# Anchovy Processing Machine with Specially Designed Sorting Mechanism

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## ABSTRACT

*Anchovy is a famous or popular fish that is rich with nutrient such as protein and calcium for such its tiny size. Normally, dried anchovies are packed into two categories which are split and non-split version. Usually, the market price of the split anchovies is higher compared to the non-split variant because they have undergone the splitting process, done either manually or through a machine that further incurred additional cost. The traditional method to split dried anchovies is to employ a group of people to split them in-half manually by hand while the automated mode uses a specially customized anchovies processing machine. The productivity of the traditional method is somewhat low and typically results in a higher operating cost compared to the automated counterpart. One of the alternatives to improve the current condition is to modify the machine by incorporating a separate feeder mechanism into the machine original structure. The feeder is a mechanism that links the storage (of the anchovies) to the entrance opening of the processing machine. This study is carried out to analyze and determine which type of feeder mechanism can best be implemented to the original structure to improve the feeding process of the anchovies into the machine. The additional feeder mechanism was developed designed in anticipation of further enhancing the productivity and efficiency of the machine.*

**Keywords**: *Anchovy, split or non-split, orientation, sorting mechanism, feeder mechanism*

## 1.0 INTRODUCTION

Anchovies also locally known as *ikan bilis*, are very popular in Malaysia and normally is comprised of a collection of relatively small sized fishes about 2 to 40 cm in length. The product is often used as a main dish for a specialized food condiment. The demand for this fish is considered high in the Malaysian food industries. The scientific name for this species is *Engraulidae* [1], and can be described as a small green fish with blue reflective skin because of the silver horizontal stripe along its fin. It normally lives and roams about in the ocean in large schools or shoals (of anchovies). Basically, there are 144 species of anchovies scattered among the seven seas of the earth [2, 3]. According to Sandi Busch in his website called *Healthy Eating*, there are several health benefits that can be obtained and amongst others, it contains *Omega-3* fatty acids [4].

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Based on a research conducted in April 2013 pertaining to the issue of nutrient, by consuming anchovy, one is able to reduce the risk of cardiovascular disease by eating 8 ounces of the oily fish per week that contain the *Omega-3* fatty acids.

Anchovies are also categorised as a fish species that contains the least amount of mercury content and hence, they are safe to consume. Other than that, it contains all the three minerals required for the growth of healthy and strong bones which are, phosphorus calcium and magnesium. In every twenty grams of fresh anchovy fillet, there are 5% of phosphorus, 3% of calcium and 2% of magnesium. Consumer also obtains 19% of the daily intake of niacin, 4% of vitamin B12 and 2% of vitamin B6 with the equal serving of anchovies. A number of researchers has reported and agreed that niacin which is also known as vitamin B3 can improve cholesterol levels and reduce the risk of heart attack while vitamin B12 and B6 can help prevent heart disease by decreasing the levels of homotycene which is a by-product of a protein breakdown that promotes the inflammation and often elevated heart disease in patients [5-7].

In Malaysia, Pangkor Island situated in Perak is well known as a production centre for salted fish, anchovies produce, dried shrimps, shrimp pastes and other variety of seafood products. Pangkor Island or simply Pangkor as it is passionately known, is blessed with five main attractions that are able to lure tourist to the destination. These attractions include beautiful coastal beaches, a number of resort islands, historical sites, rainforest, seafood and cultural activities [8]. Apart from being acknowledged by the people as a tourism center, the cleanliness of the surrounding sea had convinced consumers that the supplied anchovies are of prime or best quality. If someone visits Pangkor, it is deemed quite weird if he/she is not aware of the shops or stalls selling a variety of anchovies including the blue-eyed anchovy species. Most experienced travellers to this site can easily verify and ascertain that the anchovies here are unique from other places as they are deemed crunchier, less salty and not chewy. Thus, with these unique characteristics, the price of anchovies can be said to be a little bit higher compared to other places for certain species of anchovies.

Usually, the market or grocery shops get their anchovies through various suppliers. The anchovies come with different grades that conform to specific characteristics or properties like the size, color, appearance and physical conditions of the anchovies which can be mainly be divided into two, namely, non-split and split with the head, stomach contents and sometimes bones removed. Even though the price for split anchovies is generally higher than the non-split version, customers tend to buy the split anchovies due to time constraint, easier and convenient when preparing and cooking foods.

