D3.5. Report on the involvement of ESRs

Grant Agreement Number: 952463

Project Acronym: UMA3

Project title: Unique Materials for Advanced Aerospace Applications

Starting Date: 01/09/2020

Project Duration: 36 months

Project Officer: Antonio Vecchio

Project Coordinator: University of Miskolc (UniMi)

Author(s): Greta Gergely (UniMi), Zoltán Gácsi (UniMi)

Contributing partners: -

Due Submission Date: 30/11/2021

Actual Submission Date: 30/11/2021

Status	
Draft	
Final	X

Type		
R	Document, report	X
DEM	Demonstrator, pilot, prototype	
DEC	Websites, patent fillings, videos, etc.	
ETHICS		

Dissemination Level		
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	

Revision History

Date	Lead Author(s)	Comments
28/11/2021	Greta Gergely	minor parts are missing from the project activity section
30/11/2021	Greta Gergely	finalize

This project has received funding from the European Union's Horizon2020 research and innovation programme under grant agreement No 952463

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1. TASK DESCRIPTION OF D3.5

The D3.5 introduces the procedure for enrolling young students and colleagues, and through the description of the process, the young researchers themselves.

2. PROCEDURE FOR ESRS INVOLVEMENT

Selection of trainees needs to be conducted well defined criteria and motivation must be carefully assessed. The candidate describes his motivation in the form of a letter, which include a professional CV.

Selection criteria:

1. Under 40 years of age.
2. Participation in doctoral training or a doctoral degree obtained within 8 years.
3. At least a Q2 journal article (except of beginner PhD students) and one oral presentation at an international conference.
4. High level motivation letter (included professional CV)
5. His/her PhD topic directly connect to the research topic of the UMA³ project.

Selected early stage researchers (ERSs):

Name of the ERS	Justification
Dáneil Pethő (PhD student)	-powder metallurgy experience -H2020 experience -motivated - high ranked paper
Dr. Tamás Mikó (research fellow)	-powder metallurgy experience, -H2020 experience -motivated - high ranked papers -PhD degree
Mohammed Qasim Kareem Yasi (PhD student)	-The topic of the project was dedicated to the topic of the PhD (he did not need to submit a letter of motivation) -amibitious

3. ATTACHMENTS

3.1. Motivation letters and CVs of the ESRs

Motivational letter

Daniel Petho
University of Miskolc
3515, Miskolc-Egyetemváros, Miskolc, Hungary

2020.09.10.

Dear Prof Dr. Zoltán Gácsi,

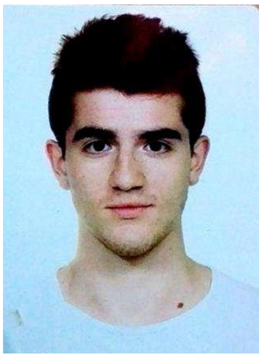
I would like to wish to submit my motivational letter to be incorporated into the UMA^3 (Unique Materials for Advanced Aerospace Applications) EU funded research. I believe, I fit well into the scope of the project, since the topic of my doctoral work is the development of Mo-Cu alloys reinforced with Al_2O_3 particles. These materials are also used in the aerospace industry, moreover the production method of my research materials includes the area of powder metallurgy, which is also closely related to the project. Moreover, I have gained relevant experiences in a previous EU funded research (ICARUS, H2020, Project No.: 713514) which could aid me in my work in the UMA^3 project.

Thank you for your consideration of me to the UMA^3 project.

Sincerely,

Daniel Petho

Curriculum Vitae



Personal information

Name: Dániel Pethő
Date of birth: 1994.08.18.
E-mail: femdani@uni-miskolc.hu
Nationality: hungarian

PROFESSIONAL EXPERIENCE

2015. 02-06.: **Trainee, SICTA**

2017.03.15-2018.09.01: **Research engineer, Institute for Physical Metallurgy, Metalforming and Nanotechology, University of Miskolc**

2018.09.01-present: **Assistant Research Fellow, Institute for Physical Metallurgy, Metalforming and Nanotechology, University of Miskolc**

Studies

2013-2016: **Materials Engineer Bsc, Specialization of Heat treatment and Metalforming, University of Miskolc.**

2017-2018: **Metallurgical Engineer Msc, Specialization of Heat treatment and Metalforming, University of Miskolc.**

2018-present **Doctoral student, Antal Kerpely Doctoral School of Materials Science and Technology, University of Miskolc**

LANGUAGES

English C1 complex

PROFESSIONAL ACTIVITY

Articles:

- T. Mikó, F. Kristály, D. Pethő, M. Svéda, G. Karacs, G. Gergely, Z. Gácsi, A. Roósz: Investigation of nanocrystalline sintered W-25 wt% Cu composite, International Journal of Refractory Metals and Hard Materials, Vol 95, 2021.

