T5.5 Case study Problem- Based Learning (PBL)

The Purpose of the elaborated Case Studies

Case studies are structured examinations of real-world situations or challenges designed to bridge theory and practice. They are developed both as a research method and as a learning tool to strengthen analytical and problem-solving skills. By engaging with authentic industrial scenarios, students gain practical insight into complex professional environments.

The purpose of this case studies is to encourage active, learner-centred engagement. They support approaches such as problem-based learning by enabling students to work independently or collaboratively, with or without instructor guidance. Through analysing theoretical concepts within realistic contexts, students learn to interpret data and test results, evaluate alternative courses of action, and develop well-reasoned, creative solutions.

This approach is particularly valuable in sectors such as aerospace, defence, and advanced manufacturing, where challenges are multifaceted and solutions are rarely singular. Because multiple valid solutions often exist, guided facilitation is frequently beneficial to help students structure their reasoning, assess trade-offs, and justify their decisions effectively.

Title of Case Study / Problem-based learning case

Repair and Remetalization of Naval Journal Bearings using Direct Energy Deposition with Laser and Wire (DED-Lw)

Prepared by SICNOVA

From: M.C. Diaz De Baldasano, A. Biehler, D. Palomo, I. del Sol, J. Zazo, D. Lobón, F. González, F. Lasagni: Repair and Remetalization of Naval Journal Bearings using DED-Lw. Progress in Additive Manufacturing, 2026 (https://doi.org/10.1007/s40964-026-01952-w)

Background:

A naval maintenance facility must repair a large journal bearing from the propulsion shaft line of a frigate.

The original Babbitt coating has suffered severe degradation due to long-term service, cavitation erosion and wear. Traditionally, the bearing would be repaired by centrifugal casting, requiring long lead times, high thermal input and extensive machining.

The maintenance team is evaluating whether **DED-Lw (Direct Energy Deposition using Laser and Wire)** can replace the conventional repair route while maintaining the required mechanical integrity and tribological performance.

Component

- Component: Naval journal bearing
- Diameter: approximately 1500 mm

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- Steel backing
- Antifriction coating:
    - Tin-based Babbitt alloy
    - Approx. 89 wt.% Sn
    - Approx. 3 wt.% Cu

Manufacturing process

- Direct Energy Deposition – Laser Wire (DED-Lw)
- Blue laser (450 nm wavelength)
- Wire feedstock
- Argon shielding gas

Illustration of the case study

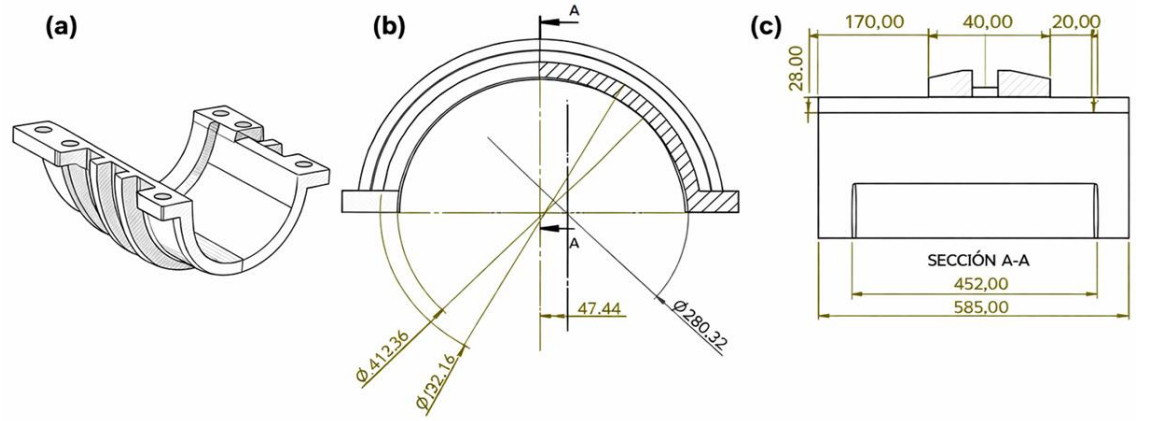


Fig 1: (a) journal bearing geometry 3D; (b) bearing diameter; (c) A-A cross section

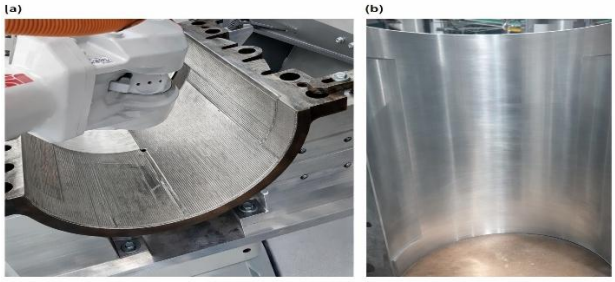


Fig 2: (a) DED-Lw deposition process applied to the journal bearing; (b) bearing after final machining.