## 2.0 DESIGN ANALYSIS

The traditional method for splitting anchovy is through employing a group of people to work on them manually using hand while the automated method is using a special customized anchovies processing machine. The productivity based on the former method is somewhat low and operating cost is higher compared to the automated route. The available automated machine is only limited to the splitting procedure; the anchovies need to be manually fed into the chute, while setting the orientation of the anchovy into three modes, i.e., head-first, tail-first and horizontal positions. The requirement that usually leads to satisfactory results is by splitting the anchovy with their head first into the cutting channels. One way is to modify the available machine by adding a separating feeder mechanism into the machine original structure. This feeder is in fact a mechanism that connects between the output of a storage and the input of the processing mechanism [9-11].

## 2.1 Driver Unit

The main mechanism that operates this machine is the electric motor, in which the main controlled variable is the rotational speed. Therefore, the selection of motor is very important to generate the desired outcome. A three-phase motor as shown in Fig. 1 is typically selected as its capability to connect with a variable frequency drive (VFD) in order to control its rotational speed. Table 1 shows the specifications of the motor that is often used for operating the reciprocating feeder mechanism.

**Figure 1:** Model of electric motor used in the machine

**Table 1**: Motor specifications

| Criteria | Value |
|---|---|
| AC Motor model | EM80B-4 |
| Power (kW) | 0.75 |
| Speed (rpm) | 1400 |
| Full Load Current (FLC) | 380 V, 2.01 A; 400 V, 1.91 A; 415 V, 1.84 A |
| Efficiency (%) | 75% |
| Power factor | 0.75 |
| Torque (Nm) | |
| • Start | 2.2 |
| • Max | 2.4 |
| Net weight (kg) | 11 |

## 2.2 Driven Unit

There are two types of belts that are widely used in the belting system, which are the flat and V belts. Normally, flat belt is made of urethane and also rubber-impregnated fabric reinforced with steel wire or nylon cords to bear the tension load while the V-belt is made of fabric and cord which are usually cotton, rayon, or nylon and impregnated with rubber. Each type of belt has its own advantage. The V-belt was selected over the rest. The reason V-belt was used for this research is that the V-belt possesses higher power transmission capacity than the flat belt because the wedging action between the V-belt and V-pulleys permits a smaller arc of contact that increases the power transmission capacity and reduces belt slip to a greater extent.

Referring to Table 1, the maximum speed of the motor is 1400 rpm and the pulley driven to driver ratio is 10:3. Thus, the output speed is calculated as follows:

$$n_o = \frac{N_i}{N_o} n_i$$

$$n_0 = \frac{3}{10}(1400) \approx 420 \text{ rpm}$$

Length of the belt:

$$2C + 1.57(D + d) + \frac{(D - d)^2}{4C} = L$$

$$2(10.63) + 1.57(6 + 2) + \frac{(6 - 2)^2}{4(10.63)} = 34.2\ in\ \approx 868.68 \text{ mm}$$

where $D$ is the diameter of the large pulley, $d$ is the diameter of the small pulley and $C$ is the distance between their centers.

### 2.3 Bearing

For the analysis of the bearings at two points on the shaft, one located at the driven pulley and the other mounted near the flywheel. A pair of angular contact ball bearings was chosen such that they are readily available in the market and economical. Both bearings were similar in size because the diameter of the shaft is assumed uniform across its length and the diameter is 25 mm. Thus, the bearings with an internal diameters of 25 mm of were used and fitted to the shaft. Figure 2 shows the locations of Bearings 1 and 2, the former of which carries the load from the platform and the flywheel while the latter carries the loads from the shaft, driven pulley and belt [12].

