Valka

Valka Cutter for Clipfish

Public Report

The development of technology for the automatic cutting of split clipfish

Project number: FHF-901537

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1. Summary

Series of tests were performed when processing clipfish with the Valka Cutter. Processing fish with the Valka Cutter does not only include cutting the fish, as the name implies, but also estimate the weight of the fish and location of bones. The Valka Cutter has been very successful in processing whitefish and salmon but, however, the Valka Cutter had not been used for clipfish before. Therefore, each of the three procedures (cutting, weight estimating and locating bones) were tested and developed individually.

2. Introduction

The fish industry is realizing the benefits from taking further steps towards improved technological developments, especially in terms of increased automation and higher yield. The clipfish and saltfish industry has seen the rapid technological improvements in the white fish industry as possibilities towards increased capabilities, in terms of improved yield, more flexible product and higher return.

Valka is specialized in production of automated equipment and software for the fish industry that increase the quality and value of fish products. Among other products, Valka has developed the Valka Cutter, a water jet cutting machine that cuts bones from fillets based on x-ray vision. In addition, a vision system is used for weight estimation, to cut the fillets into predefined portions. Valka was the first company to develop a commercially feasible cutting machine that can cut pin bones automatically from fish fillets. Furthermore, Valka has delivered such a cutting machine for ships where that development was funded by FHF.

Initially the project was set up to deliver a prototype of a cutting machine that would be able to process clipfish. Early in the project it was realized that this objective would be difficult to achieve and therefore, the objective was simplified. Instead, the focus was on realizing the requirements for a cutting machine capable of cutting clipfish. The results would be highly beneficial for the next phase of the project.

In this project the first step towards a fully capable cutting machine for clipfish is taken. The three main problems to be solved are

- Show that the water jet can cut through the spine and other bones of a clipfish
- Cut specified patterns with specified throughput of 15 fish/min
- Redesign the weight estimation vision system and potentially use a combination of x-ray technology and 3D scanning to maximize the accuracy

3. Objectives

- Project's outcome
    - Maximizing yield of the raw material with cutting into weight estimated portions – flexibility in cutting patterns
    - Possibility to add more automation to the rest of the processing line
    - Stability in portions – improved quality
    - High throughput
    - Reduced labor cost
- Objective
    - To develop a vision system for weight estimation.
    - To make a proof of concept with existing cutting machine.
    - To establish the requirements for a cutting machine capable of cutting clipfish

To meet the objectives, an improved vision system and X-ray had to be developed for the Valka Cutter, for better weight estimation and bone detection, respectively. The bone detection became more challenging compared to white fish due to the salt on the clipfish surface. Furthermore, the water jet cutter was analyzed and tested on clipfish, which is thicker and has more challenging bones compared to the fish currently processed with the Valka Cutter.

4. Project execution

The test phase of the project was divided into four different parts. The first part was to test the performance of the water cutting when used on a clipfish. The second and third parts were to analyze the performance of the weight estimation and the bone detection systems, respectively and the fourth part was to estimate the price range of the final product.

Automated water jet cutting

The first steps towards manufacturing a cutting machine capable of cutting through clipfish was to verify that the water jet could cut through the thicker fish and stronger bones, especially the spine of the fish. In the first step the current Valka Cutter design was used. The information from the first step gave input for later tests, with different specifications capable of cutting through clipfish with high confidence.

Expected throughput

The expected throughput is presented in Table 1. There are two cutting speeds for each configuration, lower speed to cut through the spine of the fish and higher speed to increase the throughput. The higher cutting speed is defined by the water pressure. The difference between the 5-robot configuration with the 300hp and the 200hp pumps lies in the higher cutting speed, where the 300hp configuration is capable of 166% higher cutting speed. To ensure as large throughput as possible a varying cutting speed is used.

Table 1: Expected throughput dependent on lower robot speed and number of robots.

	High robot speed	Medium robot speed	Low robot speed
5x robot + high pressure	16 fish/min	14 fish/min	11 fish/min
5x robot + medium pressure	12 fish/min	10 fish/min	9 fish/min
3x robot + low pressure	8 fish/min	6 fish/min	5 fish/min

Weight estimation

One of the objectives in the project was to develop a weight estimation system for clipfish. This system has been successful in estimating the weight of whitefish such as fresh cod with high accuracy.

An improved vision system was developed and integrated into Valka Cutter's software. During the development it was identified that the X-ray technology was more suitable for clipfish, rather than 3-D imaging. The improved weight estimation system was tested on clipfish samples. The samples were divided into four portions where an example of the portioning is presented in Figure 1 (the cutting line is represented with a vertical white line. Excluding the tail, 95% of the portions were within 6% of the target weight. This means that for a **150gr** portion the uncertainty is $\pm$**9gr**. The estimated weight of the tail deviates more from the scale weight compared to the other portions. This is caused by the difficulties estimating the density of the tail, as the tail has the most inhomogeneous material.