- Pethő D., Kurusta T., Kristály F., Mikó T. & Gácsi Z. (2021). The effect of ball to powder ratio on the processing of a novel Mo-Cu-Al_2O_3 composite. International Journal of Refractory Metals and Hard Materials, 101, 105657.

Institute of Physics (IOP) Conference Series

- Daniel Petho, Adrienn Hlavacs, Peter Barkoczy, Marton Benke: *The variation of earing and texture components during annealing treatments of a 3003-type aluminium alloy*
- Marton Benke, Adrienn Hlavacs, Daniel Petho, David Adam Angel, Mate Sepsi, Erzsebet Nagy, Valeria Mertinger: *A simple correlation between texture and earing*
- Adrienn Hlavacs, Daniel Petho, David Adam Angel, Erzsebet Nagy, Valeria Mertinger, Marton Benke: *The effect of Mn content on the texture of aluminium alloys in cold rolled and annealed state*
- David Adam Angel, Adrienn Hlavacs, Daniel Petho, Valeria Mertinger, Peter Barkoczy, Marton Benke: *Characterization of grain structure and crystallographic texture variation during the production of a Properzi semi-product*

Motivational letter

Dr. Tamás Mikó
University of Miskolc
3515, Miskolc-Egyetemváros, Miskolc, Hungary

2020.09.13.

Dear Prof Dr. Zoltán Gácsi,

I am writing to express my interest in the UMA^3 (Unique Materials for Advanced Aerospace Applications) EU funded research. Based on my previous works in different projects, I believe, I will fit well into the scope of this project. I have been working with special type of composites and alloys since 2016. I have experiences on the field of powder metallurgy on Titanium, Tungsten and Iron based metals. I have also relevant experiences in a previous EU funded research (ICARUS, H2020, Project No.: 713514) which could aid me in my work in the UMA^3 project.

Thank you for considering my application.

Yours sincerely,

Dr. Tamás Mikó

CURRICULUM VITAE

Personal information

Name: Dr. Tamás Mikó
Date of birth: 1986.04.26.
E-mail: femmiko@uni-miskolc.hu
Nationality: hungarian

PROFESSIONAL EXPERIENCE

2007-2008: **Trainee, DAM 2004**

2017.03.15-2018.09.01: **Research engineer, Institute for Physical Metallurgy, Metalforming and Nanotechology, University of Miskolc**

2018.09.01-2019: **Assistant Research Fellow, Institute for Physical Metallurgy, Metalforming and Nanotechology, University of Miskolc**

2019-2021: **Research Fellow, Institute for Physical Metallurgy, Metalforming and Nanotechology, University of Miskolc**

2021-present: **Senior Research Fellow, Institute for Physical Metallurgy, Metalforming and Nanotechology, University of Miskolc**

Studies

2005-2009: **Materials Engineer Bsc, Specialization of Heat treatment and Metalforming, University of Miskolc.**

2009-2011: **Metallurgical Engineer Msc, Specialization of Heat treatment and Quality management, University of Miskolc.**

2011-2013: **Doctoral student, Antal Kerpely Doctoral School of Materials Science and Technology, University of Miskolc**

2016: **PhD certificate (Material Sciences and Technologies)**

LANGUAGES

English B1 complex

PROFESSIONAL ACTIVITY

Articles:

T. Mikó, F. Kristály, D. Pethő, M. Svéda, G. Karacs, G. Gergely, Z. Gácsi, A. Roósz: Investigation of nanocrystalline sintered W-25 wt% Cu composite, International Journal of Refractory Metals and Hard Materials, Vol 95, 2021.

Pethő D., Kurusta T., Kristály F., Mikó T. & Gácsi Z. (2021). The effect of ball to powder ratio on the processing of a novel Mo-Cu-Al_2O_3 composite. International Journal of Refractory Metals and Hard Materials, 101, 105657.

