Promising design of a cutting machine for the Azov-Black Sea anchovy

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Abstract. The paper presents the design of a machine for cutting small fish using a water-air jet as a working tool. The primary technological operations in cutting the fish are removing the head and viscera as well as cleaning the abdominal cavity of the fish from the blood kidney and the black film. These operations are complex and time-consuming, due to the wide variety of volumes, lengths and shapes of the abdominal cavities, as well as the difference in the consistency of body tissues. At the same time, the abdominal cavities of fish of various species have standard features, which make it possible to use the same techniques when processing them. It is of particular difficulty in performing such operations to remove the guts of the Azov-Black Sea anchovy. An important element in the small fish cutting mechanization is the centring of the head of the fish cut with a nozzle, as well as fixing the body of the fish in the cartridge in a certain position. This design of the machine allows realizing the process of cutting the Azov-Black Sea anchovy with the complete removal of the guts.

1. Introduction
Gutting is one of the problematic operations when cutting small fish. When cutting the Azov-Black Sea anchovy, it is necessary to remove the head and ensure that the abdomen is completely cleaned of the viscera, the remains of which can give a bitter taste to the finished product, it is also necessary to preserve the integrity of the trunk. Designs of fish-cutting machines for other types of small fish, for example, sprat, Peruvian anchovy and others are known. The use of existing fish processing machines for the treatment of anchovy is not effective since the viscera of the fish are partially removed. Machines for cutting small fish are designed for one type of fish, while the design takes into account the features of the morphometric and physic-technical characteristics of the raw fish as a feedstock. Anchovy is characterized by a coefficient of ovality of about 1.0 and a significant effort (up to 0.04 N) to detach the guts in the anus area. The main difficulty in cutting anchovy is to remove the viscera of the fish. A new method for cutting anchovy, the effectiveness of which has been proven on the developed test-bed [1-3], was proposed at the Federal State Budgetary Educational Institution of Higher Education "Kerch State Maritime Technological University" at the Department of Food Processing Machines and Apparatuses. When designing a new fish-cutting machine for processing the Azov-Black Sea anchovy, it is advisable to use well-known reliable designs of individual machine nodes, as well as to consider the possibility of combining machine operations in the equipment being developed.
2. The purpose of the study
The objective of the research is to determine the most rational technical solutions that can be recommended for use in the design of a fish-cutting machine for processing the Azov-Black Sea anchovy.

3. The object of the study
The object of the research was the methods of evisceration and processing equipment for cutting small fish.

4. Materials and methods
Methods of morphological analysis and synthesis of technical systems were used in the research.

5. Discussion of the results
The process of removing the viscera of the decapitated fish is based on the process of removing the guts of a decapitated fish by a pulsed water-air stream supplied into the abdominal cavity from the side of the head. The viscera are removed from the fish through a gap in the anus. When developing the design of a fish-cutting machine, consideration should be given to solving the following problems [5]:
- dosed fish supply;
- orientation of fish head first;
- separation of fish in a stream;
- single-piece supply of fish to the working tools of the machine;
- head removal;
- removal of viscera. Depending on the design of the fish supply to the working tools, fish-cutting machines are divided into rotary and linear type machines. The authors conducted a critical review of the technical solutions of the elements for mechanizing the cutting of small fish, as applied to the processing of the Azov-Black Sea anchovy.

The use of a rotary fish-cutting machine is advisable if the main criterion is the compactness of the machine; in other cases, the processing equipment may be of a linear type. Both types of layouts have no significant performance advantages. The efficiency of the fish-cutting machine depends on the devices for pre-sorting fish into size fractions, loading fish into the machine, orienting the fish relative to the working tools and its single-piece feed. The following technical solutions are proposed for mechanizing the cutting of the Azov-Black Sea anchovy:
- The operation of preliminary sorting of fish into size fractions must be performed on an inclined tray with longitudinal slits of variable cross-section;
- Fish should not be fed into the machine in bulk but specific doses. This process allows normalizing the load on subsequent technological operations. For dosing fish, it is advisable to use a bucket elevator of a design similar to that in the MKMP fish-cutting machine;
- The orientation of the anchovy head first should be carried out on an inclined tray with longitudinal streams. For increasing the efficiency of sorting and orientation operations, the trays must be informed of transverse and longitudinal vibrations;
- Piece-by-piece loading of fish into the cartridges of a rotary-type fish cutting machine using a drum with needles of a design similar to that in the MKRM fish-cutting machine;
- Head removal operation to perform with a circular knife;
- to fix the fish in the cartridge when removing the entrails, a rubberized roller of a design similar to that used in a machine of the brand N10-IRR is used;
- Removal of the viscera with a pulsed water-air stream directed into the abdominal cavity from the side of the head section of the trunk;
- It is necessary to give a certain position when removing the viscera of the fish trunk, in which rational conditions are created for the interaction of the air-water jet on the inside.

