IRISH MANUFACTURING RESEARCH

SAM SECTOR SKILLS STRATEGY IN ADDITIVE MANUFACTURING

IAMQS

ADVANCED TRAINING COURSE
INTERNATIONAL METAL ADDITIVE MANUFACTURING COORDINATOR

Online Course | November'22 – May'23 | Duration 175 Hours

Pilot Class: CU15: PBF-LB Process

Qualification IAM Co-ordinator

Professional Profile: PBF-LB/Metal AM Process Engineer

Timeframe: 21st November- 24th November 22

Venue: Online

Organizer: IMR Irish Manufacturing Research

Version 1:19/11/2022 V7

Contents

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1. Introduction

As part of WP5, **Irish Manufacturing Research (IMR)** has been tasked with *a second re-trialling* of **Competency Unit 15 for the LB-PBF process**. The feedback to date has led us to believe that it was successful within the remit given under the SAM Project and it will build to help further define the qualification approach that needs to be taken to ensure that it is adopted by industry.

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2. Attendees

For this to be successful, it is important that attendees are present at **each Zoom session** (3 each day x 1 hour see timetable below) on **all four days** of the live training with IMR. If you cannot attend for *any reason*, you must inform katrina.farrell@imr.ie. It is important that industry is engaged, represented, and invested in the development of these qualifications. In the case of the **Competency Unit CU15**, a significant effort was put in to attract participants that are not only looking at Additive Manufacturing for industrial use but, also actively engaging in it as part of their daily jobs.

3. Lesson Plan

The syllabus for this pilot is based on the recommendation in the International Additive Manufacturing Qualification System (IAMQS) qualification guide for PBF-LB CU 15. Due to the large geographical reach of participants all the training is online. Content developed by **Irish Manufacturing Research** has been pre-recorded and will be shared at specific times to stagger interaction points with you, the attendees and whom IMR is delighted to welcome to the training programme.

As the training will be held online with live and pre-recorded sessions, several communication channels will be opened up to you consisting of a comments section on each page, feedback forms for each lesson and the email address of the lead trainers.

Everyone ideally **is required** to attend **3 hours** of live interactive training **daily**. Each day will be composed **five training and learning sessions** which are *repeated* daily.

1. Daily introduction or recap	**09.30 to 10.15 (online attendance)**
2. Pre-recorded **self-directed learning** (SDL)	10.15 to 12.15 (break for 15 mins recommended)
3. Return online for a Q&A	**12.30 to 1.30 (online attendance)**
4. Pre-recorded **self-directed learning** (SDL)	1.30 to 3.15 (break for 15 mins recommended)
5. Return online for a Q&A	**3.30 to 4.30 (online attendance)**
6. End of Session	

Red: *Indicates you are **required** to attend at the training sessions via your Zoom Link which will be provided to you daily.*

***SDL** = Self Directed Learning (In this case: Watch the video).*

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Programme CU 15 - Training Plan

Date	Delivery Mechanism	Subject	IMR Trainer	Learning Outcomes	Times
Day 1				*What you are expected to learn by the end of each training session.*	
21st-Nov-22	Online live sessions & PowerPoint with live voiceover (self-directed learning SDL)	**PBF-LB Introduction and Process 15-20 mins**	Ms. Katrina Farrell Mr. Colin Meade (Q&A)	Orientation to the training programme. Describe the PBF-LB systems, including the components and their functions	**09.30 -10.15** **12.30 -1.30**
21st-Nov-22	Online live sessions & PowerPoint with live voiceover & supporting documentation.	**PBF-LB System – Hardware**	As above.	Describe the PBF-LB systems, including the components and their functions. Recognise the characteristics of the PBF-LB build platform	**3.30 - 4.30**
Activity	**PowerPoint with live voiceover. Evening of 21st.**	**PBF-LB System – Software**	SDL	SDL Homework: watch video tutorial.	**In your own time during the evening**
Day 2					
22nd-Nov-22	Online, PowerPoint with live voiceover & supporting documentation.	**PBF-LB System – Software**	Mr. Mark Hartnett	Factual and broad knowledge of PBF-LB Systems	**09.30- 10.30**
22nd-Nov-22	Online, PowerPoint with live voiceover & supporting documentation.	**PBF-LB - Parameters**	Mr. Alex Conway	Recognise the PBF-LB parameters and the influence of their adjustment on the as built part	**12.30 -1.30**
22nd-Nov-22	Online, PowerPoint with live voiceover & supporting documentation.	**PBF-LB Feedstock**	Mr. Alex Conway	Recognise the characteristics of the PBF-LB build platform, feedstock	**3.30-4.30**

