MUSSELPRO

Grant agreement number. 863681

D2.9 MUSSELPRO Scale-up

Project Information	
ACRONYM	MUSSELPRO
Title	Demonstration of an IoT 4.0 mussel processing system for an advanced seafood canning industry.
Project coordinator	TEINCO (AUTOMATISMOS TEINCO SL)
GRANT AGREEMENT NUMBER	863681
Call-Topic	EMFF-BlueEconomy-2018
Document Type (R/DEM/DEC/OTHER)	R
Dissemination Level (PU/CO/CI)	PU
Date	20.12.2021

Document History	
Version and date	Changes
Final version 20.12.2021	

Author(s):

- TEINCO: Jose Luis Meniño, David Brunet, Pablo Alfaya, Amado Caride, Carlos Moa, Manuel Nogueira, Jose Luis Gil, Raul Pena,

- JEALSA: Salvador Duran, German Mosquera, Xose Carlos Lopez, Miguel Vidal

Content

Executive summary

The report D2.9 "MUSSELPRO Scale-up" led by TEINCO, belongs to WP2 - MUSSELPRO scale-up to its industrial DEMO unit.

This WP is dedicated to the definition of the specifications for the scale-up of MUSSELPRO and the manufacturing of the DEMO unit (at industrial scale 1:1), including the design of the vacuum cooker and the smart autoclave.

In this report, TEINCO shows the entire process of the scale-up of MUSSELPRO with the hyperspectral equipment, the vacuum cooker and the smart autoclave coupled with the IoT 4.0 system – involving the system manufacturing and integration.

1 INTRODUCTION

The MUSSELPO project is being implemented by the seafood industry experts of TEINCO and JEALSA that have joined forces to meet the needs of the seafood processing industry. TEINCO´s personnel are specialized in the development of innovative equipment for the food processing sector and in the implementation of 4.0 technologies. JEALSA is the second largest seafood cannery in the EU and its personnel are experts in the production and marketing of canned fish and seafood. Personnel of both companies have participated in multiple innovation projects, and thanks to their background and know-how, the MUSSELPRO project is being successfully managed.

In the MUSSELPRO project, we focus on the processing of canned mussels, the main stages of which are cleaning, cooking, can filling, autoclave sterilization and labeling.

Since the cooking and sterilization steps reach a temperature of 140º and 120º, among all the production costs, energy is particularly high. These two steps alone consume ≈70% of the total process energy.

Currently, mussel processing time is standard, not batch-adjusted, and within current cookers and autoclaves it is normal to have uneven heat distribution, creating cold spots. To compensate for cold spots, other spots are overheated, which decreases product quality due to dehydration and nutrient degradation.

Energy consumption in mussel canning lines can be optimized in two ways: by reducing the processing time of the cooker and autoclave, and by minimizing the current uneven heat distribution in both devices.

These are the main weaknesses of mussel canneries (and other seafood industries), and at TEINCO we have a solution: we have developed the MUSSELPRO system, an innovative cooker and autoclave that, through the use of advanced imaging technology and artificial intelligence, are programmed according to the characteristics of the mussel's characteristics. Namely, they:

- are programmed according to the characteristics of each batch of mussels, achieving a 20% reduction in the processing time, and
- avoid cold spots through intelligent algorithms and a temperature optimization and homogenization system.

We added an IoT system with 4.0 sensors that harnesses the power of process data and offers remote monitoring and preventive maintenance, augmented reality and machine learning capabilities.

Now, in the MUSSELPRO project, we have scaled up our system (from the current pilot plants to a 1:1 scale industrial DEMO unit) so that we can perform a full-scale demonstration at JEALSA's cannery, with the aim of reaching full market readiness after project implementation. This report - D2.9 "MUSSELPRO Scale-up" by TEINCO – is a summary of the scaling up process implemented under WP2 - MUSSELPRO scale-up to its industrial DEMO unit.