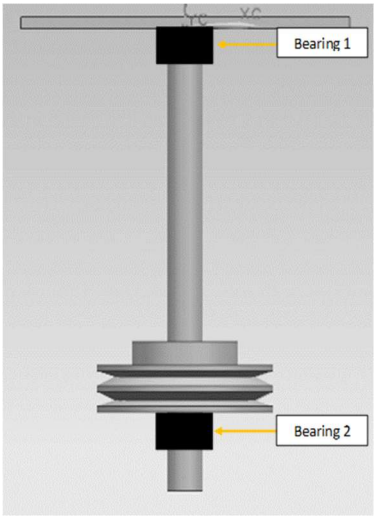


**Figure 2**: Positions of *Bearings* 1 and 2

The above setup as shown in Figure 2 was adapted from part of the apparatus designed in [13]. The calculation of the bearing loads is given as follows:

The estimated masses of the components at the main shaft:

| | | |
|---|---|---|
| Fly wheel | = | 0.1 kg |
| Platform | = | 0.5 kg |
| Shaft | = | 2.0 kg |
| Pulley | = | 3.0 kg |
| Belts | = | 0.5 kg |

The suggested radial load, $F_r$ is to be estimated about 3 to 5 times the axial load, $F_a$. In this work the highest value, i.e., 5 was used to ensure safety operation during the

experimentation. The determination of the axial load, $F_a$ and the radial load, $F_r$ is calculated as follows:

For *Bearing* 1,

$F_a$ = 0.6(9.81)
= 5.886 N
$F_r$ = 5 (5.886)
= 29.43 N

For *Bearing* 2,

$F_a$ = (2 + 3 + 0.5) (9.81)
= 53.955 N
$F_r$ = 5 (53.955)
= 269.775 N

From the analysis, the forces acting on both bearings are found to be lower than the force that can be supported. Thus, the use of this bearing can be continued for the project as it can accommodate all the loading conditions.

## 2.4 Speed Control

The frequency (in Hz) is directly related to the motor's speed (in rpm). It can be simply deduced that the higher the frequency, the higher the rpm of the motor. If the system does not require the electric motor to run at full speed, a VFD can be used to control the frequency and voltage to meet the requirements of the electric motor's load. As the system requires the motor speed to vary, the VFD can be simply turned up or down the motor speed depending on the requirement. Table 2 shows the specifications of the VFD. The VFD or known as an inverter is an electrical or electro-mechanical device that converts the direct current (DC) to alternating current (AC) which can be used at any required voltage and frequency. VFD is a device consisting of the transformer, switching and also control circuits. Figure 3 shows the VFD model used in this project.

**Table 2**: VFD specifications

| Parameter | Value |
|---|---|
| Model | ATV11HU09M2A |
| Motor power (kW) | 0.37 |
| Input line current (A) | 6 |
| Short circuit rating | 1 |
| Nominal current (A) | 2.4 |
| Max. transient current (A) | 3.6 |
| Power dissipated at nominal load (W) | 25 |

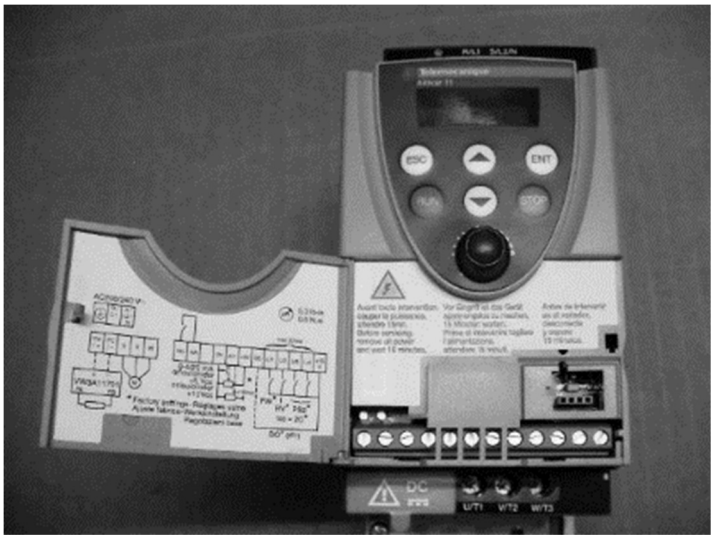


**Figure 3**: VFD model used in the research

## 3.0 RESULTS AND DISCUSSIONS

Tables 3 and 4 show the results of the anchovies falling and their orientation when they were randomly fed onto the two different platforms made from plywood and sheet metal, respectively. Meanwhile, Figures 4 and 5 present the bar charts showing the numbers of anchovies and their orientations, again for the two different platforms at a frequency of 35 Hz and a stroke of 4 cm with a 0.5 m length of the platform.