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				and other consumables. Recognise the interaction of the process heat source with the feedstock Identify the problems associated with inadequate preparation and setup of the build platform, handling and storage of feedstock and application of the gases used in PBF-LB.	

Day 3

23rd Nov 22	Online, PowerPoint with live voiceover & supporting documentation.	**PBF-LB Consumables**	Mr Mark Hartnett	Advanced knowledge and critical understanding of the theory, principles, and applicability of: – PBF-LB equipment, accessories, including build platform, feed-stock and other consumables.	**09.30-10.30**
23rd Nov 22	Online, PowerPoint with live voiceover & supporting documentation.	**PBF-LB Manufacturing Strategy**	Mr Alex Conway	Understanding of the effect of variables on the PBF-LB process Identify the variables used to define the PBF-LB manufacturing strategy Identify areas that will need thermal compensation Identify the cause of defects and propose methods for their mitigation.	**12.30-1.30** **3.30 to 4.30**

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Activity	**PowerPoint with live voiceover. Evening of 23rd.**	**Post Processing**	SDL	SDL Homework: watch video tutorial.	**In your own time during the evening**
Day 4					
24th Nov 22	Online, PowerPoint with live voiceover & supporting documentation.	**Break Out Rooms Exam Questions**	Ms Katrina Farrell	Group discussions and problem solving in AM processes.	**09.30– 10.30**
24th Nov 22	Online, PowerPoint with live voiceover & supporting documentation.	**PBF-LB Post Processing**	Mr Mark Harnett	Advanced knowledge of post processing operations and options	**12.30-1.30**
24th Nov 22	Online, PowerPoint with live voiceover & supporting documentation.	**PBF-LB Equipment and Accessories**	Mr. Colin Meade	Identify the cause of defects and propose methods for their mitigation Discuss the adequacy of selected equipment and accessories on the part manufacturing	**3.30-4.30**
	Final Round Up	**Feedback Total Zoom Contact Hours**	ALL	**Evaluation**	**4.30 – 5pm 12**

Table 1 - CU 15 Pilot Lesson Plan IAMCoordinator

4. Content Delivery Mechanism

Self-directed learning (SDL) will be achieved using a SharePoint Site that will host various multimedia content. This enables IMR to create a page of content for each module whilst making them available when required with a comments section to help facilitate engagement. To ensure that all the recorded content is delivered consistently, the training videos are hosted on the IMR YouTube site and embedded on the SAM CU 15 SharePoint. The videos in question can be found on the SharePoint link we will disseminate on Day 1 of training.

Screenshots of each page can be seen below in Appendix 1.

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5. Your Trainers

Alex Conway
Senior Additive Manufacturing Researcher with IMR.

Alex has been actively working in AM research for the past 5 years, primarily focused on process monitoring, characterisation, and optimisation for laser-based powder bed fusion. His experience has enabled him to work with the medical and aerospace industries to exploit the benefits that metal additive manufacturing can offer. He is also involved in STEM education through the training and outreach activities developed by IMR.
Education MAI Engineering, Trinity College Dublin. Thesis Title: 'Process Monitoring in Metal Additive Manufacturing and 3D Printing'. BSc in Mechanical and Manufacturing Engineering with Management Studies, Trinity College Dublin

Katrina Farrell
Learning and Development Specialist with IMR

Katrina has been working on the SAM Project at IMR for almost two years, has brought IMR through an education audit with the European Welding Federation to allow them to become an Accredited Training Body for Additive Manufacturing with the European Welding Federation (EWF) and the IAMQS in 2022. Katrina delivers training content design and facilitation on the SAM pilot training courses. Katrina is a Learning Specialist with IMR and a member of the Teaching Council of Ireland and the Chartered Institute of Personnel Development. Katrina has business experience as well as ten years Learning and Development experience, specialising in writing content and training

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delivery. Human development and coaching experience. CIPD Associate Human Resources. Institute of Leadership and Management Coaching Associate.