Angel, D.A. ; Miko, T. ; Kristaly, F. ; Benke, M. ; Gacsi, Z. ; Kaptay, G. Complex Avrami kinetics of TiB2 transformation into TiB whiskers during sintering of Ti-TiB2 nanocomposites
JOURNAL OF ALLOYS AND COMPOUNDS 894 p. 162442 (2022)

T., Mikó ; F., Kristaly ; K., Bohacs ; M., Sveda ; A., Sycheva ; D., Janovszky The effect of process control agents and milling atmosphere on the structural changes of Ti 50 Cu 27,5 Ni 10 Zr 10 Co 2,5 master alloy during short time milling
IOP CONFERENCE SERIES: MATERIALS SCIENCE AND ENGINEERING 426 : 1 Paper: 012035 , 8 p. (2018)

Angel, D.A. ; Miko, T. ; Benke, M. ; Gacsi, Z.
Characterization of ceramic particle reinforced titanium composite produced via powder metallurgy ARC HIVES OF METALLURGY AND MATERIALS 65 : 2 pp. 515-519. , 5 p. (2020)

3.2. Project Activity of the ESRs

Project activity

Daniel Petho – University of Miskolc

My range of responsibilities included the following: participation in the „Unique Materials for Advanced Aerospace Applications – UMA^3, Twinning (WIDESPREAD-05-2020) project (Project Number: 9552463 as a young researcher to aid in the powder metallurgical activities and in the writing and editing of articles (based on the results). Moreover, I had to participate in maintaining the industrial contacts (cluster). Lastly my duties included participating: in the preparation of English and Hungarian reports; in professional meetings and conferences; handling the communication with the international professional partners.

First since the start of the project I have been keeping communication with the industrial partners, involving them into the project (5 companies) and helping our project partner in their deliverable by sending out questionnaire to Hungarian partner companies and other industrial contacts. Therefore, the attitude and readiness of Hungarian companies to be included in the industrial cluster and tendering jointly for international calls and proposals could be measured. There were communications about the project (EASN Newsletter), which I have written and sent to the corresponding personnel. Moreover, there were multiple events since the beginning of the project (Training seminars held at: April 27-29th of 2021 and July 5-7th of 2021.), regarding various topics such as: general administration of EU projects, emerging concepts regarding the aviation industry, brainstorming sessions („Next horizon for Europe: the new research and innovation programme"), intellectual property rights, commercial exploitation („Training in innovation"). Based on the prior sentences most of my activities and duties are already fulfilled.

Regarding the powder metallurgical activities and articles, I have an article (in the area of powder metallurgy) undergoing writing and editing, which will hopefully be soon published. It covers the topic of Mo-Cu composites and the possibility of the usage of ceramic reinforcement (α-Al_2O_3 particles) in order to produce an MMC (Metal Matrix Composite) with enhanced thermal stability and improved mechanical properties at high temperatures. These would be beneficial since Mo-Cu (pseudo) alloys are used in microelectronics, with an emphasis on aerospace and space industry (since they are resistant to high temperature and have excellent heat conductivity, moreover, are lighter than W-Cu pseudo-alloys). The manufacturing method of the samples relies heavily on powder metallurgical technologies (Figure 1) using mechanical alloying of the powders prior to the uniaxial cold- and hot pressing.

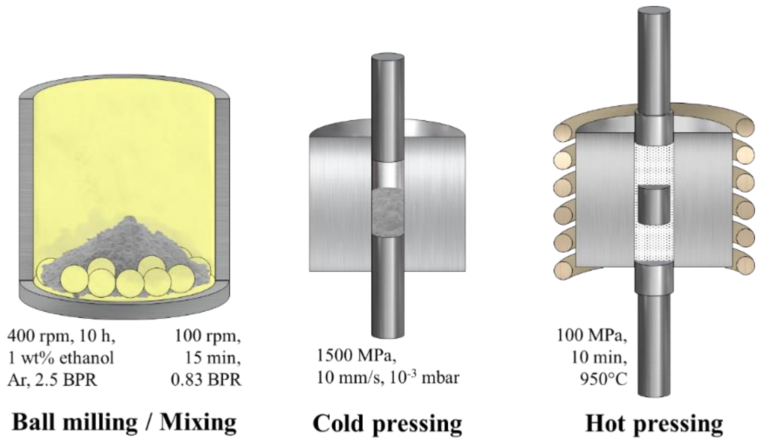
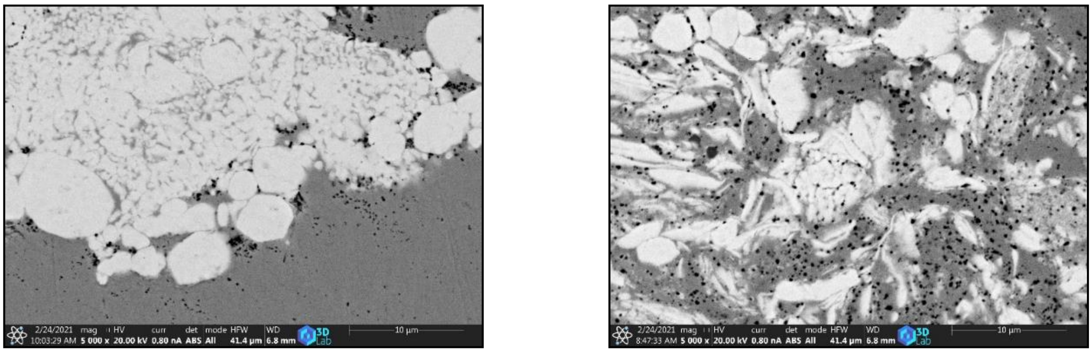


