bilasurf

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EXECUTIVE SUMMARY

This document is one of the outputs for Work Package 3 “Design and implementation of the integrated manufacturing system”. The report summarizes results of the efforts made while preparing manipulation of complex 3D shaped parts. Mechanically, the manipulation will occur by means of robot arm.

FhG-IWU will use the data from the report for preparation of the location where final demonstrator will be installed.

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ABBREVIATIONS AND ACRONYMS

Abbreviations / Acronyms	Description
DLW	Direct Laser Writing
DLIP	Direct Laser Interference Patterning
NA	Numerical Aperture
CW	Continuous Wave

1 Concept of manipulation.

1.1 Use of the robot arm

Initial design supposed using hexapod placed on X-Y stages for manipulation of the workpiece with respect to focal point of the scanning system. Such setup ensures XYZ accuracy in the range of <1 µm and angular accuracy of 3 µrad. However, hexapods have limited range of angular movement (±15°), that appeared being insufficient for manipulating considered parts, especially turbine blades, which have curvature bigger than mentioned limit. Therefore, decision was made, to use a robot arm which is capable of 6-axes movement within greater limits.

1.2 Robot selection

The mass of heaviest part to be textured is ~55 kg (the mould for impeller), which defines requirement for the robot arm. ABB robot IRB 4400/60 was selected as suitable for the Project purpose. It can manipulate 60 kg load within 160 cm from main axis and 35 kg load within 220 cm, which is more than sufficient for manipulating parts that have dimensions no more than 60 cm. Rotation limits are ± 125° for Axis 1, ± 60° for Axis 2,3, and ± 180° for Axes 4-6.

Pose accuracy is guaranteed ≤ 60 µm at maximum reach and performed testing gave results ≤ 15 µm within mentioned dimensions of the parts to be textured. Bearing in mind that the scanning field is assumed to be at least 30 x 30 mm, this accuracy is sufficient for the purpose.

For the WOP laboratory setup that is dedicated for testing positioning algorithm and modeling texturing process, ABB robot CRB-15000-5/0,95 was selected that can handle 5 kg load within area with 20 cm radius and 1,2 kg load within 95 cm area.

Both robots are controlled by means of ABB software Robot Studio, which is covered with WOP proprietary System Control Application (SCA) that handles robots, scanning heads, and laser according to fabrication algorithm and upon the feedback coming from monitoring system.

2 Modules for manipulation complex shaped parts.

According to the Project plan, there are two setups deployed having different purposes: one laboratory setup dedicated for modelling the process and testing fabrication and second one dedicated for integration of all modules developed by Consortium partners.

2.1 Laboratory setup

Laboratory setup comprises ultra-short pulse laser, beam forming optics, and beam delivery optics mounted on the honeycomb breadboard fixed on granite support. Said granite is mounted on steel frame that hosts mentioned robot CRB-15000 as well.