Mark Hartnett Technologist with IMR

Mark Hartnett is a within IMR's Design for Manufacturing (DfM) Group. He holds a BEng in Manufacturing Engineering from DIT and has recently completed a MSc in Mechanical and Materials Engineering through research, focused on the design and characterisation of metal lattice structures fabricated through AM with UCD. He is currently working to support Irish industries in the development and adoption of Additive Manufacturing technologies within new and existing process lines, with a particular focus on the medical device sector. He has worked with IMR for 5 years and in this time has been IMR's PI on APEM – AM, a Smart Eureka funded project and was the technical lead on the feasibility study DENAM which resulted the launch of a new production line supported by AM. He has significant experience across a range of both polymer and metal AM systems along with the design and development of products to exploit the opportunities offered by AM. Bachelor of Manufacturing and Design Engineering – Dublin Institute of Technology 2017. Master of Engineering Science in Mechanical and Materials Engineering – University College Dublin 2022.

Colin Meade

Additive Manufacturing Technologist with IMR.

Mr. Colin Meade is an Industrial Researcher in Additive Manufacturing at IMR. He has a B.Eng. in Mechanical Engineering and after graduating worked in the medical devices area. Colin has extensive experience in Concept Generation and Refinement, Prototyping, CAD, and Design for Additive

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Manufacturing and has a number of patents at various states of approval. He is currently exploring the potential for adoption and integration of Additive Manufacturing technology into Irish industry. Colin has extensive experience in working in early phase Research & Innovation to develop new products with significant experience in concept generation and refinement within limited budgets and has eleven US patents filed. Bachelor of Engineering Athlone Institute of Technology 2013.

