ACKNOWLEDGMENTS

This research was partially funded by the Grant of Excellence Departments, MIUR-Italy (ARTICOLO 1, COMMI 314–337 LEGGE 232/2016).

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Application of the STEAM methodology for laser scanning of historic buildings

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ABSTRACT

3D laser scanning ensures consistency and objective validation of results, further increasing the level of quality and advancing problem resolution. Combining the scanner output with auxiliary programs, the scanned images become electronic mockups.

This type of technology allows low-access environments to be integrated into the collection, as well as specific objects, maintaining their integrity and allowing the researcher to work virtually avoiding losses.

Contributing to the guarantee of historic buildings, the study is focused on the development of a new methodology to identify the pathology and assist in the restoration of heritage.

INTRODUCTION

Preventive conservation of cultural heritage refers to the identification of causes or agents that compromise the integrity of the building. In Bragança, the Portuguese city chosen for the study, there are buildings that are over 500 years old, and consequently, there is an urgent need to maintain their properties.

For the documentation of heritage, the use of 3D scanning became coherent. According to Pavlidis (2007), the laser scanner has a great advantage due to the fact that it has a great range, obtaining precision even at a relative distance. This technique allows you to capture fast, direct and accurate measurements of buildings and objects in them.

In order to protect the integrity of the monument and ensure its preservation, this study is focused on the development of a new methodology for the restoration of historic buildings such as museums, theaters and equipment. The information generated in 3D is of significant importance for storing important objects so that everyone has access virtually, preventing the physical from degrading. (REMONDINO, RIZZI, 2010). After scanning and site measurements, these new images will be treated and 3D printed.

RESULTS

Using the Scanner Focus S, the first study environment was the laboratory of the Civil Engineering course at the Instituto Politécnico de Bragança, in which 8 scenes were captured with the help of spheres for the elaboration of 3D images. After processing the images in the Scene Software, as shown in Figure 1, the objective of having the environment virtually was achieved, obtaining the result with an error margin of 1.3 mm. Then, the second environment was raised, being an outdoor area. In this case, the sphere was not used and the recognition of the 12 scenes was done manually. Figure 2 presents an example of a collected image.

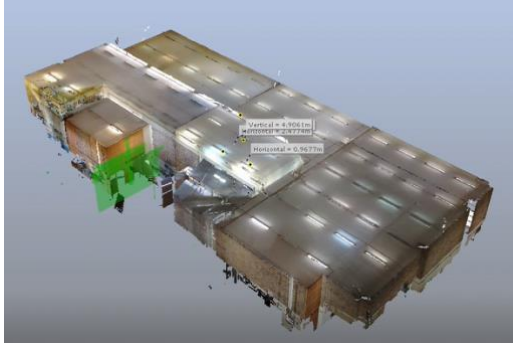


Figure 1- Final scanner result.



Figure 2- Example of image collected by scanner.

CONCLUSIONS

The results obtained in the two scenes made initially were encouraging. The image generated in 3D is in accordance with the real situation of the environment, requiring small adjustments. New developments are being carried out to improve the methodology already developed.

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Manufacture wing models to analyze air fluid flow in wind tunnel using a 3D printer

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ABSTRACT

Aerodynamics is a field that is very present in our daily lives, but we are unaware of it. One of the best examples of this is our car, which was not designed at random. This study of aerodynamics has been very important in recent years in several areas, namely motor racing and aeronautics, which is so useful for us when we want to travel.

This study consists of developing prototypes of aircraft wings for wind tunnel simulation and numerical simulations due to the high demand to be able to better develop cars, aircraft, and all means involving aerodynamics. The prototypes were created using the SolidWorks CAD software, and additive printing was done in a 3D printer using PLA filament.

INTRODUCTION

Aerodynamics is the study of forces acting on surfaces. Aerodynamic forces acting on any moving object in the air, water, or other fluids. Aerodynamic forces affect everything that moves in the air, including planes, boats, automobiles, and submarines [1], [2]. They also employ aerodynamic concepts to design and build bridges and buildings, taking into consideration the force of the air acting on them [3], [4].

SOLIDWORKS software was utilized for this project, which is a Computer-Aided Design (CAD) package with hundreds of capabilities, including the Flow Simulation area, which is where the computational portion of this project was built. Flow Simulation is a simple solution based on Computational Fluid Dynamics (CFD) and integrated into SolidWorks that enables the quick and easy calculation of liquid and gas flow.

The primary goal of this research is to model and fabricate three models, as well as to simulate aerodynamic forces using the SolidWorks software's Flow Simulation function.

RESULTS

The modeled wings are designed to be distinct from typical models; the goal of this study is to analyze flow interference for three identical models that differ in beginning diameter. The effort to print a 200 mm long model, as shown in Figure 1, was unsuccessful due to the long length as well as the geometry of the part, which did not have adequate contact with the 3D printer table. Previously 200 mm long variations became 120 mm long, with diameters of 2.5 mm, 3.0 mm, and 3.5 mm.