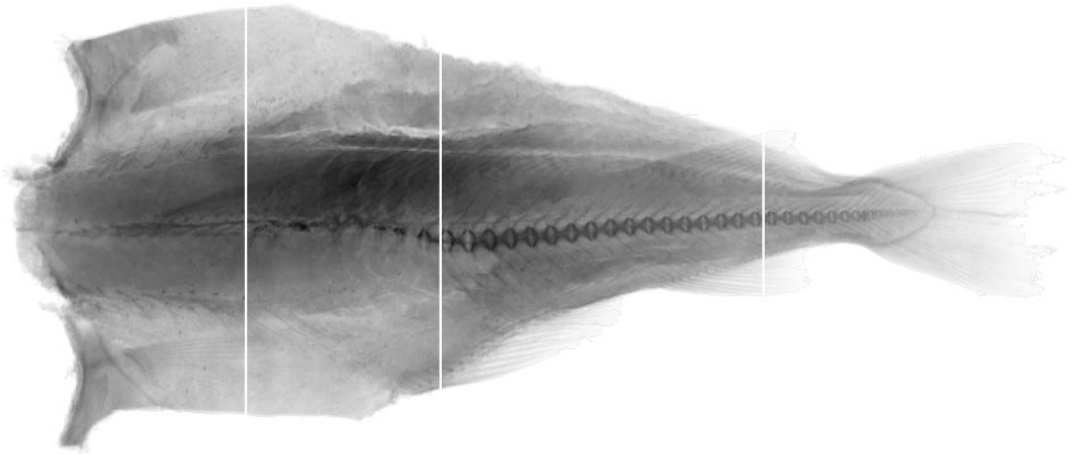
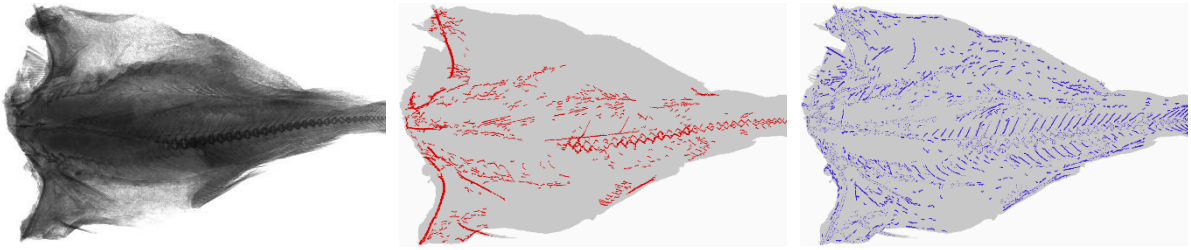


Figure 1: Cutting patter for verification of portion weight accuracy.

High resolution bone detection

In addition to the weight estimation, the X-ray system is capable of detect and locate bones. Figure 2 shows an example of the raw X-ray data (Figure a)) and two threshold levels for the bone detection (Figures b) and c)). From this data the spine and other bones can be located, resulting in variable cutting speed, increasing the throughput of the machine with high consistency of through cuts.



a) Raw X-ray figure of a fillet.

b) Bone vizibility with a certain threshold, different from c).

c) Bone vizibility with a certain threshold, different from b).

Figure 2: X-ray analysis of a clipfish sample.

Estimated price range of final product

Price range and payback period was presented to industry partners. Price information is available upon request from Valka.

5. Findings discussion and conclusion

Series of tests were performed when processing clipfish with the Valka Cutter. Processing fish with the Valka Cutter does not only include cutting the fish, as the name implies, but also estimate the weight of the fish and locate bones. Therefore, since the Valka cutter had not been used for clipfish before, each of the three procedures were tested and developed individually.

To cut through the clipfish, which is thicker and has very challenging bones, the design of the Valka Cutter had to be modified. Initially, different pressures, nozzle diameters and cutting speeds were tested and optimized. The cutting speed was optimized to achieve more consistent through-cut. During the test-phase several different cutting speeds were tested, down to 11 fish/min. The tests showed that the toughest part to cut through was the spinal column. In a test where an industrial cutting pattern was used, with a throughput of maximum 16 fish/min, a successful through-cut was achieved for 85% of the cuts. However, it is estimated that lowering the throughput to 14 fish/min,

should result in complete separation, increasing the successful through-cut from 85% to 100%. Varying cutting speed can be used to maintain as high throughput as possible but maintain a consistent through-cut. The cutting speed is reduced close to thick bones and the spine, where the bones are located with the high-resolution bone detection system in the Valka Cutter. In addition to cutting the fish, the Valka Cutter uses 3D and X-ray cameras to estimate the weight of the fish. The weight estimation system has been quite successful in weighing white fish and by adjusting the system of clipfish, 95% of the samples were within 6% of the target weight.

The combination of the cutting and the weight estimation results in highly flexible production line. The automated production line (Figure 3) presents increased possibilities, where the fish can be cut into different portions, increasing the flexibility of the final product. The high flexibility offers the possibilities to meet different requirements, expanding the markets for the product.