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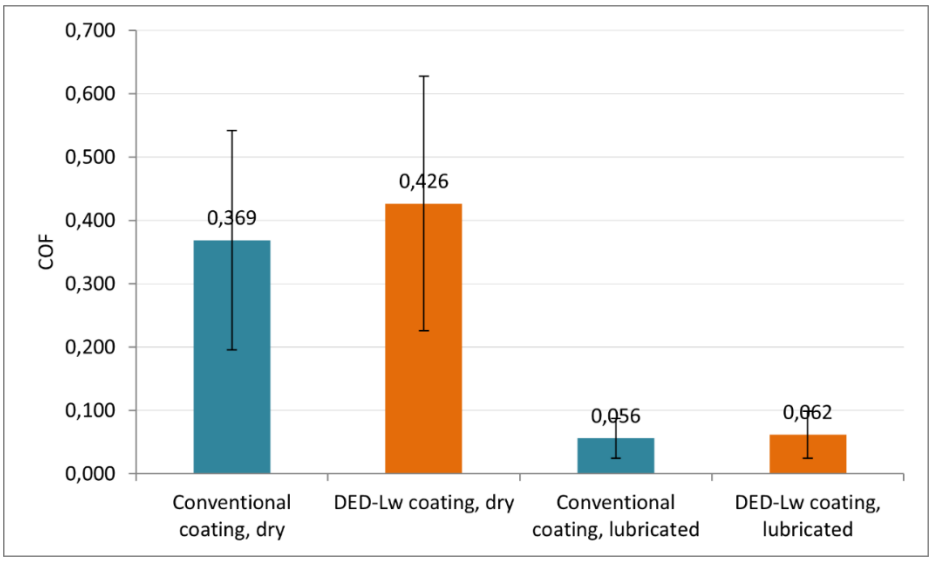


Fig 3: Mean coefficient of friction (COF) values with standard deviation for conventional and DED-Lw coatings.

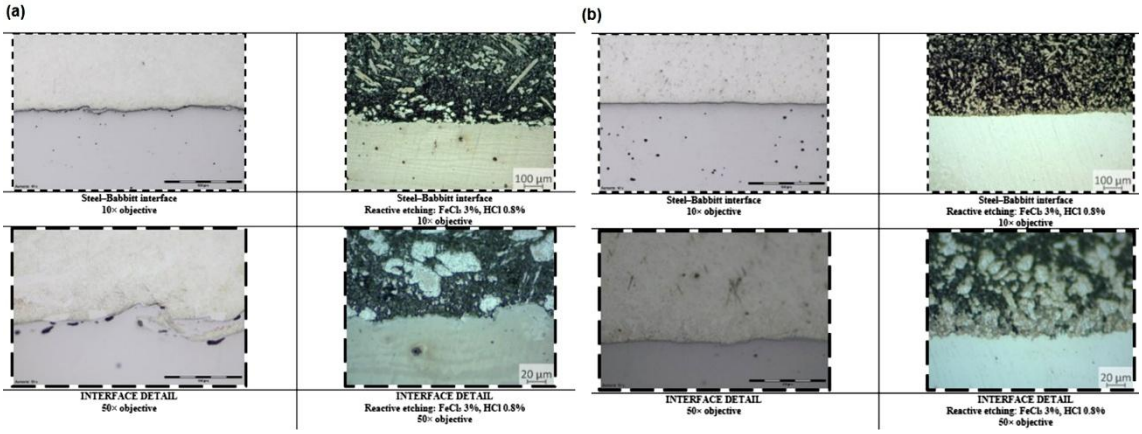


Fig 4: Optical micrographs of the steel-Babbitt interface: (a) conventional coating; (b) DED-Lw coating.

Technical challenge

The engineering team must determine whether DED-Lw is a suitable industrial repair process.

Students should analyse:

Process Selection

- Why is DED-Lw preferable to centrifugal casting?
- What are the main advantages and limitations?

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Process Optimisation

- Which parameters most influence coating quality?
    - Laser power
    - Wire feed rate
    - Travel speed
    - Energy density
- Why is there only a small processing window?