The wings were generated vertically due to inadequate contact with the printer's bed, as seen in Figure 2. Vertical printing would eliminate the requirement for supports, which would subsequently be shown in practical tests to be unsuccessful. The brackets were printed vertically to minimize the necessity for them, decreasing the component's material and texture.

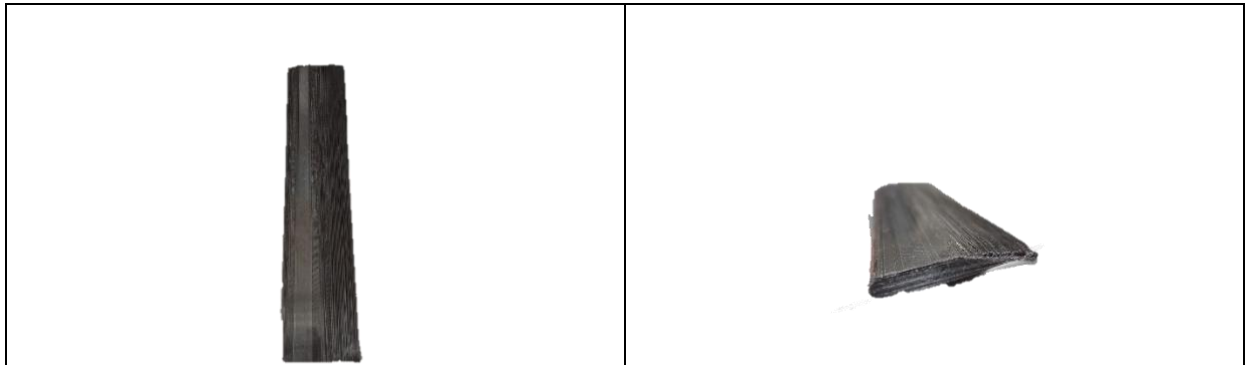


Figure 1 - Models with 3D printing defects.

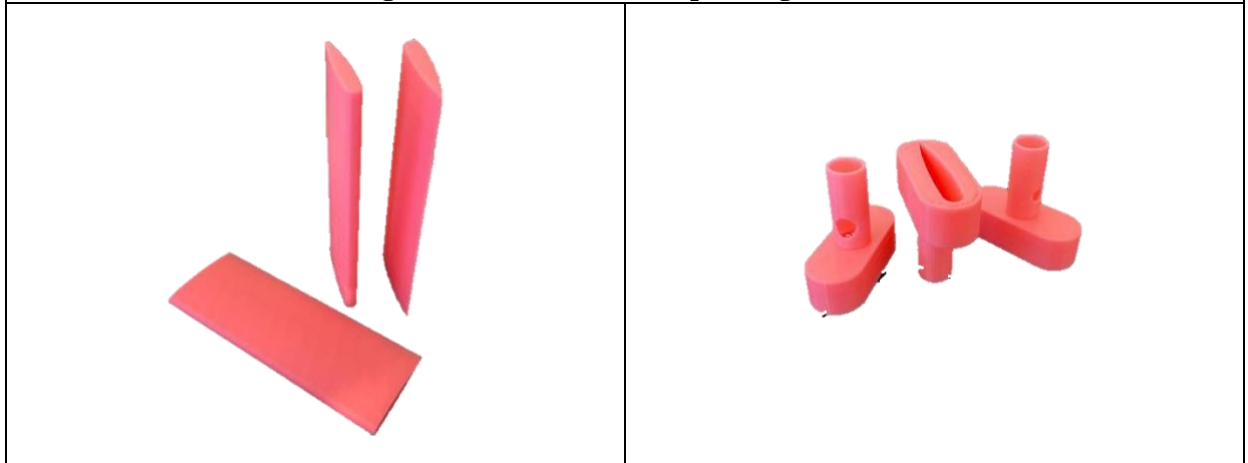


Figure 2 - Models made with 3D printer.

CONCLUSIONS

In this study, an airplane wing model that does not adhere to the previously utilized standard was created. Modeling and manufacturing were completed successfully, thanks to the adaption of printing in vertical form without the need for support.

ACKNOWLEDGMENTS

P Moreira acknowledges POPH (Programa Operacional Potencial Humano) QREN (Quadro de Referência Estratégico Nacional) - Tipologia 4.2 promotion of scientific employment funded by the ESF (European Social Fund) and MCTES (Ministério da Ciência, Tecnologia e Ensino Superior). The support of Universidade do Porto Pluridisciplinar projects program is also acknowledge. The FBG sensors were kindly supplied by FiberSensing.

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Mechanical characterization of specimens manufactured in 3D printing

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ABSTRACT

The use of additive manufacturing (3D printers) in the direct fabrication of commercial items is widespread, owing to the advancements and popularization of computer design programs (CAD) and 3D printers, particularly in the previous 10 years. Shimadzu Autograph AGS - X series universal testing machine was used for both tests. PLA+ can withstand larger stresses than ABS, with 44.2% and 25.73% higher tensile and yield strains, respectively. The modulus of elasticity of PLA+ is shown to be 61.99% greater than that of ABS. The goal of this study is to describe the most often used materials and procedures in 3D printing, as well as to characterize ABS and PLA polymers through tensile testing.

INTRODUCTION

The history of surgery was marked by several events that allowed us to evolve into the complex practices we know today. The need to inspect the body cavity to obtain more accurate diagnoses motivated the development of equipment that made it possible to perform these procedures without causing much harm to the patient. Initially used as a technique to obtain a diagnosis, laparoscopy has evolved into a minimally invasive surgical technique. This technique facilitated the patient's recovery, as it did not require the abdominal cavity to be fully opened to perform a particular surgical procedure.

The objective of this project is to perform mechanical characterization in 3D printing using FDM technology, in addition to ABS and PLA polymers. To compare experimental data with values from the literature for the mechanical characteristics of traction specimens made in FDM printers using PLA and ABS polymers.

RESULTS

Figure 1 depicts the tensile test specimens printed in PLA+ and ABS. Figure 2 shows that the findings for ABS and PLA+ were somewhat higher than the averages observed in the literature [1]–[4], owing to various unanalyzed characteristics that differed from one another. You start with the polymer (ABS or PLA+), which implies that each thread of material has distinct mechanical characteristics. A previously mentioned factor that, along with others, determines the tensile strength of PLA+ is its color, therefore the selected color (black) owing to the chemical makeup, typically mineral, ends up diminishing or increasing the object's resistance.

Figure 3 shows that the values obtained are quite close to the results obtained in the literature [1]–[4][5]–[7], demonstrating a similar behavior despite environmental changes and other characteristics. In the case of PLA+, the color of the filament influences the modulus of elasticity values, resulting in an increase in stiffness.

Figure 4 depicts a comparison of the two materials' average tensile and yielding stresses. PLA+ resists greater stresses, which are 44.2% and 25.73% higher than the tensile and yielding strains sustained by ABS, respectively.

Figure 5 demonstrates that the modulus of elasticity of PLA+ is 61.99% more than that of ABS, indicating that PLA+ is a more stiff polymer than ABS and, as a result, more brittle.

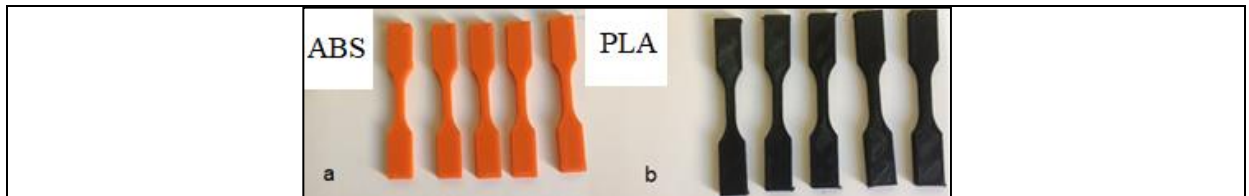


Figure 1 – PLA+ and ABS specimens to the stress test.

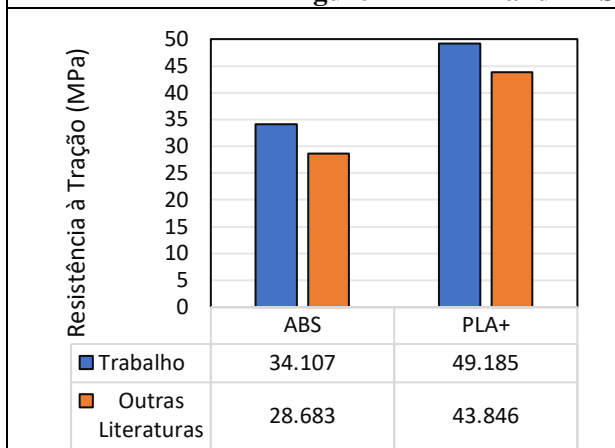


Figure 2 - Tensile strength values of Samples in ABS and PLA.

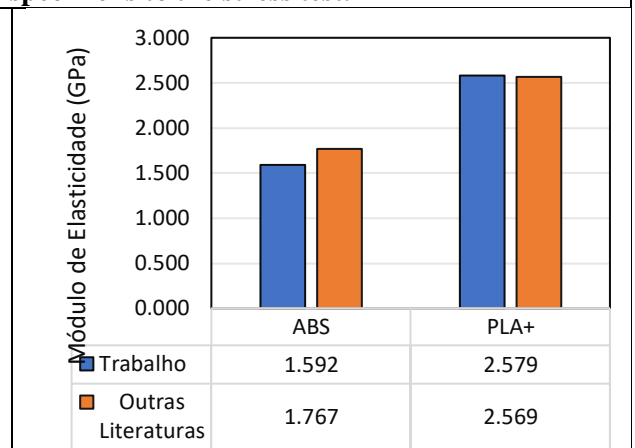


Figure 3 - Values of the elastic modulus of the samples in ABS and PLA.

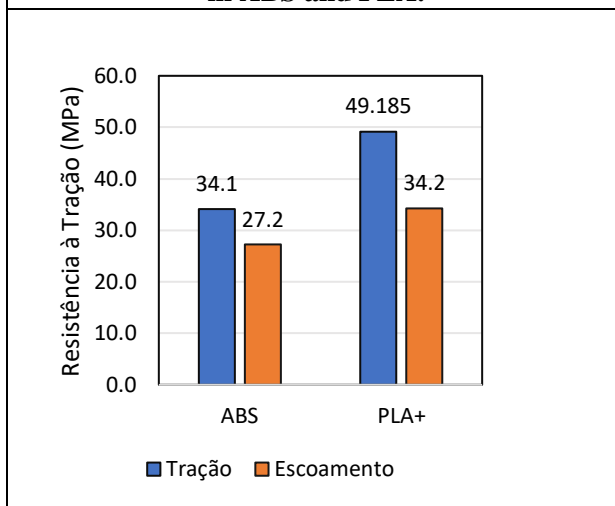


Figure 4 - Average tensile stresses

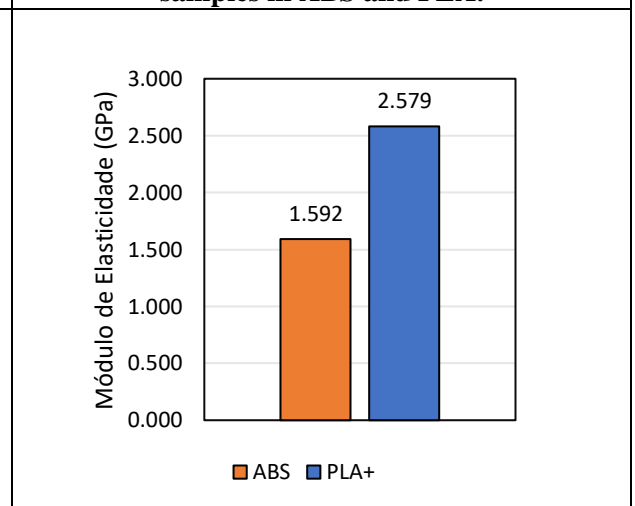


Figure 5 – Average elastic modulus

CONCLUSIONS

As a result, the specimens were successfully manufactured utilizing the Robox Dual 3D printer. The specimens were made following ASTM standards and tested using a Shimadzu Universal Tensile Machine Autograph AGS - X series. The tensile strength and modulus of elasticity of the specimens can be evaluated and analyzed based on the tensile test results. In general, the average values reached are a little higher than those found in the literature; this can be attributed to the color, filament origin, and 3D printer type. As

a result, PLA+ has a higher tensile strength than ABS, equaling 44% and yielding 25%. In the comparison of the modulus of elasticity, PLA+ again stands out, reaching an increase of 62% about the value of ABS.

ACKNOWLEDGMENTS

P Moreira acknowledges POPH (Programa Operacional Potencial Humano) QREN (Quadro de Referência Estratégico Nacional) - Tipologia 4.2 promotion of scientific employment funded by the ESF (European Social Fund) and MCTES (Ministério da Ciência, Tecnologia e Ensino Superior). The support of Universidade do Porto Pluridisciplinar projects program is also acknowledge. The FBG sensors were kindly supplied by FiberSensing.

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Manufacture and development of a 3D printing handle for laparoscopic application

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ABSTRACT

Laparoscopy is a minimally invasive surgery (MIS) technique that began to be developed approximately a century ago and due to its advantages, such as the rapid recovery of patients, it has become the focus of several studies for the improvement of the equipment and the technique. However, the equipment has a serious ergonomic problem in its configuration, which causes several musculoskeletal problems for surgeons causing, for example, muscle pain, temporary paresthesia, and fatigue, among other long-term pathologies. The study and development of new handle models and the reduction of the forces required for their manipulation are of fundamental importance in the field of laparoscopy. In this sense, this work presents the integration of the product development method of Pahl and Beitz (2007) and the DSR (Design Science Research) method for the development of a laparoscopic instrument, to be applied in tweezers and scissors, that meets the ergonomic requirements presented in the literature.

INTRODUCTION

The history of surgery was marked by several events that allowed us to evolve into the complex practices we know today. The need to inspect the body cavity to obtain more accurate diagnoses motivated the development of equipment that made it possible to perform these procedures without causing much harm to the patient. Initially used as a technique to obtain a diagnosis, laparoscopy has evolved into a minimally invasive surgical technique. This technique facilitated the patient's recovery, as it did not require the abdominal cavity to be fully opened to perform a particular surgical procedure (Amato 2016)(Almeida 2002).

All technological advances in this field have focused on the patient's well-being and recovery; however, it has only been in recent years that attention has been paid to the health problems that physicians may develop as a result of the continuous use of these devices. The most serious issues are concentrated in the field of ergonomics, because the surgeries are lengthy and necessitate specialized permanence for an extended period of time (Berguer et al., 1999).. The goal of this work is to design an ergonomic pistol-type instrument that can be applied to laparoscopic instruments used in minimally invasive surgeries to reduce the efforts applied by the surgeons' fingers and improve their positioning during surgery.

RESULTS

The pistol model was chosen because, according to the literature, it has a more comfortable format than traditional handles, as shown in Figure 1. Figure 2 highlights some details of the prototype, demonstrating how it meets the requirements of the literature. Figure 2 (A) shows the 135° angle between the axis and the handle, which

keeps the hands in a neutral position (Gonzalez, Salgado, and Moruno 2015; Van Veelen et al. 2003). The location of one of the control mechanisms is highlighted in Figure 2 (B).

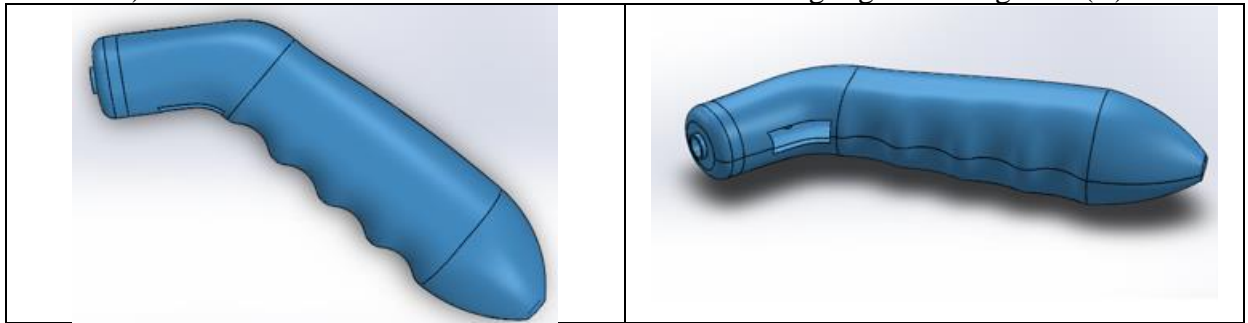


Figure 1 - Handle prototype versions.

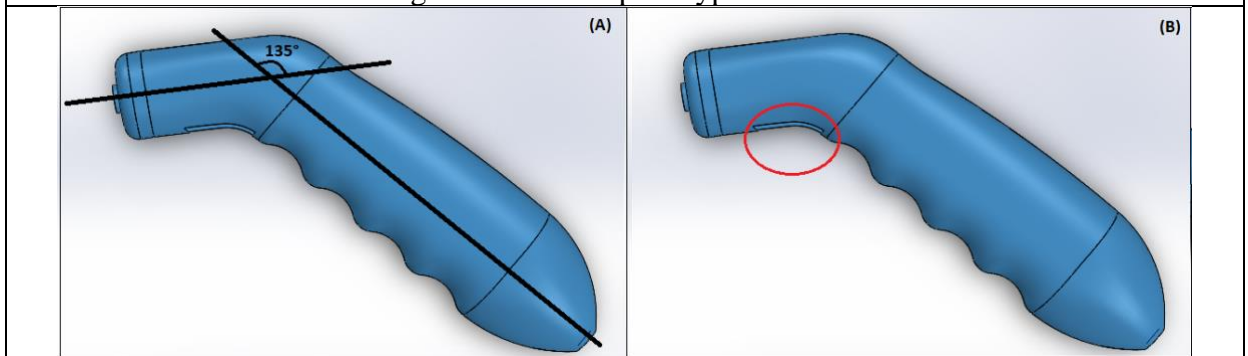


Figure 2 - Ergonomic features of the prototype.

The handle is ergonomically designed for the fingers and adheres to the requirement that the grip be done with the palms of the hands for a larger contact area. The cylindrical cross section was chosen because it is more comfortable, and the diameter adheres to the recommended range of 30 to 50 mm in the literature. Other details worth mentioning are all edges are rounded, the design is symmetrical, and the cable length is approximately 125 mm, which is considered more comfortable.

CONCLUSIONS

In this work, a model of an ergonomic laparoscopic instrument was developed, for application in tweezers and scissors for minimally invasive surgeries. After an extensive review of the literature, the need for new models of laparoscopic instruments that meet ergonomic requirements to avoid musculoskeletal injury to their users was proven.

During the development of the present study, it is believed that one of the most important points found was the proof that the pistol grip model is more comfortable for the user. This fact directed the entire project toward the final model presented.

ACKNOWLEDGMENTS

P Moreira acknowledges POPH (Programa Operacional Potencial Humano) QREN (Quadro de Referência Estratégico Nacional) - Tipologia 4.2 promotion of scientific employment funded by the ESF (European Social Fund) and MCTES (Ministério da Ciência, Tecnologia e Ensino Superior). The support of Universidade do Porto Pluridisciplinar projects program is also acknowledge. The FBG sensors were kindly supplied by FiberSensing.

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Tensile and flexural strength of flax fiber reinforced composites with and without chemical treatment

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ABSTRACT

PLA composites were reinforced with a natural fiber, flax fiber. A Taguchi L18 matrix was created and for each test 6 specimens were run, varying the temperature, fiber percentage, fill percentage of the specimens, and whether or not the flax fiber was treated. As for the treatment of flax, when applicable, it was treated with sodium hydroxide (NaOH). The temperatures used are 190°C, 200°C and 220°C. The percentage of fiber varies in 10, 15 and 20 fiber strands. The filling percentage of the specimen varies between 25%, 50% and 100%. This was followed by a study of the tensile and flexural strength of the reinforced composites. The optimal combinations for increased tensile and flexural strength were obtained with the following parameters for tensile: with/without chemical treatment, with a temperature of 200°C, 10 fibers and a filler percentage of 100%. For bending the parameters are: with chemical treatment, a temperature of 190°C, 10 fibers and a fill percentage of 100%. With the confirmation tests a value for the maximum tensile stress of 19.38 MPa and for bending of 73.20 MPa was obtained.

INTRODUCTION

Polymeric materials that derive from petroleum in their composition have volatile organic compounds that can cause damage to the environment and human health. With the increasing demand for sustainability and due to the energy crisis that has been experienced, it is necessary to find alternatives. Many automotive components use synthetic fibers for strength, so it is necessary to conduct a study in order to circumvent the causes of these products and find a sustainable way to replace them. Natural fibers, are fibers that are not synthetic or manufactured. These fibers come only from animals or plants. Natural fibers have unique characteristics such as abundance, non-toxicity, high performance, versatility, and easy processing at low cost. The natural fiber reinforced polymer composites (NFPCs), have several applications, besides the automotive industry, also in the construction industry due to their strength, low density, biodegradability and high lifetime. The fibers most used in industrial applications are flax, knaf and hemp because of the fiber's strength properties. Flax fiber is considered one of the strongest fibers, because it has a very complex structure. However, since natural fibers have some limitations, the formation of the composite and the treatment parameters must be controlled in order for the product to improve its properties. Due to these limitations it is necessary to proceed to the use of treatment processes that can be chemical or physical. One of the most commonly used chemical treatments is the alkaline one, in which the cracks are submerged in an alkaline solution, namely NaOH (sodium hydroxide), for a relative period of time. This increases the fiber's surface roughness and improves its mechanical properties. For the substitution of products that do not come from renewable sources, it is possible to use biodegradable polymers, i.e. products from renewable sources, such as composites with natural fibers. PLA (polylactic acid) is a biodegradable polymer, with much technological interest due to its applications in the environmental field. It is a type of impact-modified filament for the 3D printer, which is sustainable. Natural fibers can be added to PLA to reduce environmental and production costs.

This study aims to compare the tensile and flexural strength of flax fiber reinforced composites by analysing the influence that the amount of flax fiber, the temperature, the percentage of filler and the presence or absence of NaOH treatment have on the mechanical strength of the composites.

RESULTS

Figure 1 shows the mean values of the maximum stresses for the 6 specimens in each test. It can be seen that test 6 obtained the highest maximum tensile stress value for the tensile test with a value of 19.98MPa. For the bending tests, the one with the highest stress was test 8 with a value of 72.94MPa.

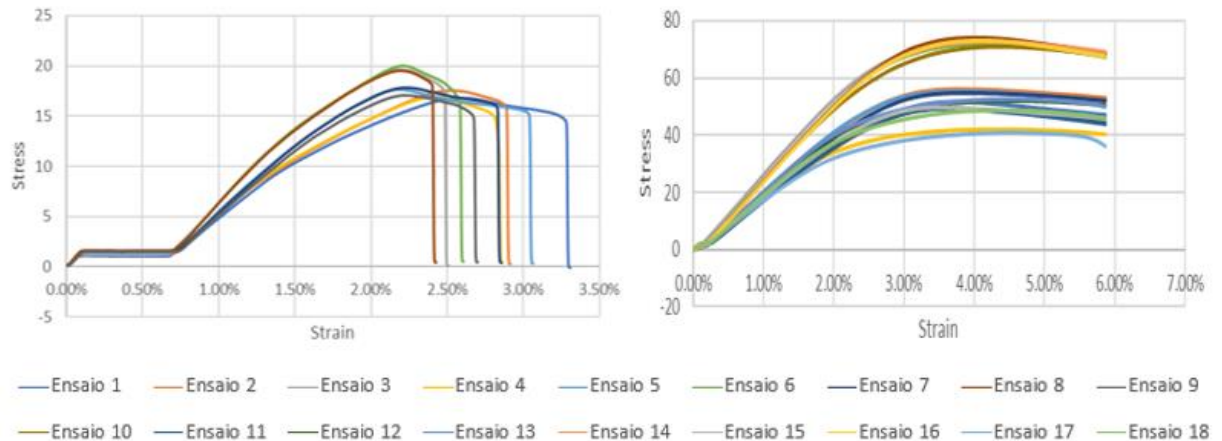


Figure 1- Stress-strain for tensile and flexural strength, respectively.