2 GENERAL BACKGROUND

2.1 Mussel canning production

Mussels canning production takes place along a processing a line with multiple steps. Briefly, these are: (i) mussels washing and cleaning, (ii) mussels cooking in the cooker, (iii) meat removal from the shells, (iv) cans filling with the cooked mussels and the liquid medium (oil, water…), (v) cans sterilisation in the autoclave and (vi) labelling and dispatch.

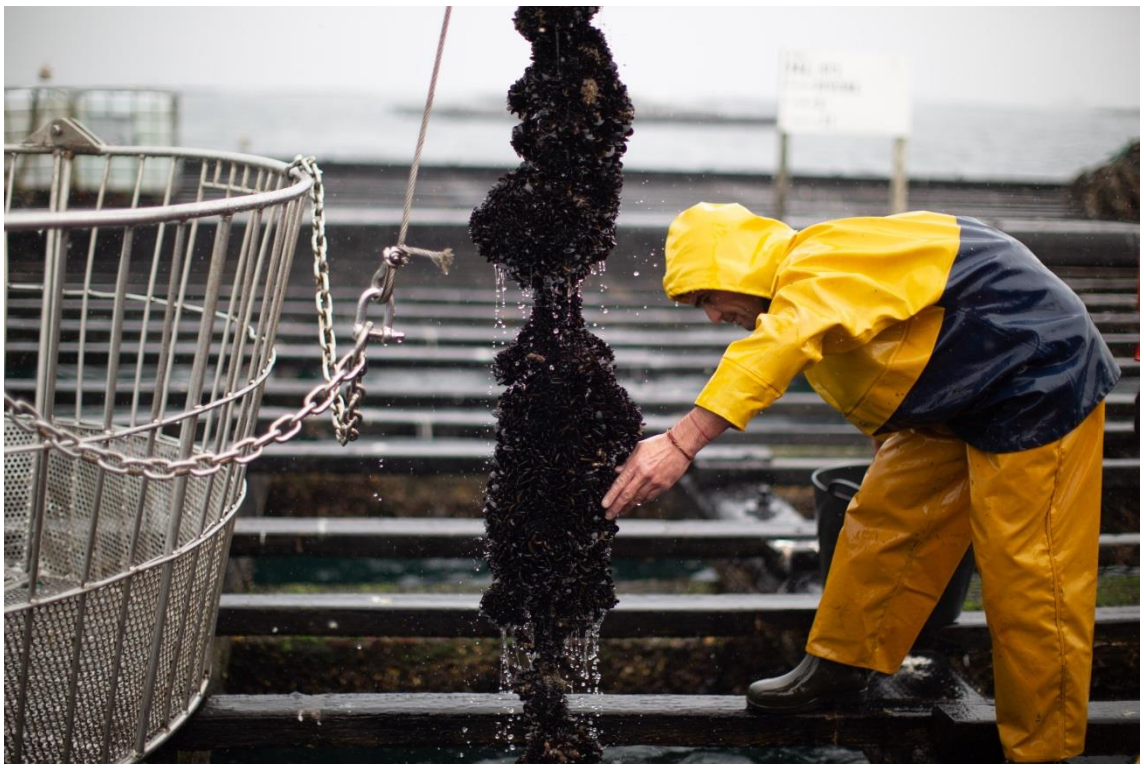

Figure 1 Mussels.

The mussel canning process is characterized by high energy consumption. This is mainly due to the cooking and sterilisation steps. Indeed, these two steps alone consume **more than 70 % of the total energy** used in the sector. High energy consumption cannot be avoided, but it can be optimized. The best approach to do so is by making an efficient use of the energy and by reducing processing times.

However, in the state-of-the-art, **energy is not efficiently used, and processing time lasts more than necessary**. Moreover, product quality is also negatively affected.

2.2 Mussel canning industry needs

Based on the above analyses of the canning industry's weak points, we highlight the following needs of the industry:

- **Reduce energy consumption:** by minimizing processing times and processing inefficiencies in the cooking and sterilization phase, thus improving processing efficiency and profitability,
- **Improve final product quality**: by decreasing the negative impact of processing on the product.

Figure 2 Mussels process plant.