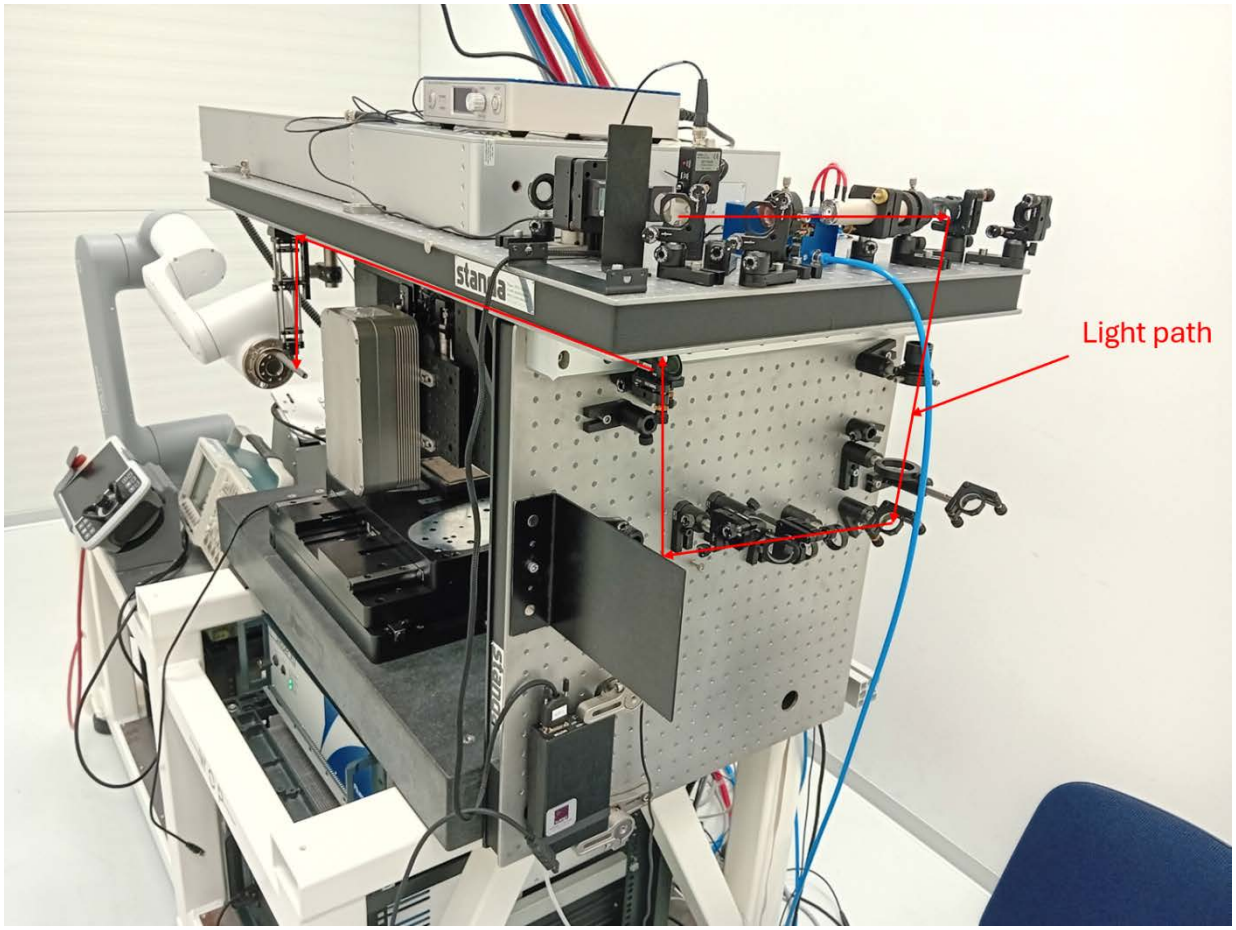

FIGURE 1. LOOK AT LABORATORY SETUP.

The laser beam is focused with NA close to one that is supposed to be used for DLW on production setup and allows to test the positioning for that process, where scanning is imitated by linear movement of the robot arm.

The purpose of laboratory setup is to make sure that commands and controls generated by SCA place the workpiece in the required place and with required orientation, i.e., its tangent plane is perpendicular to the axis of the scanning beam. The accuracy of positioning is evaluated by the result of DLW process.

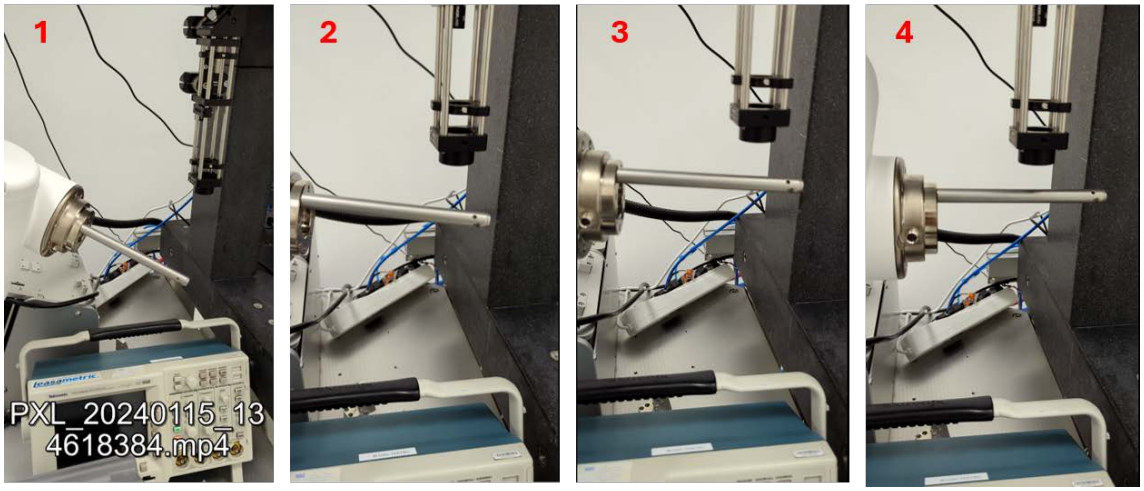

FIGURE 2. EXCERPT FROM VIDEO CLIP SHOWING MANIPULATION OF THE TARGET SHAPE.

In Figure 2, there is a sequence of images showing how round workpiece is brought to required position (images 1-3) and imitated scanning starts (image 4).

2.2 Demonstrator setup

As mentioned above, IRB 4400/60 robot is dedicated to install in the location of the final Demonstrator. It is mounted in interim location at WOP and is used for further testing of positioning algorithm.

