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[D12.1]
[Specification of sensors and devices needed]

Abstract:

This deliverable contains the specification of the sensors and devices needed to collect relevant data associated with the use cases of PPS2 at Bosch BT, Bosch TT and OLI.

The use cases covered are:

- U1A - Predictive Maintenance of a Smart Presses at Bosch TT;
- U2 - Leakage Test Reliability at Bosch TT;
- U3 - PCBA Quality Tests at Bosch BT;
- U4 - Predictive Maintenance of Molding Injection Machines at OLI;

where the following use case do not require further sensor or device installation:

- U1B – Bottleneck Identification and Prediction at Bosch TT.

For U1A and U4, the main goal is to have devices that, not only, acquire additional data relevant for the intelligent algorithms, but also, allow to test a mechanism to deploy machine learning computational containers to run on the edge devices.

For U2 and U3, the main goal is to enrich (if necessary) the set of data features for improving intelligent algorithms.

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Document relating to:

Activity	**A12**	
Task	**A12.T12.2**	Technical evaluation of the available devices as valid applications for each use case
Delivery date	**M9**	March/21
Confidentiality Level	**1**	1 – Confidential
Responsible Promoter		Bosch BT
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Contents

1. Introduction

In task T11.1, common data formats were specified which are essential for the development of models to forecast machine failure, predict equipment degradation, besides other methodologies planned in PPS2. This deliverable, associated to task T12.2 and based on the analysis of existent sensors and available data, intends to specify the sensors and devices required to collect data to enrich and complement the existent datasets with new parameters. In this scope, the main goal is to ensure that the essential parameters to develop the predictive models are being preprocessed and adequate devices are installed for deploying machine learning algorithms for the edge computing. In future work T12.3, the specified devices and sensors will be installed in the shop-floor, which will allow PPS2 frameworks to take advantage of the selected devices.

In this regard, it was checked the specifications and use case usability of available devices (e.g. XDK/Bosch, IOTiP/Fraunhofer, DEMA/UA). Nevertheless, the choices were made for considering standard IoT devices as Raspberry Pi and NVidia Jetson Nano, as described below.

2. Specification of sensors and devices needed for the Use Cases

2.1. U1A - Predictive Maintenance of Smart Presses at Bosch TT

This use case focuses the attention on a class of smart presses that is critical for the performance of the production line of U1A. Being already equipped with several type of sensors and devices, a preliminary data analysis was carried out, to confirm that the measurement of vibration is a key information for predictive maintenance algorithms (as referenced in the literature). Then, it was decided to add an extra device for vibration analysis with the ability to deploy machine learning algorithms in an edge computing manner as a standard prototype device.

Table 1 - Sensors and devices for U1A.

	Type	Quantity	Technical specification
Raspberry Pi 3 B +	Device	1	WiFi, 4GB RAM,
ESP32	Device	1	WiFi, BLE, dual core
IMU GY-91	Sensor	1	Resolution 16bit, Gyroscope + accelerometer, 10 degrees of freedom

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2.2. U2 - Leakage Test Reliability at Bosch TT

The aim of U2 is to improve leakage test reliability via data correlation with ambient measures. For operation purposes, these equipment tests need to be very sensitive. Although this sensitiveness is controlled, equipment misbehavior can happen in situations that do not actually represent an error/fault; related to changes in ambient temperature, vibration, bad localization or even usage time; somehow related with its high precision. Such bad behavior usually produces false product rejections. After evaluation of the existent sensors and devices, the following sensors and devices were acquired and have been already installed on site.

Testing Procedure

The test is carried out by a production machine controlled by a PLC (Programmable Logic Controller) that controls a specific leakage meter (ATEQ D520).

The test consists of:

1. Setting a specified air pressure on the leakage meter and testing part (this pressure must be between a given interval – defined as the pressure tolerances).

2. Wait a specific amount of time for air stabilization.

3. Measure the air flow induced by the leaks on the testing part.

4. This measured air flow must be between a given interval (flow tolerance) in order to be recognized as a good part.

More details about how this leakage is measured can be found on the image below extracted from the ATEQ D520 User Manual.

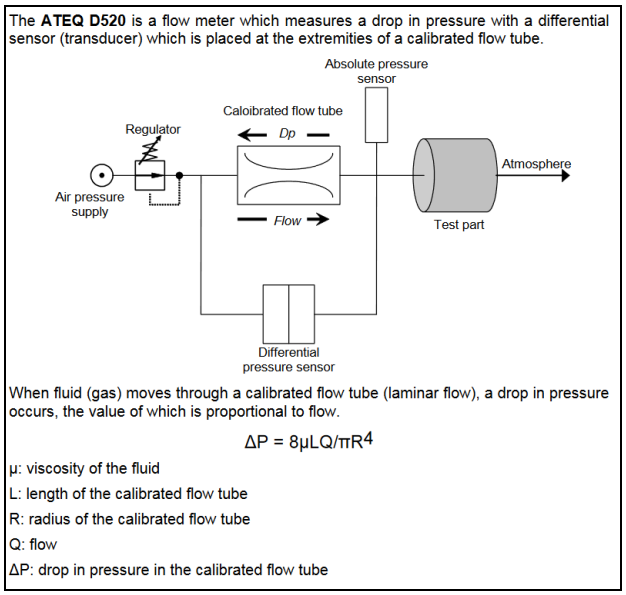

Figure 1 - Leakage measure procedure.