2.3 MUSSELPRO system increases efficiency and product quality

To respond to the needs of the canning industry, MUSSELPRO is going to revolutionize the canned mussel sector by solving its main weaknesses. The MUSSELPRO system is an innovative technology-based solution that optimizes and controls mussel cooking and sterilization conditions, adjusting processing times and temperature levels to the characteristics of each batch of mussels to be processed.

It combines four key enabling technologies (KETs): hyperspectral imaging and computer vision, vacuum processing and augmented reality, a combination not currently applied in the state-of-the-art canning industry.

We have developed an advanced cooker and a smart autoclave. Each of them has:

- A self-developed control system, capable of programming the processing time and temperature according to the characteristics of the raw material. For this purpose, a hyperspectral equipment developed specifically for MUSSELPRO measures the characteristics of the mussel and sends the information to the control system of the cooker and the intelligent autoclave.
- A self-developed system for optimizing temperature and homogenization. Managed automatically by the control system, it avoids the creation of cold spots. Thus, uneven heat distribution and overheating problems are avoided.

In addition, harnessing the power of data, MUSSELPRO integrates an IoT 4.0 platform. It receives and processes data from the vacuum cooker, the smart autoclave and the hyperspectral system; allowing to offer more services: (i) real-time remote monitoring and telemaintenance, (ii) augmented reality visualization and (iii) machine learning capabilities.

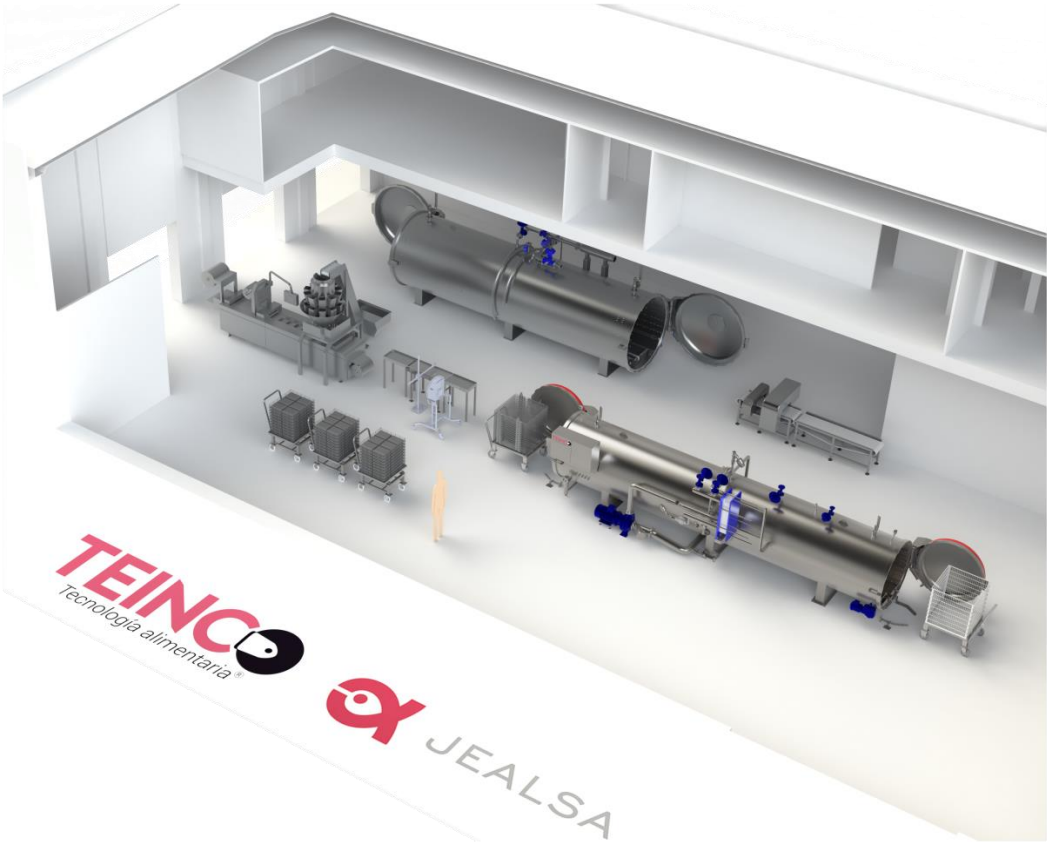

Figure 3 The MUSSELPRO system.