Figure 1.: Manufacturing steps one after the other from left to right.

The final products can have different microstructures depending on the previous processes. On the image below (ss) you can see a composite with the same composition of **49.5**Mo-**49.5**Cu-**1**Al_2O_3 but the left was mixed, and the right was ball milled. Therefore, completely different microstructure developed. The main focus was on the homogeneous distribution of the fine α-Al_2O_3 particles, but the Mo agglomerates have also been comminuted by the milling process. Moreover, the mechanical alloying introduced numerous crystal lattice defects to the metallic phases, hence much lower crystallite size was achieved. This resulted in the hot pressed samples (that were previously milled in powder form) to have much higher hardness (265-266 HB) compared to the previously mixed samples (138-155 HB). There will be a detailed description within the article and a previous article of ours can also be checked out at (https://www.sciencedirect.com/science/article/pii/S026343682100189X) revealing more about the research topic.



a) b)

Figure 2.: The microstructure of the hot pressed samples with different prior powder technology: a) mixing; b) ball milling.

Project activity

Dr. Tamás Mikó - University of Miskolc

In the first period of the UMA[3] project, I have started an investigation on the 17-4PH martensitic, precipitation-hardening stainless-steel powder. My objective was to get information about the behavior of this type of powder during cold pressing and sintering. This research was carried out in collaboration with Mohammed Qasim Kareem PHD student.

Its ability to develop very high strength without low ductility and its superior corrosion resistance to other steels of similar strength, have made this type of steel very attractive to designers and engineers in the field of aero industry. Table 1 shows the chemical composition of the 17-4PH powder.

Table 1: Powder chemical composition

Alloy	Weight Percent (%)						
	Fe	Cr	Ni	Cu	Nb+Ta	C	other
17-4PH-A	Balance	17	4.5	4.0	0.3	<0.07	<1.0

Due to the low carbon content of the martensitic matrix ensures the relatively high ductility while the small precipitates work as a reinforcement. The low carbon content of the powders is optimized for aerospace applications. In order to achieve the highest strength requires apply heat treatment on the sintered parts to produce precipitates throughout the matrix. The highest yield strength of the heat-treated parts could be around 1300 MPa with ~10% ductility. The as-received powder shows a spherical morphology with a low inside porosity (fig 1.). The etched surface of the powder particles shows that the powder particles were made up more grains.