6. Appendices:

Appendix 1 – SharePoint Site Screenshots

- **Training Days 1 to 4 (exemplar pages)**

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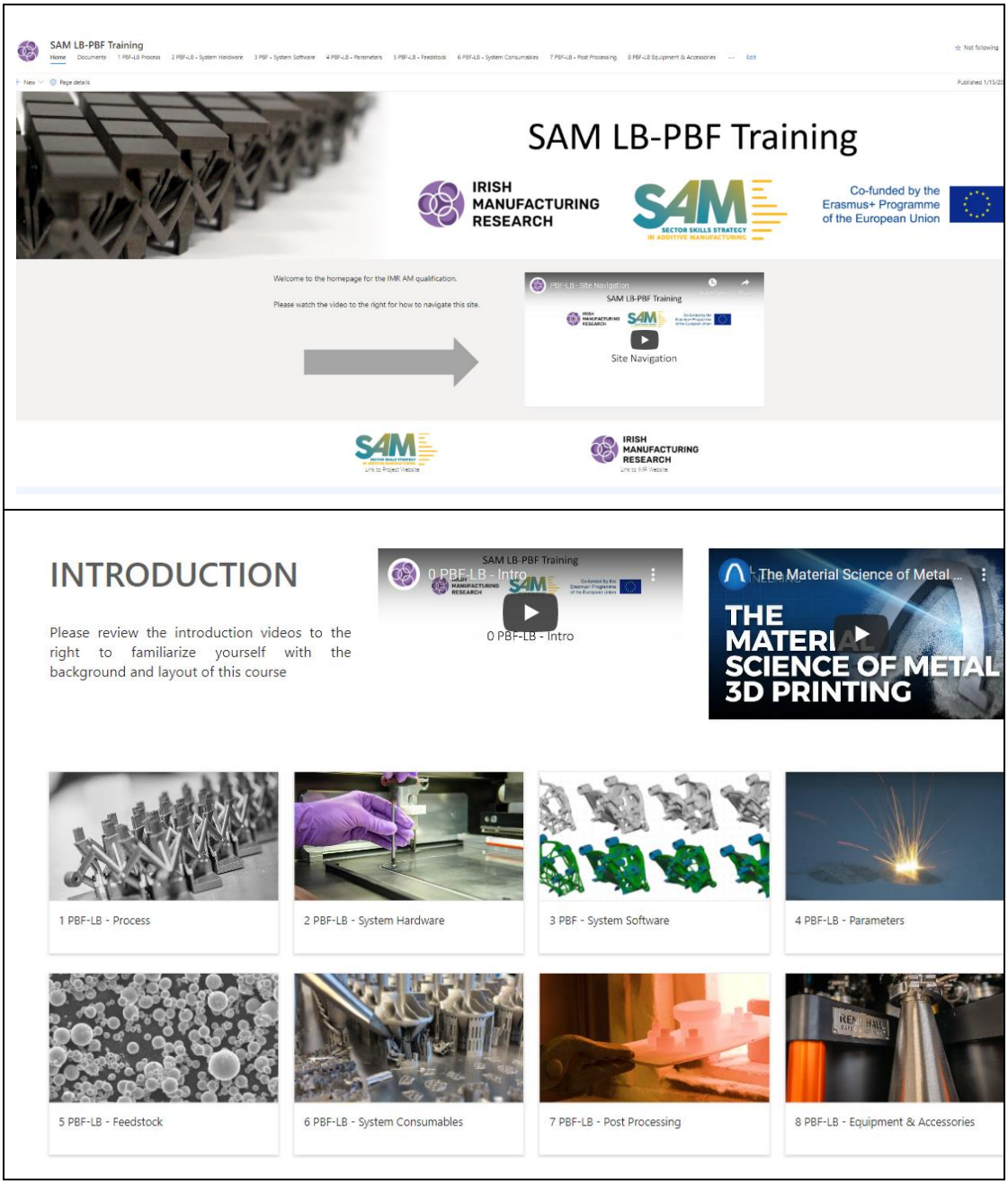

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2 PBF-LB - System Hardware

The purpose of this section is to describe the Metal Powder Bed Fusion Hardware from an introduction through to more advanced concepts.

Hardware:
Overview of the system

- Power source
- Powder management system
- Chamber
- Gases
- Filters
- Sieves
- Powder cans
- Build platforms
- Powder recoater

Examples of different PBF-LB systems

- Monitoring system
- Cleaning system

Please ensure to fill in the form below so your completion is recorded.

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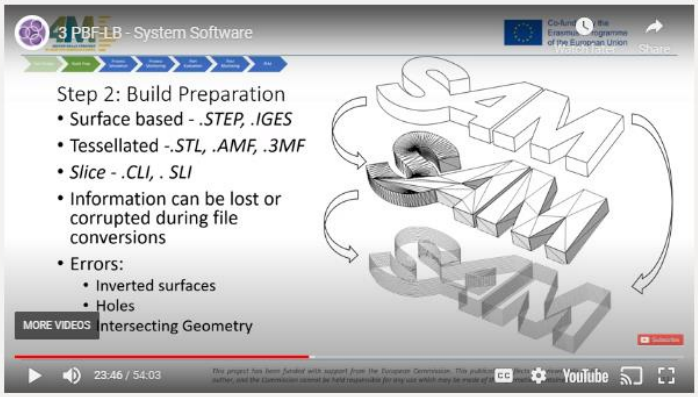
3 PBF-LB - System Software

The purpose of this section is to describe the software workflow for Metal Powder Bed Fusion from an introduction through to more advanced concepts.

Software:
Examples of PBF-LB Software Systems

Please ensure to fill in the form below so your completion is recorded.