MUSSELPRO is very versatile. On the one hand, the vacuum cooker and the smart autoclave are manufactured on demand according to each customer's needs. On the other hand, these can be installed in existing processing lines or in new processing lines. In addition, if the customer wishes, their existing equipment can be upgraded, implementing the control systems and the temperature and homogenization optimization system. In this way, the customers do not have to buy all the system´s equipment, but only the upgrades that are a key differentiating factor.

Finally, it is possible to connect other equipment of the processing line to the network so that the control systems can have a broader view of each batch and further optimize processing times and temperature.

Below, in Figure 4, we show a schematic representation of the mussel processing line with the MUSSELPRO system implemented (highlighted in orange) and a representation of the hyperspectral system, the vacuum cooker and the smart autoclave:

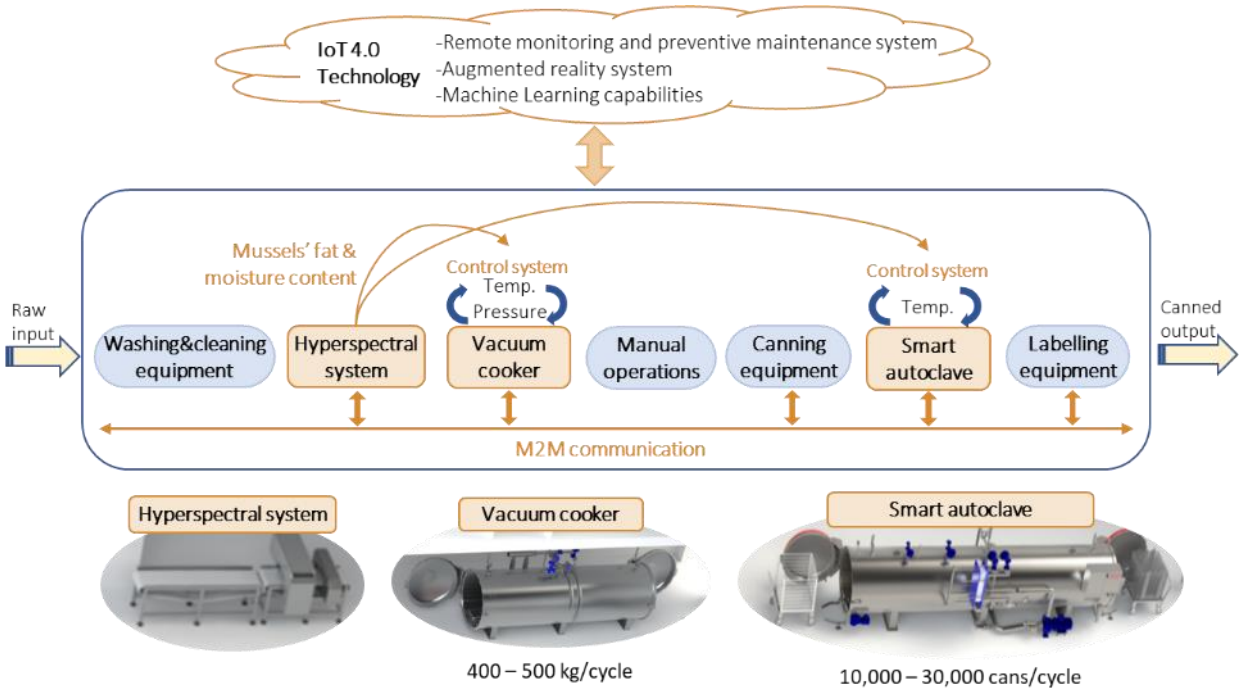

Figure 4 The MUSSELPRO system in the mussel canning process

The MUSSELPRO system allows for full optimisation and control of the parameters of mussel cooking and sterilisation, adjusting the temperature and processing time to the mussels' characteristics of each batch as well as enabling homogenous temperature conditions and better heat transmission to the inside of the processed product.