A schematic diagram of the design of the fish-cutting unit of a rotary-type machine for processing the Azov-Black Sea anchovy is given in Figure 1. The operations of sorting, feeding fish into the machine, headfirst orientation are not shown for clarity, technical solutions of the relevant units are known [5].

Fish is supplied into the machine along the channels 1 to the spring stop 2 and is lined up. Then the drum 3 with needles 4 feeds a row of fish into the cartridges 5. When the operating drum 6 rotates,
fish is fixed in the cartridge with straps 7. Next, the fish cartridge fits under the circular knife 8, which removes the head. When the drum moves, the fish cartridges pass in front of the nozzles of the air-water collector 11, the pulsed water-air jet enters the abdominal cavity of the fish, which leads to the removal of the viscera.

With further rotation of the drum, the clamps disengage from the cartridges. A cut piece of a trunk without viscera is taken out of the machine along the inclined tray. For fix the fish in the cartridge, belts are used, worn on pulleys 9 and 10. The pulleys are mounted on the axles and are driven directly from the operating drum due to the plates on the belt that meshes with the drum cartridges. With an effective drum diameter of 380 mm, theoretical productivity can be 200 fish/min.

It was experimentally established that when cutting the Azov-Black Sea anchovy using a pulsed water-air jet, it is possible to remove the viscera freely, and mechanical damage to the muscular tissue of the fish trunk is observed (Figure 2).

![Figure 1. Design scheme of rotary fish cutting machine: 1– gutter; 2 – spring thrust; 3, a drum; 4 – needles; 5 – cartridge; 6 – operational drum; 7 – belts; 8 – a knife; 9 – air-water collector.](image1)

It has been established that an important element in the mechanization of cutting anchovy is the centring of the head cut off the fish with the nozzle, and the fixation of the body of the fish in the

![Figure 2. Photographic image of defects with the poor-quality cutting of small fish](image2)
cartridge in a certain position. In experimental studies, following mechanical methods of fixing fish were considered, i.e. rectangular and wedge-shaped clamps (Figure 3).

![Image](image1.jpg)

**Figure 3.** View of the position of the clip in the cartridge

For increase, the reliability of fixing fish in a cartridge, the use of vacuum is proposed. A feature of the design of the cartridges is the presence on the side surface of two grooves-windows located horizontally: the first window is for pressing the front of the trunk, the second window is for fixing the fish body in the cartridge in a specific position (Figure 4).

![Image](image2.jpg)

**Figure 4.** Cartridge layout

The vacuum is created in the cavity between the walls of adjacent cartridges using a vacuum system that includes a vacuum pump, an electric motor, a receiver, a vacuum manifold, and electromagnetic valves. Solenoid valves control the duration of the vacuum in the cartridge; at the same time, the fish are loaded into the cartridges. At a specific section of the operational drum, a pulsed water-air jet removes the viscera. When the operational drum moves, the fish head is removed with a circular knife. The viscera are removed by a pulsed water-air stream simultaneously in 20-30 fish. The fish is fixed in the cartridge using a wedge-shaped clamp and vacuum through a vacuum system.
6. Conclusion

The most rational technical solutions are proposed. They can be recommended for use in the design of a fish-cutting machine for processing the Azov-Black Sea anchovy. In the design of a fish-cutting machine, it is important to ensure the removal of the viscera with a pulsed water-air jet at a certain position of the cartridge trunk. The use of vacuum ensures centring of the head cut off the fish with the nozzle and the fixation of the anchovy trunk.

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