3 PBF - System Software

* Required

1. Please enter your name below: *

Enter your answer

2. Have you completed all content on this page? *

Yes

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4 PBF-LB - Parameters

The purpose of this section is to describe the Metal Powder Bed Fusion process parameters from an introduction through to more advanced concepts.

Laser/Optical Parameters

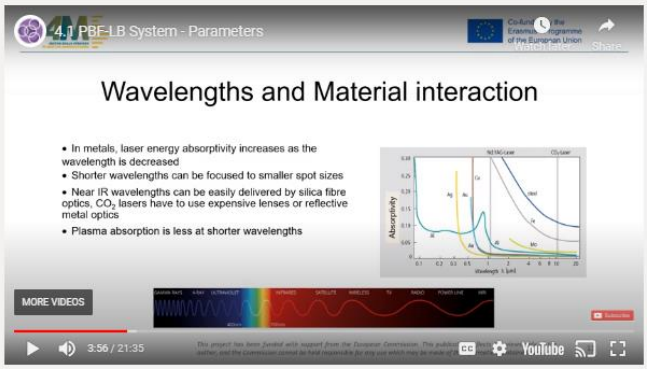
- Laser Power
- Focus
- Laser Beam Profile
- Scanning Parameters
- Hatch and edge distance

Process Parameters

- Layer thickness
- Dosing factor
- Gas flow rate
- Laser Travel Speed
- Beam off set
- Pre-heating temperatures

Note - you may need to adjust the YouTube playback quality to 1080 HD for comfortable viewing of some content

Please ensure to fill in the form below so your completion is recorded.



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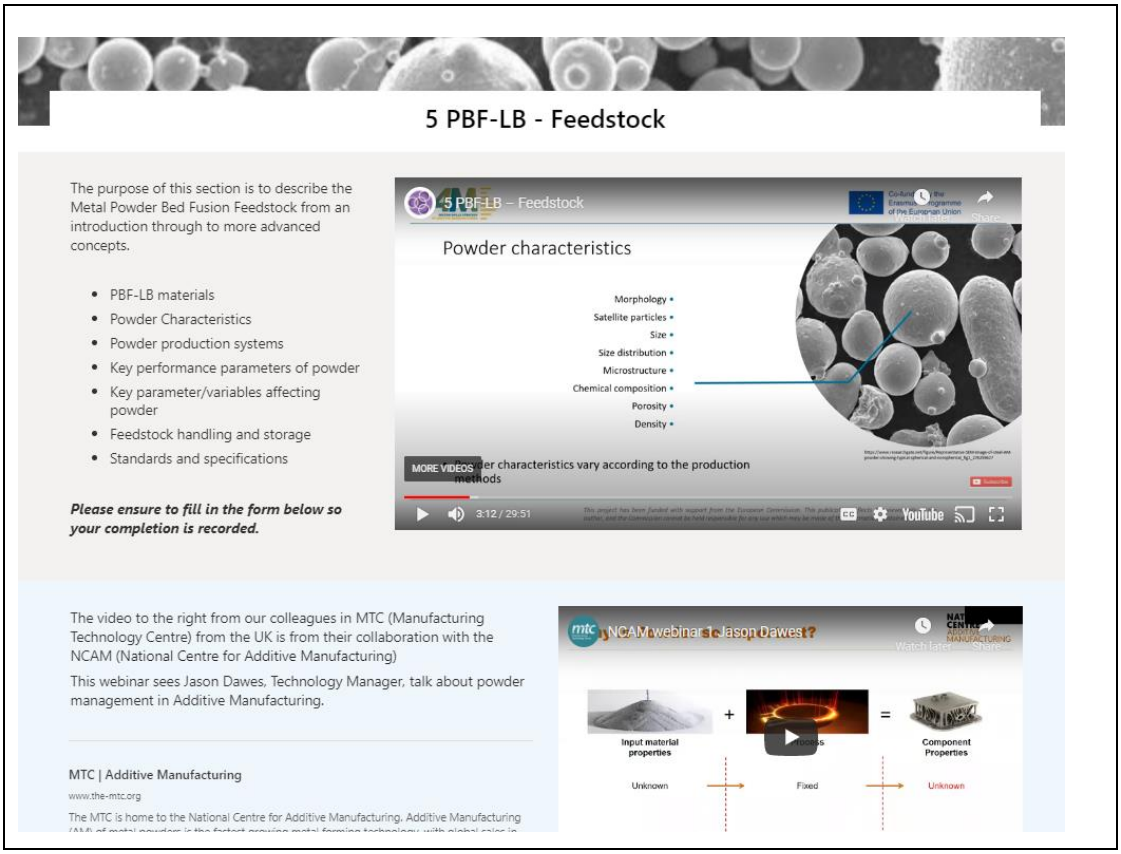

