ISIS@MACH ITALIA

Experiment Proposal

Experiment number GP2024025

Principal investigator (*)	Dr ESTER FALLETTA, CONSORZIO PHYSIS SRL SB, ITALY		
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Experiment title	Investigating the Source of Imperfections in Forged Brass Items Using Raman Confocal Microscopy		
MRF Instrument	**Raman Confocal Microscope**	**Days requested:** 3	
Access Route	Direct Access	**Previous GP Number:** -	
Science Areas	Materials	**DOI:** -	
Sponsored Grant	None	**Sponsor:** -	
Grant Title	-	**Grant Number:** -	
Start Date	-	**Finish Date:** -	
Similar Submission?	-		
Industrial Links	RGF SRL		
Non-Technical Abstract	Hot pressed brass, widely used in various industries for its fluidity and durability, is prone to defects like porosity and surface roughness during die-casting, affecting its mechanical and aesthetic properties. Additionally, surface treatments like graphite coatings, meant to improve characteristics or corrosion resistance, introduce complexity due to their interactions with brass, potentially worsening defects. Raman confocal microscopy, sensitive to carbon structures, is employed to study these defects and the impact of graphite treatments, aiming to enhance the understanding of defect origins and optimize casting and treatment processes.		
Publications	-		

ISIS neutron and muon source

E-platform: No

Instruments	**Days Requested:**
Access Route	**Previous RB Number:**
Science Areas	**DOI:**
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Similar Submission?	
Industrial Links	

Sample record sheet

Principal contact	Dr ESTER FALLETTA, CONSORZIO PHYSIS SRL SB, ITALY		
MRF Instrument	**Raman Confocal Microscope**	**Days Requested:** 3	
Special requirements:			

SAMPLE

Material	Copper, Zinc	-	-
Formula	Cu, Zn	-	-
Forms	Solid		
Volume	4 cc		
Weight	10 g		
Container or substrate	No special need	-	-
Storage Requirements	-	-	-

SAMPLE ENVIROMENT

Temperature Range	RT - K	-	-
Pressure Range	atmospheric pressure - mbar	-	-
Magnetic field range	No - T	-	-
Standard equipment	-	-	-
Special equipment	No special equipment needed	-	-

SAFETY

Prep lab needed	Yes	-	-
Sample Prep Hazards	No	-	-
Special equip. reqs	-	-	-
Sensitivity to air	No	-	-
Sensitivity to vapour	No	-	-
Experiment Hazards	No	-	-
Equipment Hazards	-	-	-
Biological hazards	no	-	-
Radioactive Hazards	No	-	-
Additional Hazards	-	-	-
Additional Details	-	-	-
Sample will be	Disposed by IS	-	-

Investigating the Source of Imperfections in Forged Brass Items Using Raman Confocal Microscopy

1. Background and Context

Brass, a durable alloy widely used in the forging manufacturing process, serves a multitude of applications across the automotive, consumer electronics, and hardware industries. Its superior fluidity, mechanical resilience, and ease of forming distinguish it as a preferred material. Nevertheless, the forging process of brass is susceptible to the introduction of various defects including surface roughness and inclusions, (i.e. of graphite, that is added in the stamping process as lubricant), which can significantly undermine the articles' mechanical integrity and aesthetic qualities. Furthermore, surface treatments, such as galvanic coatings, employed to enhance surface characteristics or improve corrosion resistance, add another layer of complexity. These treatments can interact with the brass substrate in ways that are not fully understood, potentially exacerbating defect issues. Raman confocal microscopy, known for its sensitivity to carbon structures, offers a promising avenue to investigate these microstructural defects and the effects of graphite-based surface treatments on hot pressed brass. This research aims to uncover the microscopic origins of defects and their interactions with surface treatments, contributing to the optimization of both forging processes and post-forging treatment protocols.