Metallurgical Challenges

Explain why depositing Babbitt on stainless steel is difficult.

Consider:

- Low melting temperature of Sn alloy
- High melting temperature of steel
- Wetting behaviour
- Metallurgical bonding
- Heat input

Quality Control

Which inspection techniques should be used?

Consider:

- Ultrasonic Testing (UT)
- Radiographic Testing (RT)
- Brinell Hardness
- Optical microscopy
- SEM/EDS
- Tribological testing

Validation

How would you demonstrate that the repaired bearing is suitable for naval service?

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Detailed solution/ process

Process parameter optimisation

A Design of Experiments (DoE) was performed to evaluate:

- Laser power
- Energy density
- Wire feed speed
- Deposition rate

The objective was obtaining:

- Stable melt pool
- Continuous beads
- Good overlap
- No porosity
- No lack of fusion

The optimum parameter combination provided:

- Stable deposition
- Highest productivity
- No relevant indications
- Acceptable radiographic quality

Surface preparation

Before deposition:

- Remove degraded Babbitt completely.
- Abrasive blast substrate.
- Clean using solvent.
- Ensure suitable roughness.
- Clamp bearing accurately.

Material Characterisation

The repaired coatings were evaluated by:

Mechanical

- Brinell hardness

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Tribological

- Dry sliding wear
- Lubricated wear
- Coefficient of friction
- Material loss

Metallurgical

- Optical microscopy
- SEM
- EDS

Non-destructive testing

- Ultrasonic inspection
- Radiography (only at sample level)

Results

Compared with centrifugal casting, DED-Lw produced:

- Lower wear volume
- More stable coefficient of friction
- More homogeneous hardness
- Good metallurgical bonding
- No significant internal defects
- Reduced thermal distortion

Validation

The repaired bearing was:

- Installed aboard a Spanish Navy frigate.
- Ultrasonically inspected.
- Checked using Prussian Blue contact tests.
- Operated during sea trials.

The bearing completed sea acceptance tests without operational anomalies.

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Discussion Questions

1. Why is DED-Lw more suitable than centrifugal casting for repairing high-value naval components?
2. Explain the importance of energy density during DED processing.
3. Which defects are most likely to appear if excessive laser power is used?
4. Why is ultrasonic testing required even if radiography is acceptable?
5. Why is tribological testing critical for journal bearings?
6. Why does a more homogeneous microstructure improve bearing performance?
7. Which acceptance criteria would you define before returning the bearing to service?
8. How could this repair methodology be transferred to aerospace maintenance?

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Competence unit coverage:

	AILEEN competence units	Covered CU
AW_01	Welding: Advanced Metallic Materials in Aerospace and Defence Sectors	
AW_02	Welding: Advanced Welding Processes and Equipment in Aerospace and Defence Sectors	
AW_03	Welding: Advanced Welding Applications in Aerospace and Defence Sectors	
AW_04	Welding: Introduction to brazing technology Knowledge for quality brazed joints	
AW_05	Welding: Fundamentals of Industrial Brazing: Main Processes, Quality Standards & Applications	
AI_01	Inspection: Non-Destructive Testing (NDT) in Additive Manufacturing for metals and polymers	
AI_02	Inspection: Metrology in Additive Manufacturing for metals and polymers	
AI_03	Inspection: Inspection of AM parts. Material Quality	
AAM_01	AM: Qualification, Certification and Standards for AM in A&D	X
AAM_02	AM: Quality Assurance & Quality Control for AM in Aerospace & Defence	
AAM_02/3	AM: Design of AM parts for A&D (2 courses - for DED & PBF)	
AD_01	Digital: Introduction to Digital Technologies in Advanced Manufacturing	
AD_02	Digital: Data Acquisition and Analysis	
AD_03	Digital: Industrial Internet of Things (IIoT) and Advantages in Advanced	
AD_04	Digital: Artificial Intelligence and Advantages in Advanced	
AD_05	Digital: Automation and Advantages in Advanced Manufacturing	
AD_06	Digital: Potentials of Advanced Simulation and Modelling in Advanced	
AD_07	Digital: Potentials of Digital Twins and Smart Factory Automation in Advanced Manufacturing	
AD_08	Digital: Unlocking the Potential of 3D Models Beyond Technical Drawings in the Aerospace and Defence Sector	
AG_02	Green: Sustainable Design and Environmental Compliance in Aerospace and Defence	
CU AAM_04	AM for Aerospace and Defence	X

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