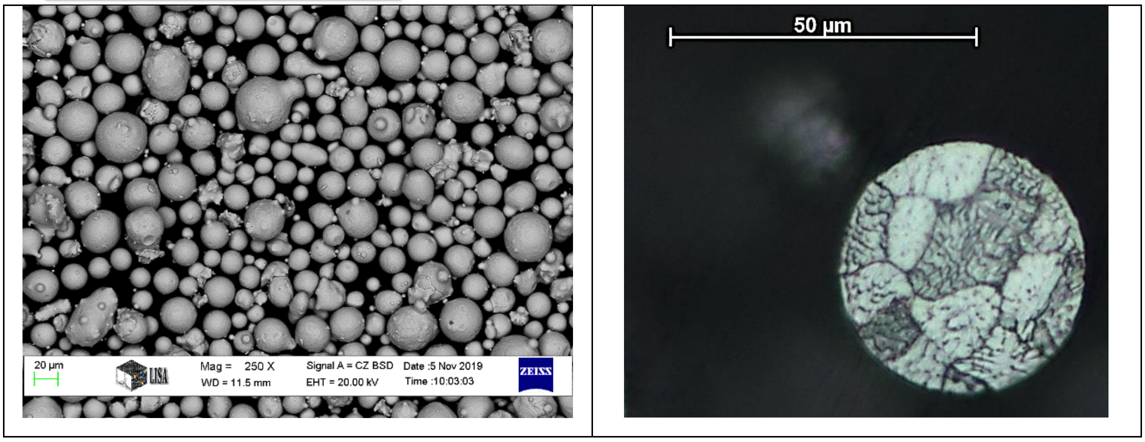


Figure 1: SEM images of the as received powder

The particle size distribution of this powder can be seen in the Table 2.

Table 2: Particle size distribution

Alloy	Particle Size Distribution			
	Nominal Range [µm]	D90 [µm]	D50 [µm]	D10 [µm]
17-4PH-A	-45+15	45	30	19

The microhardness of the as-received powder particles was determined by Vickers method (HV0.01). The average value was 290 ±26. A part of the as-received powder was sieved into 3 different size fractions namely 15 µm to 32 µm, 32 µm to 45 µm and 45 µm to 63 µm. The compressibility of the smallest size group was investigated by using cold pressing at different pressures. The cold pressing was carried out in a self-designed and manufactured die tool set (fig 2.).

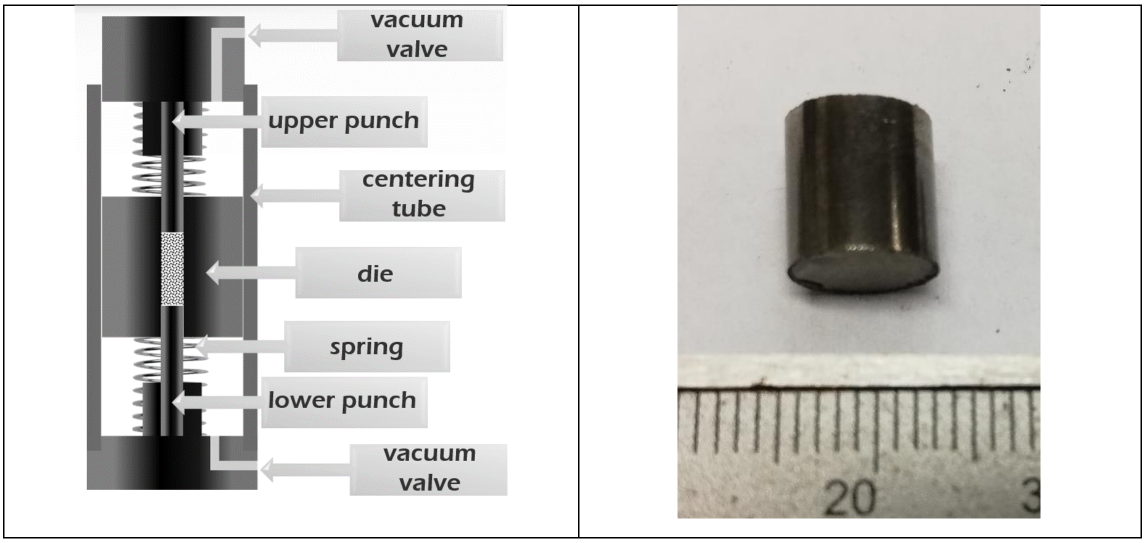


Figure 2. Die set for cold pressing

In order to decrease the friction between the die wall and the powder, I used graphite lubrication on it. This also decreases the ejection force during the remove of the sample from the die. The cold pressing was carried out in vacuum. The cold pressing rate was 10 mm/min. When the pressure reached the desired value, the upper punch moved back to the initial position (fig 3).