2. Proposed experiment

This proposal is part of a dual campaign, merging insights from Raman confocal microscopy and scanning electron microscopy. The **aim** of this experiment is to deeply understand the origins, characteristics, and distribution of microstructural defects in brass forges articles, including how these may be influenced by surface treatments, particularly those involving graphite additives. Specifically, we hope to: a) identify and characterize the types of microstructural defects present in brass forged articles, such as porosity, surface roughness, inclusions, and any anomalies introduced or affected by graphite presence in the treatments; b) understand the mechanisms behind the formation of these defects during both the forging process and subsequent surface treatments; c) evaluate the impact of surface treatments on the defects and overall integrity of the brass articles; d) propose improvements in the forging process and surface treatment applications to minimize defect formation and improve the mechanical and aesthetic qualities of the final products. The analysis of sections obtained from the same samples subjected to surface analysis will also be carried out. This strategy aims at unveiling the presence of internal defects, inclusions, and material inhomogeneities that are not visible on the surface.

Raman confocal microscopy is a pivotal tool for this experiment due to its unique capabilities. Chemical Specificity: Raman spectroscopy provides detailed information about the chemical composition and molecular structure of materials. This is particularly important for identifying the nature of defects and the effects of graphite or other carbon-based additives used in the articles manufacturing process. Spatial Resolution: confocal microscopy allows for high-resolution imaging of the sample surface and subsurface layers, enabling the precise localization and characterization of defects within the brass matrix and at the interface with surface treatments. Non-destructive Analysis: this technique requires minimal sample preparation without altering or destroying the samples, preserving the authenticity of the defects and surface treatments for accurate analysis. Sensitivity to Carbon Structures: given the experiment's interest in graphite surface presence, Raman spectroscopy's sensitivity to carbon structures makes it an ideal method for analysing how these coatings interact with the brass substrate and influence defect formation.

The **data** obtained from Raman confocal microscopy will be analysed through several steps. Spectral Analysis: each defect and treated surface area will be analyzed to identify the specific Raman signatures, which indicate the chemical composition and molecular structure. This will help in identifying the types of defects and the presence of graphite or other coatings. Image Analysis: high-resolution images obtained from confocal microscopy will be analysed to assess the morphology, size, distribution, and depth of defects. Image processing software will be used to quantify these characteristics across different samples. Correlation and Statistical Analysis: data on defect characteristics will be correlated with information on forging parameters and surface treatment conditions to identify patterns or causal relationships.

3. Summary of previous experimental proposals or characterisation

Historically, the understanding of defect formation in brass forging and the effects of surface treatments has been constrained by a reliance on empirical methods and trial and error. This approach lacks the detailed insight and predictive capability that sophisticated analytical tools like Raman confocal microscopy can provide. Particularly for SMEs in the forging sector, access to such advanced analysis and the requisite expertise is often limited. Although some literature provides a foundational understanding of metal forming, microstructural analysis, and surface treatments on brass alloys,[1-3] a detailed exploration of these elements' interplay, especially regarding graphite-based additives in the manufacturing process, is notably absent. This research aims to fill that critical knowledge gap.

4. Justification of experimental time requested

As detailed in section 2, Raman confocal microscopy is a pivotal tool for this experiment due to its unique capabilities. We request 3 days of experimental time to analyse 24 samples: 12 samples where the surface will be thoroughly investigated (flat samples will be used to help in the analysis) and 12 samples obtained by sectioning the forged articles. This number ensures diverse representation from different batches or treatment conditions. The first day will be dedicated to collecting low-resolution Raman 2D maps from all 12 samples. The second day will focus on collecting Raman spectra and high resolution maps on regions of interest selected from on a preliminary review of the collected data to identify key patterns, anomalies, and areas requiring deeper investigation. This step is crucial for effective time management and prioritizing detailed analyses. The final day is reserved for the analysis of sections, based also on the compilation of initial findings. This structured approach allows for thorough examination while maintaining a strict timeline.

[1] Kunčická, Lenka, and Radim Kocich. "Effects of Temperature (In) homogeneity during Hot Stamping on Deformation Behavior, Structure, and Properties of Brass Valves." Advanced Engineering Materials 24.7 (2022): 2101414.
[2] Pantazopoulos, G. "A review of defects and failures in brass rods and related components." Practical Failure Analysis 3.4 (2003): 14-22.
[3] Liu, Wei, et al. "Component Analysis of Defects in Secondary Special Brass Alloy." TMS 2020 149th Annual Meeting & Exhibition Supplemental Proceedings. Springer International Publishing, 2020.