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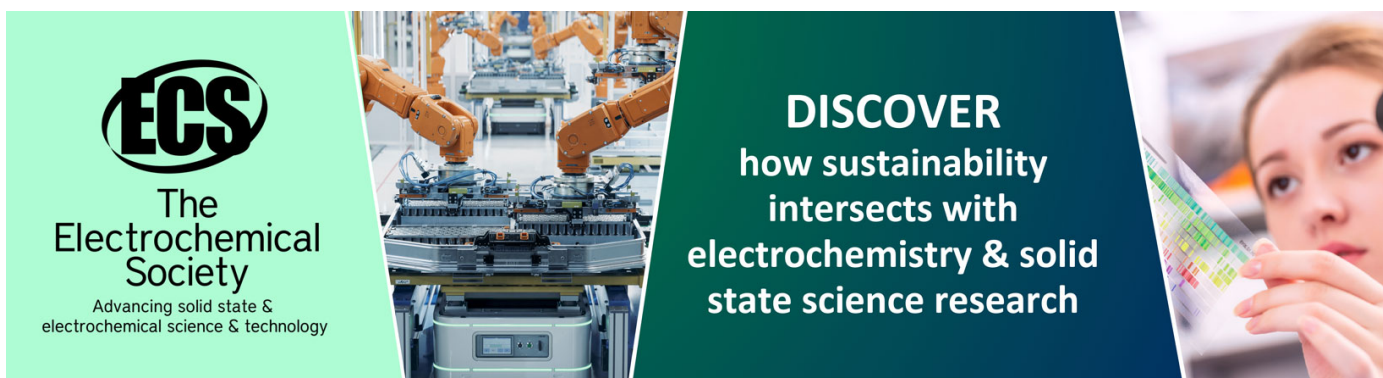
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Design and Performance Evaluation of Semi-Automatic Fish Cutting Machine for Industry

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Abstract. A half-cutting fish cutting machine was designed, fabricated and evaluated for performance. The major components of the machine were made up of three main parts: mainframe (case), conveyor/rotator and cutter component. The conveyor and disc cutter are powered by a single phase, 1400rpm and 1hp electric motor. Analysis on size (length, width, depth) of fish, size of disc cutter and gap of roller at the cutter component had been made. The performance of the machine was evaluated using 5 types of major fish that used for salted fish industry. The results showed that this machine can produced 5 times more productivities compared to existing (manual) method. From the analysis data, the machine can produce an average of 21 fish/minute, so the average time to half-cutting 1000 fishes is 47 minutes. More energy saving and less labor needed for fish cutting process. Also, 81.2% significant time saving were obtained from this machine. This new innovation is an alternative choice to existing heavy-duty machines in the market with more expensive cost.

1. Introduction

The fishery sector has been playing an important role as a major source of animal protein in Malaysia for decades. In 2017, total fishery production of the country amounted to 1.7 million tonnes, including close to 1.5 million tonnes from capture and 0.2 million tonnes from aquaculture (excluding seaweeds) [1]. The total number of fishers in 2017 was estimated to be about 132305 with an additional 21156 people was engaged in aquaculture full-time.

The production of traditional fish products is an important means of preserving fish in these countries. Traditional fish products include products that are boiled, dried, salted/cured, smoked, marinated, fermented, minced/comminuted, and powdered [2]. Fish processing such as the making of shrimp paste (belacan), pickled shrimp (cencaluk), salted fish, dried cuttlefish, jelly fish, fish sauce, fermented fish (budu), fish crackers, fish balls and fish cake, has traditionally been family operations in fishing villages. However, there has been an increasing trend towards commercial operations lately, with industrial scale set-ups [3-4].

The production of salted fish products is usually synonymous with the fishing community. In Malaysia there are many types of fish used to produce salted fish including sepi, Gelama, Cencaru, Pari, yellow Selar, Pebbles, Talang and many more. Usually the process of cutting and cleaning fish is using traditional methods. The process of cutting and cleaning are using a knife and involve more workers. However, with modern technology these processes can be made faster by using specialized



machines. The product is dependent on the demand and the machine is designed to produce the product according to the current demand.

1.1 Review of Existing Cutting Machines

Most studies on cutting machines are focused only on the removal of the head and tail especially sardine products [6-8]. In addition, there are also machines that separate the contents of the fish only [10], cut the bottom of the fish's stomach [11] and separate the contents of the fish. At present there are no machines that can control the clearance rate behind the fish. Therefore, the development of this machine is expected to assist in the production of 'butterfly-cut' fish (figure 1) for the purpose of producing salted fish products. In addition, the production of these machines further diversified the fish processing technology and helped local entrepreneurs own far less expensive machines than foreign machine products.



Figure 1. Butterfly-Cut Fish

Salted fish processing has been a traditional way of preserving fish, but it is not commercially available. Salt fish is only processed from surplus fish for sale or low quality fish. Some of the most commonly used types of fish are salmon, cauliflower, thorns, tin and stingray. Fish are removed from the scales, stomachs and cut from the top and opened in a 'butterfly-cut' shape. Ready-to-cut fish are cleaned from blood and fat stains. For local entrepreneurs the work of clearing and removal of fish stomachs is usually done manually. Therefore, the cleaning work requires a lot of workers at one time. In addition, the blade point used must always be sharp and the workers need specialized skills to ensure even quality cleavage. When there is a high demand the rest of the work needs to be accommodated and require a lot of workers. In addition, the fish frying work is also difficult because the fish are generally soft in nature which if not used correctly it can damage the fish structure. Therefore, in order to facilitate and ensure the quality of fish clearance a fish clearing machine is proposed to facilitate and expedite the fishery clearing process.

2. Materials and Methods

Detailed design is the process developing the design so that it is dimensionally correct and co-ordinated, describing all the main components of the building and how they fit together [13-17]. The parts of the semi-automatic fish splitting machine are made up of three main parts: frame (case), conveyor / rotator component and cutter component. The main part of the mover is the component that moves the fish using the conveyor belt to the cutter until it is released. It involves gearbox, pulley and V-belt systems. The machine (figure 2) consists of frame on which are mounted a chain conveyor, driving system which connects with all units over the machine. The conveyor will be powered by an induction motor (1hp, 1400 rpm). Almost all of the materials used in the machine are stainless steel type. The fish will be cut on the dorsal side using a disc blade with diameter 10 inch (figure 3).



Figure 2. Semi-Automatic Fish Cutting Machine

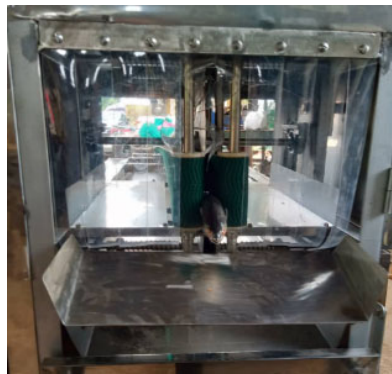


Figure 3. Disc Cutter

There are 4 sets of rollers used on the left and right sides. Two rollers are placed before the disc cutter to guide the fish to the disc cutter while the other two rollers are placed on the front of the disc cutter which serves to guide the fish out after completing the clearing process (figure 4).



Figure 4. Fish position before entering Teflon roller

Machine performance is highly dependent on the physical, mechanical and other properties such as diameter, length, width, disc cutter/ blade size to cut, the gap of roller and the speed of conveyor. Machine testing has been performed several times using several different fish samples. In addition, to

see the change in the quality of the spacing between the rollers varied at different distances. Several samples of different species of fish have been used in experiments.

3. Results and Discussions

Table 1 shows the result of test run for 40 samples from 5 types of fish that commonly used in salted fish industry. The length, height and thickness of fish are taken into consideration as they affect productivity [16-18]. From the result, the thickness factor affects the cutting of a butterfly-cut. The cutter blade cannot make a smooth cutting of the butterfly-cut for a fish with thickness less than 19mm (fish thickness <19mm). To measure the productivity, machine performances are considered.

Table 1. Result of physical properties of 40 samples (5 types of fishes)

Parameter	Min	Max	Mean	Std
Gelama				
Length (mm)	210	240	225	10.247
Height (mm)	65	70	68.5	3.202
Thickness (mm)	22	27	25	1.949
Cencaru				
Length (mm)	300	330	314	10.198
Height (mm)	65	75	71	3.742
Thickness (mm)	33	36	34.9	0.943
Selar				
Length (mm)	220	250	233.3	9.428
Height (mm)	65	75	69.2	3.436
Thickness (mm)	30	32	31.2	0.898
Duri				
Length (mm)	260	270	267.5	4.330
Height (mm)	65	75	70	3.536
Thickness (mm)	22	25	23.6	0.992
Tenggiri				
Length (mm)	290	370	340	32.660
Height (mm)	80	110	98.3	10.672
Thickness (mm)	26	45	39.2	7.426

From the data sheet, it is known that the gearbox ratio of the motor is 20: 1 and this gearbox works to reduce the motor's rotation speed to 70 rpm. The pulley diameter of the roller to move the conveyor belt is 8cm.

Formula;

$$Hp = \frac{N \times T}{5252} \quad (1)$$

$$\text{Then } T = \frac{1 \times 5252}{1500} = 3.5 \text{ Nm} \quad (2)$$

Whereas:

T = Torque (Nm)

N = Rotation per minute (rpm)

$$\begin{aligned}
 V &= rpm \frac{(R)}{60} \\
 &= 187 \frac{(4)}{60} \\
 &= 12.5 \text{ cm/s.}
 \end{aligned}
 \tag{3}$$

Whereas: V = Velocity
 R = Radius

The cutter consists of disc cutter, induction motor, roller and clamp. It is known that the motor rotation speed is 1400 rpm with the pulley diameter mounted on the motor measuring 8 cm. The motor rotation will be connected using the V-belt to the clutch roller and disc cutter. The disc cutter size is 10 ". The motor pulley diameter used is 8 cm while the pulley roller clutch diameter is 8 cm and the pulley on the disc cutter is 20 cm, so the roller rotation for the disc cutter is: $1400 (4/10) = 560$ rpm. If both pulley sizes are the same, then the rotation speed is constant. The roller pulley measures 4 cm, then the roller speed on the clamp is formulated,

$$\begin{aligned}
 V &= rpm \frac{(R)}{60} \\
 &= 1400 \frac{(4)}{60} \\
 &= 93.3 \text{ cm/s.}
 \end{aligned}
 \tag{4}$$

From the theoretical analysis, it is found that the rotational speed of the motor moving the conveyor belt is 12.5 cm / s which is equivalent to 750 cm per minute. While the rotational speed of the motor that rollers on the clamp is 93.3 cm / s, which equals 5598 cm per minute.

Theoretically, from the data obtained, it is found that the speed of rotation of the motor moving the conveyor belt is 12.5 cm / s which is equivalent to 750 per minute. While the rotational speed of the motor that rollers on the clamp is 93.3 cm/s, which equals 5598 cm per minute. From practical analysis data, the length of conveyor belt used in this machine to fish is 120 cm.

$$\text{Total fish cut per minute} = \frac{V \text{ putaran roller conveyor belt}}{L \text{ conveyor belt (letak ikan)}} \times \text{fish on conveyor} \tag{5}$$

For young fish, trout and fish of the size of 22 cm ~ 26 cm, 4 fish can be placed on the conveyor in 1 rotation. Therefore,

$$\begin{aligned}
 \text{Total fish cut per minute} &= \frac{750 \text{ cm}}{120 \text{ cm}} \times 4 \\
 &= 25 \text{ fishes/minute}
 \end{aligned}$$

Whereas for snails, sharks and fish of any size in the 30 cm ~ 36 cm link, 3 fish can be placed on the conveyor in 1 rotation. Therefore,

$$\begin{aligned}
 \text{Total fish cut per minute} &= \frac{750 \text{ cm}}{120 \text{ cm}} \times 3 \\
 &= 18 \text{ fishes/minute}
 \end{aligned}$$

Table 2. Performance evaluation of semi-automatic fish cutting machine.

Cutting Method	Machine	Traditional Hand Tool
Average cutting fish/minute (pcs)	21	4
Average cutting time for 1000pcs (minutes)	47	250
Average efficiency (%)	84	16

The final performance evaluation of fish cutting machine was carried out and presented in Table 2. The results revealed that the average fish production using machine is 21 fishes/minute, compared to traditional hand tool is only 4pcs/minute. Significant differences between machine use and manual methods used in salt/dry fish processing areas are increasing more than 5 times productivity. For the 1000 fish to be cut, the time required for the manual method is 250 minutes (4 fish / minute). External factors such as individuals splitting their fish or resting are ignored. While from the analysis data, the machine can produce an average of 21 fish / minute, so the average time to split 1000 fish is 47 minutes. Significant time savings of this machine compared to manual method is 81.2%.

From the analysis, the type and size of fish from the length and height angles did not affect the cutting. But the thickness will affect the rest of the fish whether or not they can be properly cut out. Pin cutter position and disc cutter height should be adjusted if smaller fish thickness size is used. In practical analysis, it is found that the number of fish that can be cut also depends on the size of the fish and the external labor factor of placing the fish on the conveyor belt. However, the project of the machine that has been produced has been standardized based on studies on several salt fisherman sites. This machine differs from the heavy duty factory output at a much lower cost. This machine is also more cost-effective for small-market markets.

4. Conclusion

The semi-automatic fish splitting machine has been successfully developed to help the fishery company to boost productivity. Good and neat butterfly-cut finishes have been achieved from the development of this machine. More energy saving and less labor needed for fish cutting process. This new innovation is an alternative choice to existing heavy-duty machines in the market with more expensive cost.

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