3 MUSSELPRO Scale-up

3.1 The manufacturing of MUSSELPRO demo unit

The MUSSELPRO system upscaling involved demo unit design and manufacturing, as well as system integration. The upscaling tasks were implemented successfully, resulting in the MUSSELPRO demo unit ready for operation at industrial scale. Below, we present the photos of each of the manufactured components of the demo unit.

- **The vacuum cooker.**

Figure 5 The MUSSELPRO cooker

- **The smart autoclave.**

Figure 6 The MUSSELPRO smart autoclave.

- **The hyperspectral system.**

Figure 7 The MUSSELPRO hyperspectral system

- **The IoT 4.0 system**

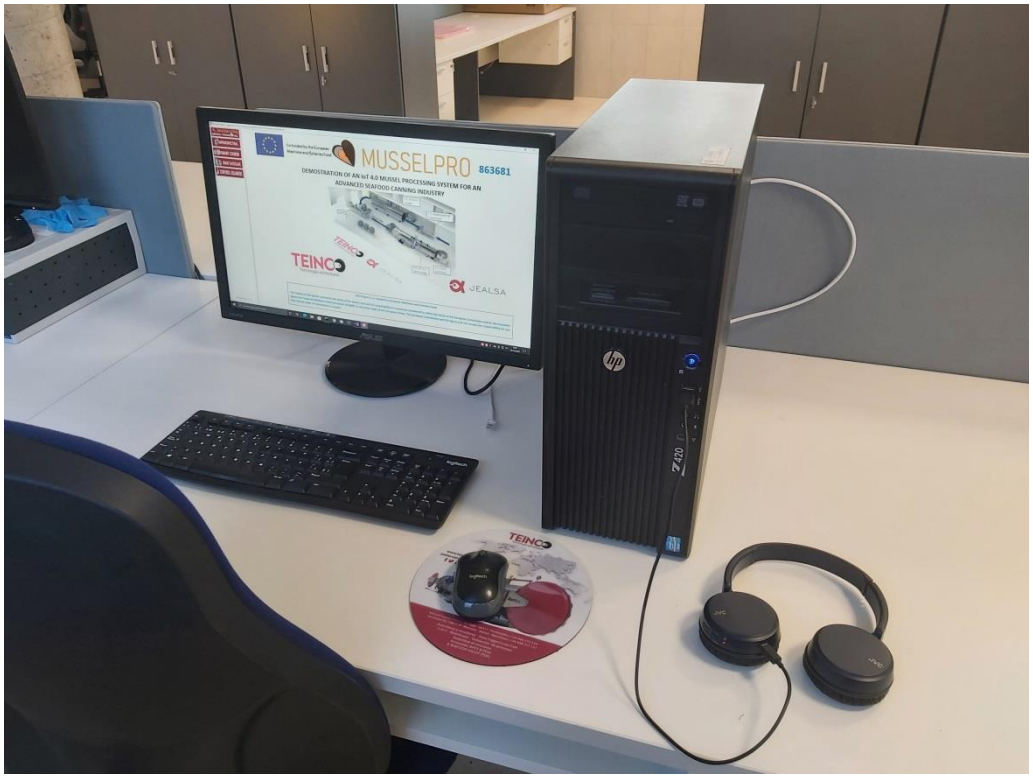

Figure 8 The MUSSELPRO IoT 4.0 system

3.2 The MUSSELPRO system integration

Along with the manufacturing of the mechanical parts of the demo unit and adjustment of the IoT technology, we designed and developed a system that integrates a machine-to-machine network, allowing the interconnection between the system components, as well as its connection with other processing equipment in the canning plant. The schematic representation of the interconnection of the MUSSELPRO components is shown in Figure 9 – presenting the network as well as communication between the network.