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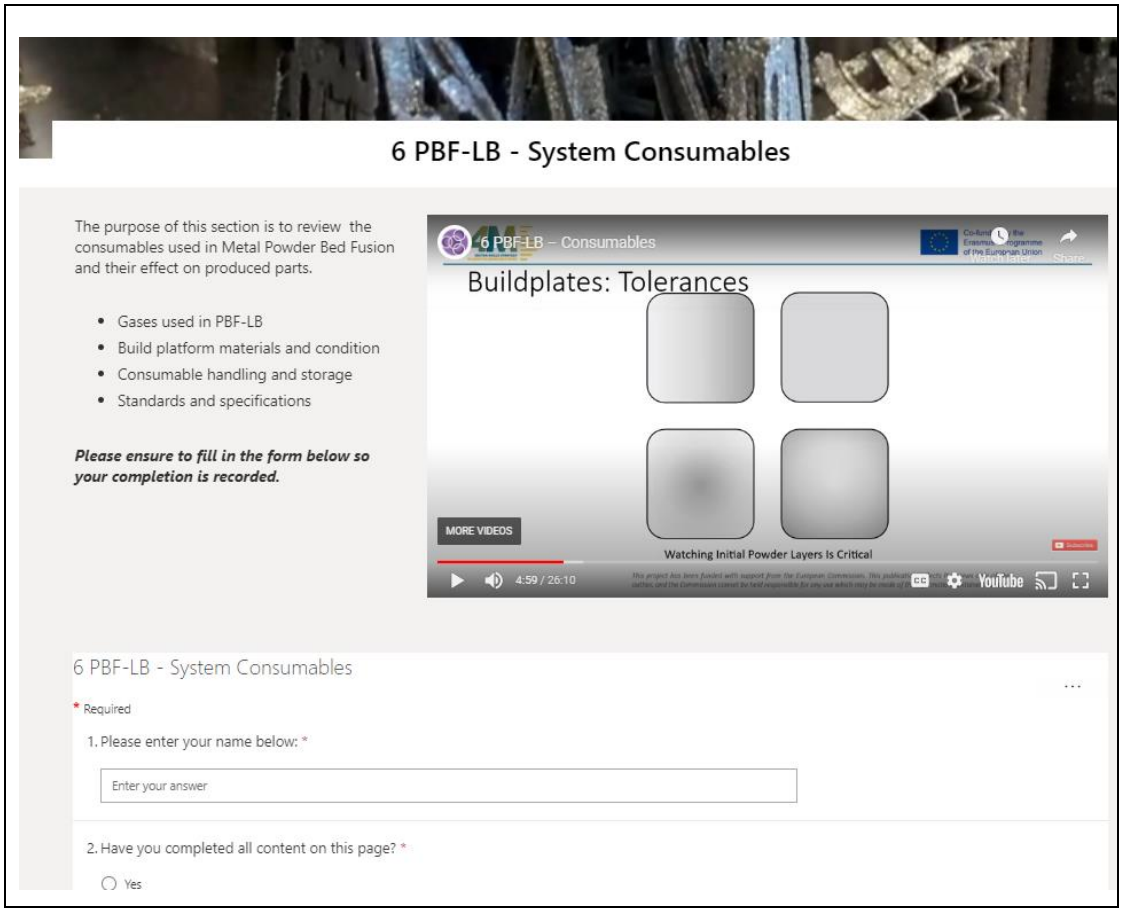

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7 PBF-LB - Post Processing

The purpose of this section is to describe the fundamentals of Metal Powder Bed Fusion Post Processing of printed parts.