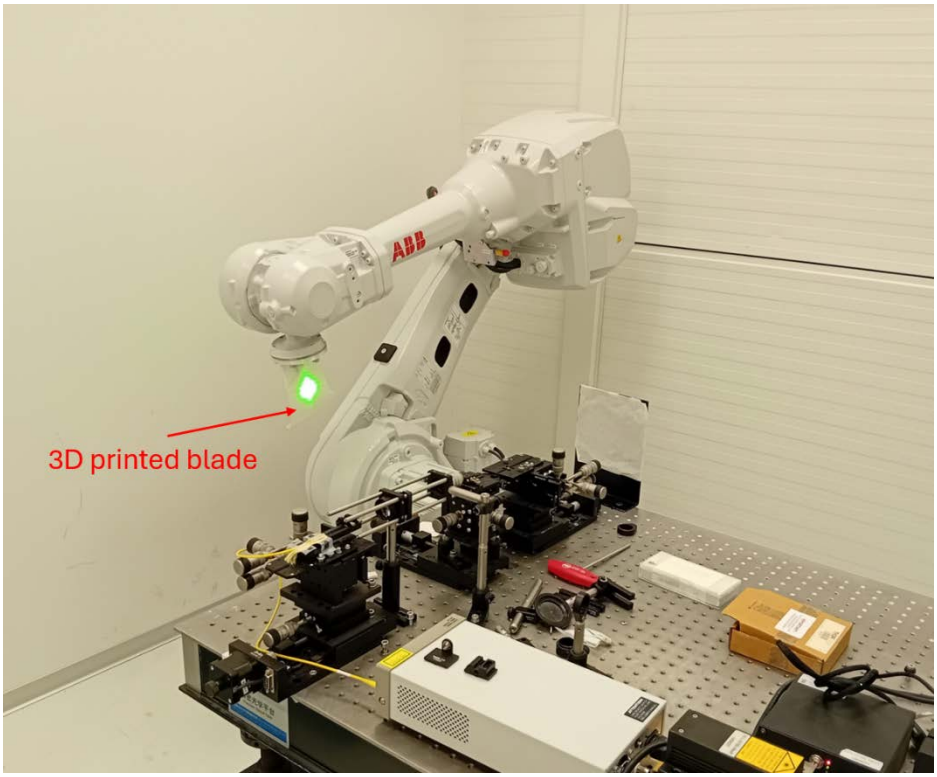

FIGURE 3. VIEW ON MANIPULATION MODULE OF DEMONSTRATOR.

CW green laser is currently used for imitating texturing beam.

All modules coming from the partners will be mounted on the honeycomb optical table seen on the Figure 3 that is placed next to the robot arm.

2.2.1 3D printed model.

Using drawings provided by GHYDRO, turbine blade model was printed from the plastic that contains all fixing and positioning holes as the original one.

FIGURE 4. 3D PRINTED BLADE OF THE TURBINE.

2.2.2 Gripper to the parts

For accurate texturing of the parts considered in the Project, precise grippers are required. Gripper of complex form was designed and manufactured to manipulate 3D printed model of the blade.

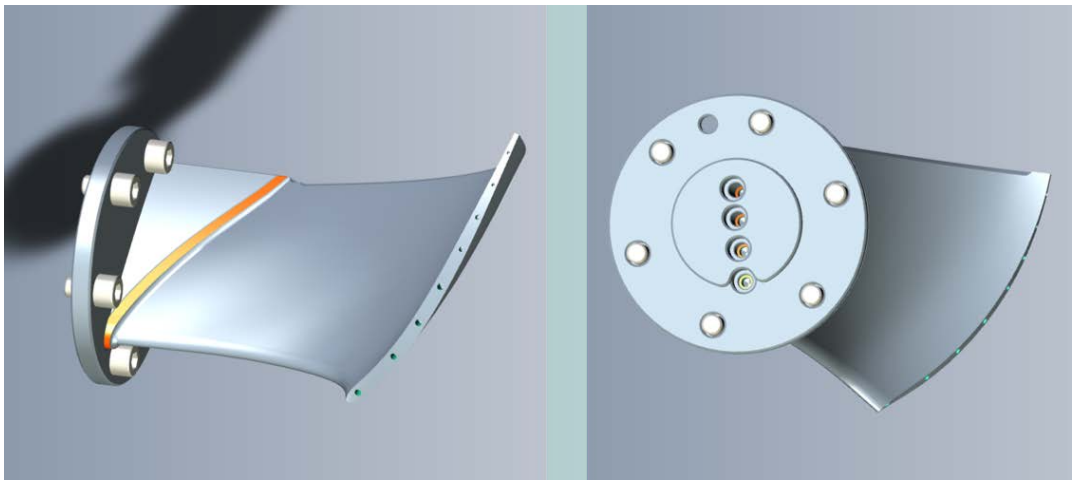

FIGURE 5. GRIPPER FOR THE BLADE FROM FIG. 4.

2.3 Location for the demonstrator

A discussion with FhG-IWU was held to define requirements for installation of quite heavy robot arm. Preliminary requirements are listed in Table 1.

TABLE 1. LIST OF REQUIREMENTS FOR INSTALLATION.

#	Requirement	FhG-IWU response
1	Floor space for safe operation no less than 3.5 x 3.5 m	YES
2	Power line with separate RCD	YES
3	Basement or ground floor preferred.	YES, basement and a vibration-decoupled foundation
4	Water supply	YES
5	Fume suction	YES
6	Compressed air	YES

Based on the discussion, FhG-IWU is ready to deploy the Demonstrator in the best possible way. Consortium Council has approved installation of the Demonstrator at FhG-IWU facilities.

CONCLUSIONS

1. Two manipulation setups are installed and tested in operation.
2. Manipulation robot dedicated for the Demonstrator is ready for integrating with further modules.
3. The place for destination of the Demonstrator is selected that complies with the requirements.