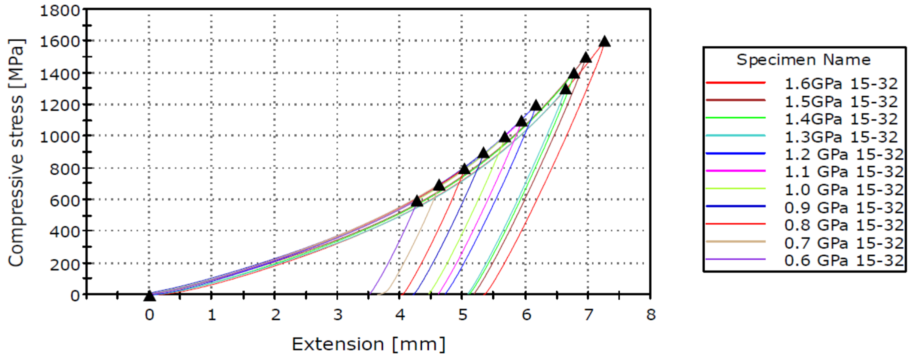


Figure 3. Shrinkage during at different cold pressing

The maximal cold press value was 1600 MPa. Below 600 MPa, the green samples were brake down during the ejection process. The tap density of the as-received powder is 4,4 g/cm^3. The density of the solid bulk material is 7,81 g/cm^3. The relative density of the manufactured green samples was determined by using geometric method. The weight of the cylindrical samples was around 3 grams, and the diameter was 8.27 mm. The height of the green samples was changed based on the applied pressures. Figure 4 shows the measured density as a function of the cold press.

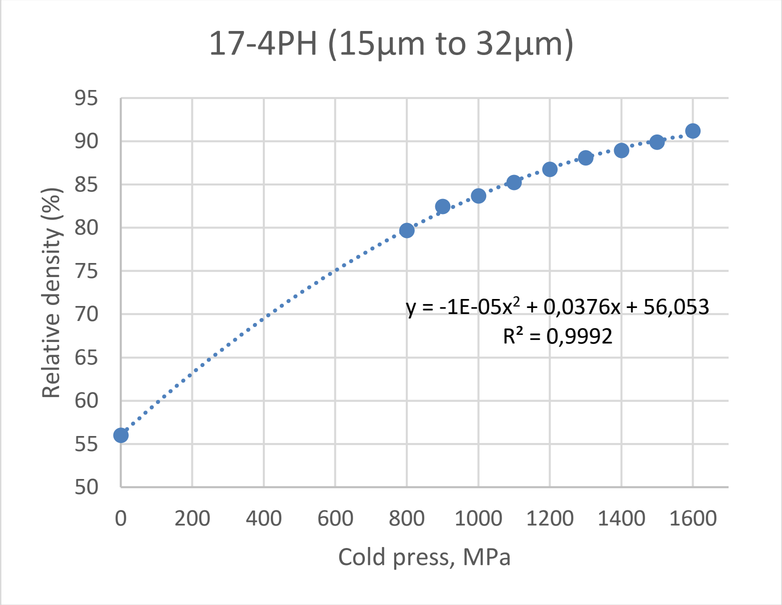


Figure 4. Relative density vs. cold press

After the cold pressing, the green samples were sintered at 1200°C in vacuum for different time in order to investigate the shrinkage during the sintering. The sintering was carried out also in a self-designed and manufactured sample holder tool set (fig 4.). Three zones electric furnace was used for sintering the samples. In order to hinder the oxidation of the green samples, a welded ended stainless-steel tube was used as sample holder. Before the heating the sample holder was filled up with argon and then it was vacuumed. The heating and cooling rate was 10 °C/min, and the holding time was 1 hours respectively.

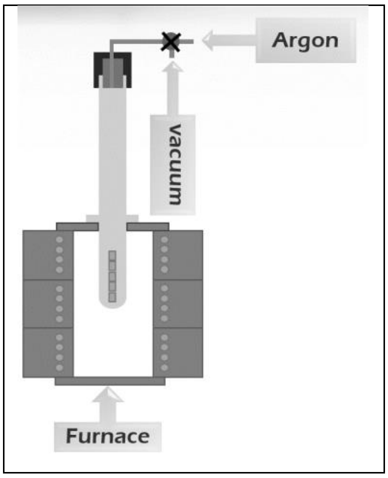


Figure 4. Sintering assembly

After each sintering, the densities were measured by geometric method. The results can be seen on the fig 5. Based on the measured values it can be stated that the density of the samples increased more in that samples which cold pressed at lower press values. Increased the sintering time, the relative densities were increased also. The highest density was 95.8%.