With the use of analysis of variance, it is possible to verify that for tensile and flexural strength, the most significant control factors are temperature and the filling percentage of the specimen, with the remaining factors varying. That is, for tensile strength, the percentage of filler was very significant with 96.69%, followed by temperature, fiber percentage, and the use or not of fiber treatment, with 1.12%, 0.22%, and 0%, respectively. For flexural strength, the percentage of filler was also the most significant with 95.42%, followed by temperature, the use or not of fiber treatment, and the percentage of fibers with 0.85%, 0.29% and 0.17%, respectively.

CONCLUSIONS

After analyzing the results of this study, it is possible to conclude that the maximum stress for the tensile test is 19.98 MPa and for the bending is 72.94 MPa with a standard deviation of 0.36 and 2.09 respectively. It can be admitted right away that flax fiber reinforced composites have higher flexural strength than tensile strength.

With the analysis of variance, it was found that the percentage of filler was the parameter with the greatest contribution to the increase in tensile and flexural strength with percentages of 96.69% and 95.42%, respectively.

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Electronic solution with joysticks for laparoscopic equipment

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ABSTRACT

It is noted in many studies health problems related to musculature in surgeons who handle laparoscopic instruments. Many attempts of new models for handles of these equipment's have already been proposed in an effort to combat this ergonomic problem in this type of instrument.

The developed work aimed to develop an electronic solution for laparoscopic instruments in order to provide greater comfort to surgeons in the area. As a complement, a handle was manufactured to illustrate the system after downscaling for the surgeon to handle. Also, as a complement, a manual laser measuring plate was developed for future tests with the system attached to the handle. During the elaboration of the work was involved in the process the use of an Arduino Uno board among other electronic components, besides the design of parts in software, the use of 3d printing and laser cutting. The results obtained after the assembly of the electronic mechanism showed that it is possible to obtain the necessary movements for a surgical tool through an electronic drive, avoiding musculoskeletal injuries in surgeons who handle this equipment due to less repetitive efforts during operations.

INTRODUCTION

As technology advances in the world, it also tends to reach the medical field. Surgeries have become less and less invasive thanks to this. Laparoscopic surgeries are being performed more and more because of their great advantages in terms of performance by the surgeon and recovery by the patient. In general, it is a method of surgery that can replace the vast majority of general surgeries performed in the region of the pelvic and abdominal cavity (**Saudecuf, 2015**). The whole procedure is done by the display where the image of the internal part of the patient is shown with the aid of a camera that can pass through the small incisions made. In general, laparoscopic procedures last at least 1 hour (**Tung, 2015**). However, the laparoscopic instruments used still have a great need of development in design. Together with the length of surgery and the primary problematic development of these tools, today there are great complaints from those who handle them. It is reported that the design of the handle affects the posture of the upper extremities of the surgeon's body, which causes discomfort and fatigue (**ER, 1997**), besides the need for repetition of the task with the high pressure exerted on the fingertips and prolonged uncomfortable positions caused by the current models that contribute to biomechanical discomfort and possible injury to the surgeon (**LACOMBE, 2003**).

This work intends to develop, through the elaboration of circuit in Arduino and actuators programmed in C++ language besides the manufacture of an adequate mechanism, an electronic solution for laparoscopic equipments able to fill the lack of comfort and safety existing in current models and increasing the chance of injury prevention in those who handle them.

RESULTS

The circuit, shown in figure 1, was assembled with an Arduino board, a joystick and two servomotors to obtain the proposed movements for the laparoscopic tool. The C++ code responsible for the movement commands was adapted during several attempts and tests in order to obtain the best action angulation of the servomotors and the correct actuation of each servomotor for each axis requested in the joystick. The mechanism system fixation step was carried out with several adaptations related to servomotor clearances, being also necessary the design in SolidWorks and printing of specific 3d parts for the system. The final result of the assembly is shown in figure 2. An experimental handle, which is shown in figure 3, was also developed in SolidWorks software and printed in 3d for the purpose of illustration of how the system would look like after the downgrade for official use.



Figure 1- Assembled circuit

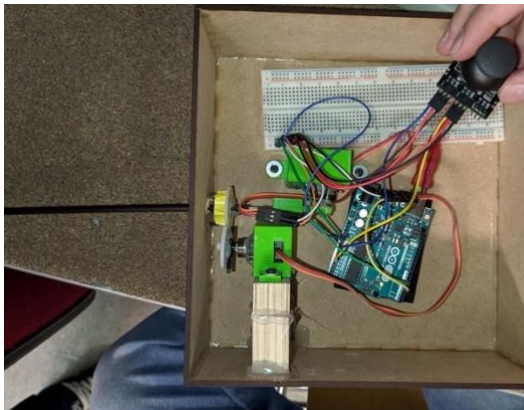


Figure 2- Experimental setup



Figure 3- Experimental handle.