To complement the mentioned test pressure and flow (measured by the ATEQ D520) records, a set of external sensors were installed on the machine as shown on the following image.

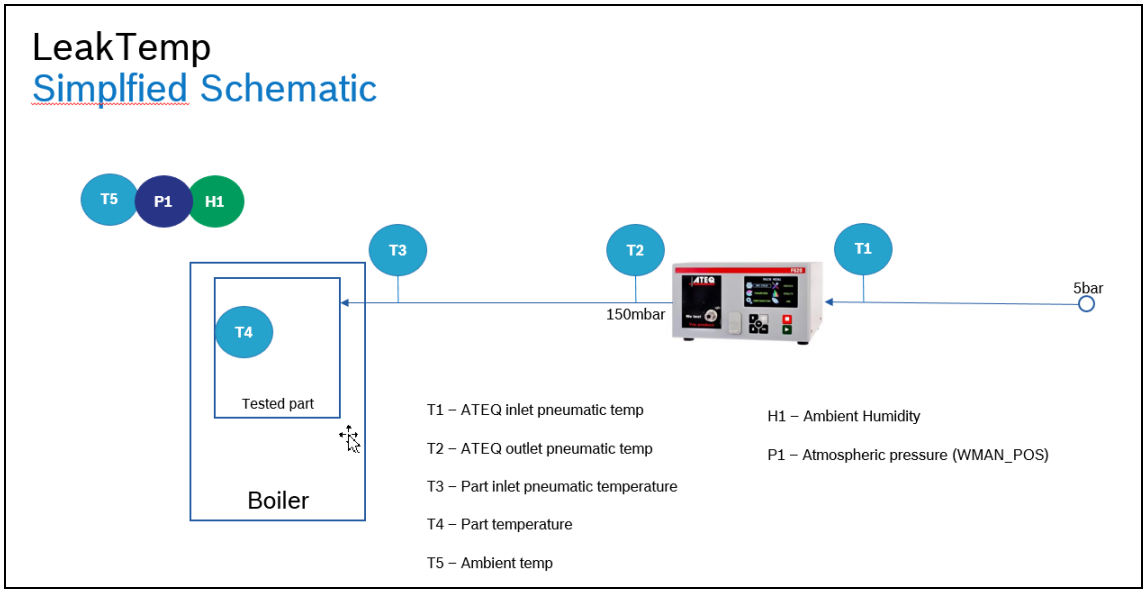

Figure 2 - Sensors and devices installed in U2.

2.3. U3 - PCBA Quality Tests at Bosch BT

As described in the form application, the initial aim of U3 was to improve the reliability of quality control tests made on equipment subject to external vibrations by predicting product rejections and using innovative techniques for root cause analysis. After detailed analysis of the PCBA quality test, it was clear that no vibration data was required to attain the proposed objectives. In this way, no sensors or devices was installed.

2.4. U4 - Predictive Maintenance of Molding Injection Machines at OLI

A survey of available sensors in the molding machines in OLI was made, including firmware. A selection of machines was made for the first prototyping of the system. After this analysis, it was decided that was necessary to measure new parameters, such as ambient temperature and pressure. Moreover, the pressure measurement was not an automated process, because the data displayed by an analogic manometer was not registered. Thus, to automate this process, was decided to use a new device with a vision camera.

Bellow, in Table 2, are presented the specified devices and sensors to measure ambient temperature and humidity, as well as to automate the averaging of the pressure in the molding machine.

The specified devices are microcomputers widely used in IoT (internet of things) applications and have the necessary computational requirements to fulfil the mentioned issues related to the data collection. The camera, is a global shutter and is compatible with the microcomputer jetson nano, enabling to automatically read and register the pressure on the manometers, by applying artificial vision techniques. The sensors enable the measurement of ambient pressure and humidity, near the molding machine's silo, are compatible with the selected low voltage devices.

Table 2 - Sensors and devices for U4.

	Type	Quantity	Technical specification
Development board Raspberry Pi CM4 IO Board	Device	2	WiFi, 4GB RAM, 32GB Flash
Raspberry Pi Compute Module 4	Device	2	WiFi, 4GB RAM, 32GB flash
Microcomputer kit jetson nano	Device	2	WiFi, 4GB RAM, 16GB flash
e-CAM24_CUNX – Color Global shutter Camera for NVIDIA Jetson Xavier NX/NVIDIA Jetson Nano	Camera	2	Global Shutter, Gstreamer-1.0 support for video recording and network streaming
DHT11 Temperature Humidity Sensor	Sensor	5	Temperature range: 0-50 °C ± 2 °C error Humidity: 20-90% RH ± 5% RH error
MAX6675 K-Type Thermocouple Module and Sensor	Sensor	5	Temperature range: 0 °C-1024 °C Resolution: 0.25 °C

This concludes the description of sensors and devices needed for the PPS2's use cases.