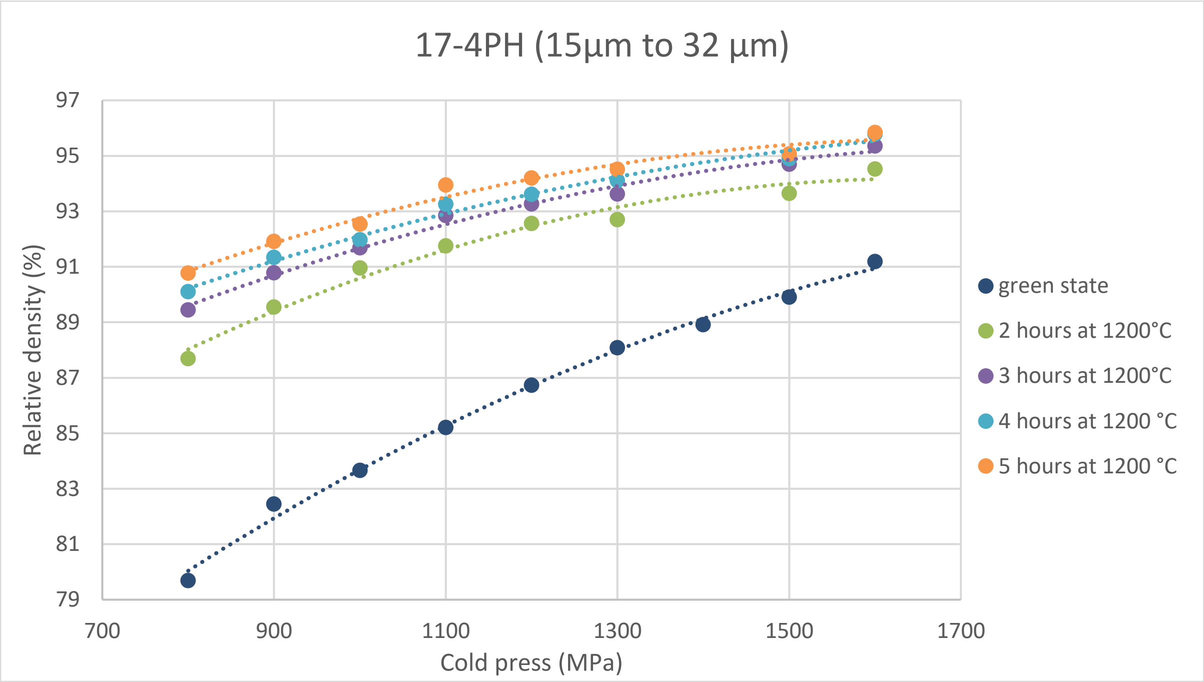


Figure 5. Relative densities after different sintering time

PhD Activities of Mohammed Qasim Kareem Yasi

Theoretically, the work started with analyzation more than 70 papers (spring semester 2021 till present time) to compare the using of conventional powder metallurgy (CPM) and Selective Laser Melting (SLM) methods for producing precipitation- hardening martensite stainless steel materials (17-4PH grade).

From literature reviews, we found few studies documented this type of 17-4PH stainless steel powdered materials, because this powder has very high strength and has low compressibility for manufacturing by CPM technique. Most of authors used the same cold pressing rages (up to 800 MPa) which are suitable for softer material such as 316L but not sufficient for 17-4PH.

Cold pressing

Therefore, our first experiment started with applying huge cold pressing (1.6 GPa), that no one used before, and investigate the effect of such high pressure on compressibility of 17-4PH as a green sample density. additionally, the high cold pressing was applying for samples with different particle sizes of 17-4PH powder such as: less than 32 µm, 32 to 45 µm and 45 to 63 µm, these particle sizes were obtained by sieving process of the reference 17-4PH powder which has particle size distribution 15 to 63 µm. Green 17-4PH samples with ~8.25 mm dia., and ~7-7.8 mm high were prepared.

Nevertheless, the effect of particle size on densification of green samples was studied. The investigation included two types of 17-4PH powder, 17-4PH as original powder (17O) and 17-4PH as Re-Used powder (17R), from 3D printing collected chamber.

Sintering

Consequently, 17O and 17R green samples with different particle size were sintered at 1200 °C for 1 hour at 10 °C/min in a vacuum atmosphere. Cross-sectional of 17O and 17R sintered samples were prepared for optical analysis and Vickers hardness tests.

Compression test

All produced samples were subjected to compression test to determine the yield stress and compressive strain.

Other investigation conditions

Furthermore, some of samples put through different heating rate such as: 30 C/min. Different sintering times was applied also. And the investigations still continuing on applying different cold pressing with different particle sizes in both for original and Re-Used 17-4PH powders. In the scheme below we can summaries our investigations steps: