DELIVERABLE D2.2

Laboratory setup for rock melting

Lead Beneficiary: FhG-IAPT

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ABBREVIATIONS AND GLOSSARY OF ACRONYMS

Acronym	Extended definition
Al	Aluminum
CA	Consortium Agreement
CAD	Computer Aided Design
D	Deliverable
DCM	Dissemination and Communication Manager
D&C	Dissemination and Communication
EC	European Commission
EM	Exploitation Manager
EP	Exploitation Plan
FDM	Fused Deposition Modeling
GA	Grant Agreement
HE	Horizon Europe
IPR	Intellectual Property Rights
LBM	Laser Beam Melting
M	Month
PBF	Powder Bed Fusion
PC	Project Coordinator
PDEC	Plan for Dissemination and Exploitation including Communication activities
SC	Steering Committee
Ti	Titanium
V	Vanadium
VRE	Virtual Research Environment
WP	Work Package

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PUBLISHABLE SUMMARY

In WP2 Task 2.2, Fraunhofer IAPT created the laboratory setup for the experimental development and testing of the new laser drilling process. The technical equipment includes a high-power laser system, a processing optics, a drill string with a special 3D printed drill head, and a gas feeding system, with which the process gas can be tempered. As shown in figure 1, the drill string is mounted at a robot that realise the movement during the drilling process. The process application takes place inside a press container, which acts as a safety enclosure.

Figure 1: Laboratory setup at Fraunhofer IAPT

1. INTRODUCTION

In the DeepU project, a new laser drilling process is developed to create a scaled model of a heat exchanger for deep geothermal energy exploitation. For this purpose, rock is to be melted by a high-power laser and expelled from the borehole. This process requires a drill string with an innovative drill head, which Fraunhofer IAPT generates in WP2 of the project.

During the drilling, the processing head is immersed in the rock, whereby a free annular space must be created around the entire drill string, through which the melted rock can escape from the drill hole and be pushed to the surface with the help of the gas. The processing head closes off the drill string at the bottom. Its main task is to direct a stream of nitrogen or an inert gas onto the molten rock.

An area with a diameter of 50 millimeters must be available in the center of the drill string in order to guide the laser beam from the optics above the earth's surface to the effective point of the melting process at the end of the borehole. The processing head can be equipped with a diverging lens to expand the laser beam below the drill string and enlarge the bore diameter.

Fraunhofer IAPT is also responsible for the experiments in the project and their preparations.

2. DEMONSTRATION OF THE LABORATORY SETUP

Fraunhofer IAPT realized the laboratory setup, consisting of three basic components: the laser system, the gas feeding system and a press container. The movement during the laser drilling process is carried out with the help of a robot hanging below a large gantry system.

2.1 LASER SYSTEM

Fraunhofer IAPT provides a 30 kW high-power laser system for the experiments (see figure 2). The laser beam is guided through the drill string by the processing optics, which is especially designed for such high laser power. Optics, drill string and drill head are mounted one above the other at the robot. Drill string and drill head can penetrate the roof of the press container in order to melt the rock material inside (see figure 1).

Figure 2: High-power laser system for the experiments

2.2 GAS FEEDING

Gas is needed to carry the laser-melted rock out of the borehole. Pressures of up to 30 bar can be used in the setup. The gas is supplied from a tank, from which the gas is routed through the drill string to the drill head and exits through nozzles in the direction of the melt. In order to increase the effectiveness of the gas use in the experiments, the gas can be preheated on its way to the drilling head. Figure 3 demonstrates the inductive heating system that is part of the laboratory setup. The inductor has a power of 40 kW and enables to heat the gas lines red hot (see figure 3).

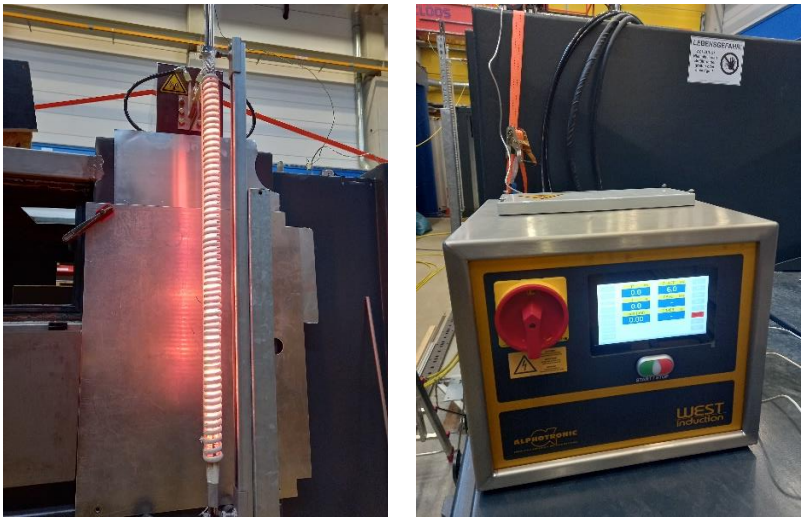

Figure 3: Inductive heating system for the gas

2.3 PRESS CONTAINER

A press container, which was originally intended for the disposal of waste paper, primarily serves as a safety housing in the laboratory, so that the experiments can be carried out despite the high pressures and temperatures prevailing in the process. It is also possible to use the press container to compact loose soil formations such as sand and embed stones in them. Figure 4 shows how the drill head with the drill string is guided through an opening in the cover plate of the container. Rock material is piled up inside the container to be processed with the new laser and gas drilling method.

Figure 4: Rock setup inside the press container