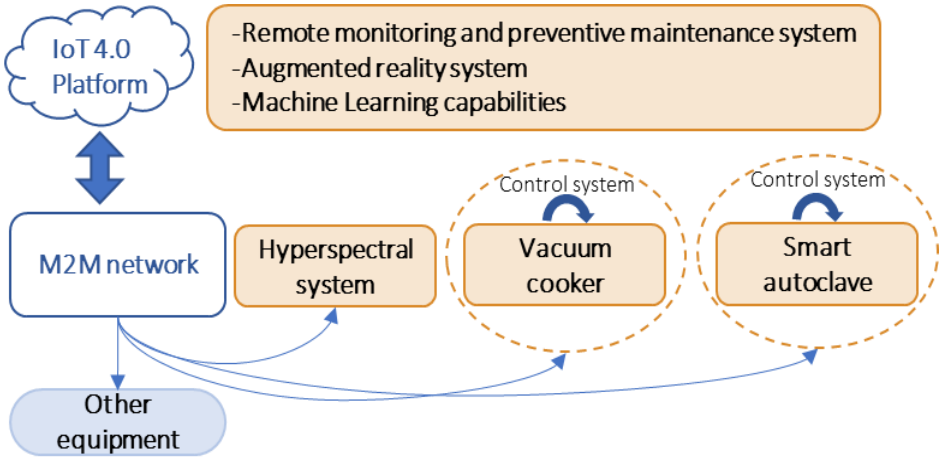

Figure 9 The MUSSELPRO system interconnection

The combination of the four interconnected components and four KETs allows for full optimisation and control of the parameters of mussel cooking and sterilisation, adjusting the temperature and processing time to the raw matter characteristics of each batch as well as allowing for homogenous temperature conditions and better heat transmission to the inside of the processed product. All this thanks to the IoT 4.0 technology software in the cloud which continuously receives and processes data. The IoT 4.0 technology software will also enable remote monitoring in real time, remote maintenance of the equipment anywhere in the world and visualization of the machine through augmented reality. It also enables Machine Learning for better performance of the vacuum cooker and the smart autoclave.

3.3 Main data and system parameters

During IoT technology adjustment and system integration, the following types of data have been selected to be communicated in the network and to the cloud or internal server:

1) Hyperspectral product quality data and analytical data:

- Product data,
- Cooking, sterilisation data time,
- temperatures,
- F0

2) Process data:

- Raw material: origin, type, etc....
- Type of defrosting.

- Cooking times and temperature.
- Tempering times and temperature.
- Autoclave: times, temperatures, pressures, F0, type (phases),

3) Machine data:

- Energy:
- Operations
- Maintenance

3.4 Description of the Architecture

The MUSSELPRO system architecture including the M2M network and the cloud were designed. The control system was designed and implemented using Schneider PLCs and automatons. The MUSSELPRO system architecture has the following characteristics:

1) Cybersecurity

All data transmission and storage are secured with encryption. Data flow is outbound only from the network. It runs on secure cloud industrial service data centers world-wide.

2) Machine specifications

To achieve the objectives at machine level, Real Time Control, Monitoring + Trends, Gateway, Alarms, Secure Remote Access, Improve operation through augmented reality technologies, the following are implemented in the system architecture:

3) IoT Platform specifications

The solution will allow us to track machine operations (timeseries database), calculate performance and monitor alerts. The Original Equipment Manufacturer (OEM) visualises its entire installed fleet of machines and each end customer has access to its machines.

4) Maintenance Strategy

The maintenance system developed in MUSSELPRO will not be a corrective maintenance but will follow the strategy of implementing preventive and predictive maintenance. This is to optimise the process and to avoid process stops.

4 CONCLUSIONS

This document compiles the results of the scaling of the MUSSELPRO System (in WP2). All activities were successfully completed (design, manufacturing and integration), resulting in a MUSSELPRO demo unit ready for demonstration. Along the demonstration, the demo unit will be modified and improved as we test the system in industrial conditions. Therefore, the structure described in this document may change in the coming months to optimize it as much as possible and adapt it correctly to the needs of a production plant.