Topics covered include:

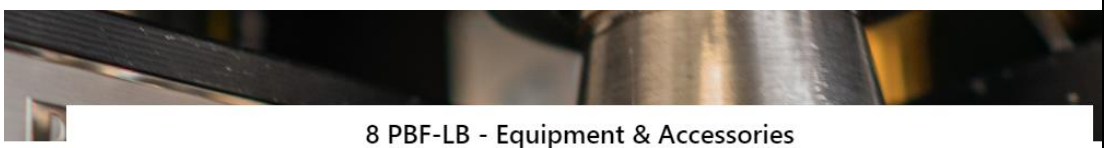
- Powder removal
- Stress relieving operations (thermal/mechanical)
- Heat treatment
- Surface finishing

Please ensure to fill in the form below so your completion is recorded.

7 PBF-LB - Post Processing

* Required

1. Please enter your name below: *



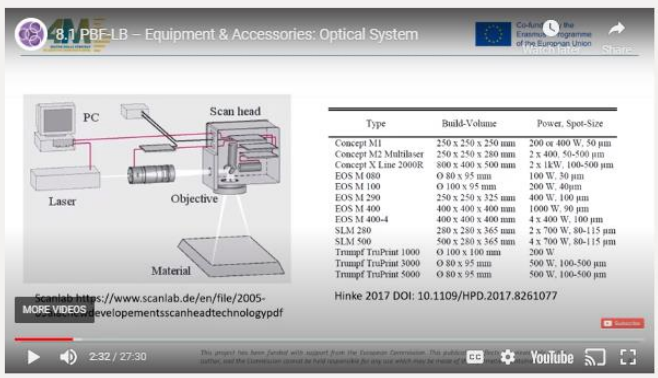
8 PBF-LB - Equipment & Accessories

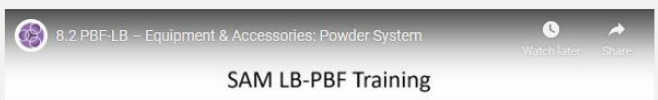
The purpose of this section is to describe the Metal Powder Bed Fusion Equipment & Accessories typically used.

Topics included are:

- Optical system components
- Powder feeding system
- Gas system
- Sieves and filters
- Deposition direction
- Deposition rate/ Production rate
- Distortion avoidance methods (e.g. thermal compensation)

Please ensure to fill in the form below so your completion is recorded.





9 PBF-LB - Manufacturing Strategy

The purpose of this section is to describe the Metal Powder Bed Fusion Manufacturing Strategy from an introduction through to more advanced concepts.

Topics covered include:

- Fixturing
- Positioning and nesting
- Layer thickness
- Dosing factor
- Interaction of layers
- Distortion avoidance methods (e.g. thermal compensation)
- Deposition rate/ Production rate
- Hybrid build strategies
- Scanning strategy:
- Hatch and edge distance
- Start-stop strategies
- Parameters adjustments along the layer
- Orientation:
- Supports
- Build time
- Mechanical parts

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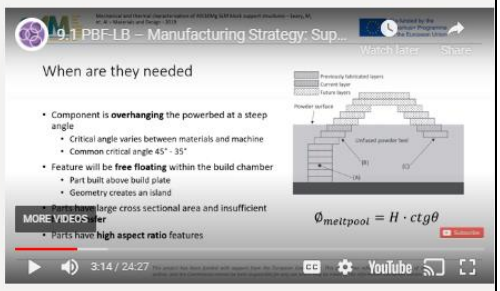

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Important Links

International Additive Manufacturing Qualification System (IAMQS)

European Welding Federation (ewf.be)

Irish Manufacturing Research SAM Project https://imr.ie/pages/sam/

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