CONCLUSIONS

After the execution of all the idealization, design, assembly and tests of the system, besides the analysis of the results obtained at the end, the objective was reached in demonstrating that it is possible to develop laparoscopic instruments accompanied by an assistant electronic solution with the intention of minimizing risks of injuries of laparoscopy surgeons. For future works it is of utmost importance that the prototype goes through a downscale so that it can be used effectively.

ACKNOWLEDGMENTS

Thanks to the work supervisor João Rocha and Professor Jorge Santos for the support and support in the idealization and realization of the work. It is also necessary to thank the college Uni Evangélica and the Polytechnic Institute of Bragança that provided support with its infrastructure in their laboratories, especially the FabLab.

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Construction of an optimized 3D Printer, programmed by Arduino and designed in SolidWorks software

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ABSTRACT

The 3D printer is a prototyping machine capable of producing three-dimensional objects, distributed in 3D software, which are built after layer through an additive process. This project aims to develop a low-cost open-source 3D Printer controlled by Arduino. It also aims to deepen the topic of rapid prototyping and provide the community, internal and external, of the Polytechnic Institute of Bragança (IPB), with a base for developing these printers so as to benefit from the study of new technologies and their replication. The most common and economical model, of a 3D printer, uses the technique of modeling by fusion and deposition (FDM - Fused Deposition Modeling), which is the base technology of our project. At the beginning of the project, we were proposed to design a 3D printer. In this there was the electronic/programming part already validated, with the need to build the mechanical part of it. Thus, we proposed to continue the base of the existing project, having carried out all the mechanical modeling of the printer and validating the design of the various parts that had to be raised in order to meet the various requirements this one demanded. There was also a survey of suppliers of various parts on the market from which an extensive list of references, suppliers, values, quantities, and forms of acquisition was drawn up. In order to make the final physical assembly possible, they were machined as aluminum parts, obtaining structural strength and reliability of the set. Aluminum parts were marked in order to able to use the “leftovers” existing in the mechanical workshop and thus manage to reduce and consolidate the final cost of the project.[3]

INTRODUCTION

The present project arose from the need to create a large 3D printer for the Fablab laboratory of the Instituto Politécnico de Bragança. At the beginning of this one, we were proposed to continue a project for a 3D printer. In this one there was an electronic/programming part already validated and there was a need to build the mechanical part of it. So we proposed the basis of the current project and continued until today a mechanical modeling of the creator as valid and the design of the various pieces that had to be created as a behavioral project end as typical characteristics of this project. Also that of the suppliers of various parts on the market from which a list of references, suppliers, values, various forms of acquisition was prepared. The one presented here is based on the analysis, modeling, creation and assembly of a D-printer using FDM technology that guarantees a greater robustness of the components seen to guarantee a greater extension and reliability mostly used [3].

RESULTS

In this project we were able to understand the entire process involved in this technology, from the materials used, the different types of printing filaments and associated technical

areas. This complementing our intense research work and looking for new solutions for the practical and technical realization of this 3D printer, we prepare an inventory of parts, functional design in solidworks with the actual measurements used, through the projection and completion of the project. We faced several difficulties such as the collision of pieces in solidworks, which we resolved by adapting and testing several times until reaching the final result presented here. Of all the pieces created for this purpose, we highlight the printing platform, which will support the heating plate, which is where the 3D pieces will be built [4]. Three attempts were made in order to reduce the weight of the part without compromising the normal functioning of the structural set, as described in the chapter “design in solidworks”. For this purpose, the stress and strain installed were studied by applying a distributed load of 1kg along the platform in order to represent the weight attributed by the heated table, adding to the component to be built. This was calculated knowing that the weight of the heated table of dimensions (300x200mm) is approximately 300g and that the structure built in PLA filament in the maximum printing dimensions of the printer (200x180x450mm) is approximately 600g, leaving a safety margin of 100g. This entire project was a challenge at different levels, both in terms of geometric design and modelling, and in the selection of the best option for the components, in terms of quality/price. To this end, an inventory was drawn up and the material needed to build the 3D printer was ordered. Tables of suppliers, parts and corresponding acquisition value were also prepared. As described throughout this work, the final purchase and assembly value of this printer was €550.55 + taxes. Aluminum cutting and drilling were carried out in the mechanical workshop of ESTIG's mechanical technology laboratory. 62 The final assembly of the components was carried out in ESTIG's FABLAB laboratory and a level was used to level the aluminum rails, this operation being carried out on top of the CNC, since its table is perfectly leveled to the ground, which facilitates the our assembly accuracy.

CONCLUSIONS

With this project, one of the conclusions we obtained after gathering all the components of this printer, is that its monetary cost, although higher compared to others in the market of the same category, remains below when faced with: quality of components, rigidity of the structure and adaptability of the existing components as well as superior print dimensions. The robustness of the components was achieved by oversizing to ensure greater longevity and reliability due to the aluminum mostly used. In this way, the guidelines of all the objectives defined by this work were fulfilled, which defined, among others, some existing materials to be included and the desired size of printing capacity.

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