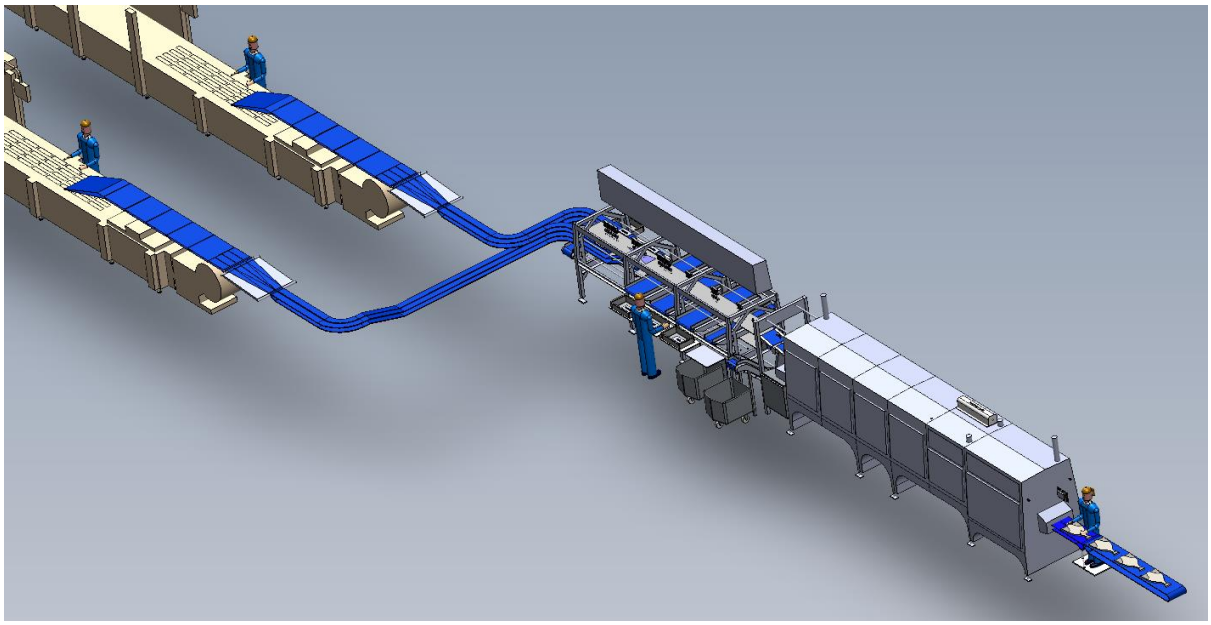


Figure 3: An automated production line, including the Valka Cutter, a grader and packaging.

5.1. Summary of findings:

Detailed overview of results achieved:

- Increase consistency in cutting through the fish is the **proof of concept,**
- **High throughput** where fish per min ranges from 5-16,
- **Stability** in portions which improves **consistency** and potential for different markets,
- Portion weight estimation where **95%** of the portions were **within 6% of target weight,**
- Has the possibility of meeting **cutting patterns** defined by different **market requirements** (portions/price),
- The water jet cutter is highly flexible where there are **endless possibilities,**
- **Reduced labor cost,**
- **Reduced waste** compared to using conventional methods with saws,
- **By eliminating manual saws** in the process, **the risk of cutting incidents** should be **eliminated.**

5.2. Future work

In this project the focus was on demonstrating the “proof of concept” in terms of separated cutting, weighing and locating bones in clipfish, all essential features to process clipfish with the Valka Cutter. To take the project further, a prototype of a dedicated cutting machine should be built to evaluate the

performance, combining the key features defining the Valka Cutter. With a working prototype, various cutting patterns can be explored and tested. The variety in possible cutting patterns is one of the strengths of the Valka Cutter and increases the flexibility of the final product, opening doors for new marketing possibilities. Additionally, with the introduction of the Valka Cutter, the processing line can be made more automated where for example portion graders can be added. As a return, the increased automation of the processing line reduces labor cost.

Another aspect of the results is a better definition on the capabilities of the Valka Cutter, as its application has been pushed to the limits and, in the end, the limits were extended in terms of cutting thicker fish and bones with new technology. The extended limits increase the number of possible products that can be processed with the Valka Cutter.

5.2.1. Summary of future work

- Build a dedicated cutting machine,
- More flexible cutting patterns,
- Increased marketing possibilities,
- Possibility to add more automation to the rest of the processing line.

6. Main findings (English and Norwegian)

- Cutting through the thick spine was accomplished.
- Industrial cutting pattern was successfully tested.
- A throughput of 16 fish/min was achieved.
- The vision weight estimation system was improved to handle clipfish where 95% of portions were within 6% of target weight.
- High resolution bone detection – Enables various cutting speed for higher throughput.

7. Deliverables

A detailed overview of all deliverables in the project.

L1: Meeting minutes: Review of specifications

L2: Meeting minutes: Evaluation process with presentation

L3: Meeting minutes: Demonstration of cutting split clipfish at Valka AS

L4: Budget and plan for next phase

L5: Final report according to FHF's guidelines: Proof of concept and demonstration

L6: Administrative report according to FHF's guidelines

L7: Note: Estimated price range of final product

L8: Presentation at clipfish seminar

- The project was delayed and therefore limited results were available when the clipfish seminar took place.