**Table 3:** Results of the anchovy orientation using plywood platform

| Batch | Head-first | Tail-first | Horizontal |
|---|---|---|---|
| 1 | 6 | 4 | 0 |
| 2 | 7 | 3 | 0 |
| 3 | 9 | 1 | 0 |
| 4 | 5 | 2 | 3 |
| 5 | 6 | 3 | 1 |
| 6 | 7 | 1 | 2 |
| 7 | 5 | 2 | 3 |
| 8 | 8 | 1 | 1 |
| 9 | 7 | 1 | 2 |
| 10 | 5 | 3 | 2 |
| **Total** | **65** | **21** | **14** |

As can be seen from the results for every conditions, it can be said that the number of the anchovies 'flowing' head-first are increasing. From the experiment, it is observed that the main variables to manipulate in finding the the probability of the anchovies to flow head-first are the motor frequency, length of stroke, type of platform and also the length of platform.

**Table 4**: Results of the anchovy orientation using metal sheet platform

| Batch | Head-first | Tail-first | Horizontal |
|---|---|---|---|
| 1 | 7 | 2 | 1 |
| 2 | 8 | 1 | 1 |
| 3 | 8 | 2 | 0 |
| 4 | 6 | 3 | 1 |

| | | | |
|---|---|---|---|
| 5 | 7 | 3 | 0 |
| 6 | 7 | 2 | 1 |
| 7 | 8 | 2 | 0 |
| 8 | 7 | 2 | 1 |
| 9 | 8 | 3 | 1 |
| 10 | 9 | 1 | 0 |
| **Total** | **75** | **21** | **6** |

As for the motor frequency, a question may arise - how does it affect the orientation of the anchovies? The answer is that basically, the frequency is directly related to the motor's speed. It can be simply deduced that the higher the frequency, the faster will be the rotating speed of the motor. If the system does not require the electric motor to run at full speed, the variable frequency drive (VFD) can be used to control the frequency and voltage to meet the requirements of the electric motor's load. As the system requires motor speed to vary, the VFD can simply increase or lower the motor speeds to meet the specific requirements. Thus, by increasing the motor frequency, the motor speed can be correspondingly increased and hence increasing the reciprocating motion of the platform as well.

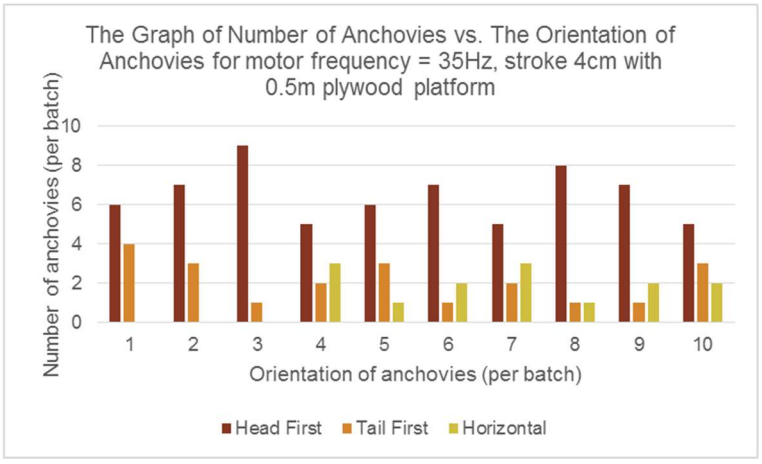


**Figure 4**: Graph of *Number of Anchovies* vs *Orientation of Anchovies* for a motor frequency of 35 Hz, stroke of 4 cm and with a plywood platform

The second parameter is the types of platform used in which basically, both platforms have different values of the coeeficient of friction, i.e., different surface roughness. Friction is the force resisting the relative motion of the solid surfaces in contact in relation to the fluid layers and material elements sliding against each other. It can be proven that either just only by touching both surfaces of the platforms, the roughness can be approximated and the fact that the friction coefficients of the contact materials can be readily obtained by referring to a suitable handbook or relative website. The higher the friction coefficient implies the higher the friction effect of the surface. Thus, it also signifies that the probability of the anchovies to orientate (move) is higher on the metal sheet surface than the plywood counterpart. Also, the resistance to prevent it from orientating based on the head-first configuration on the platform surface is lower compared to the plywood surface.

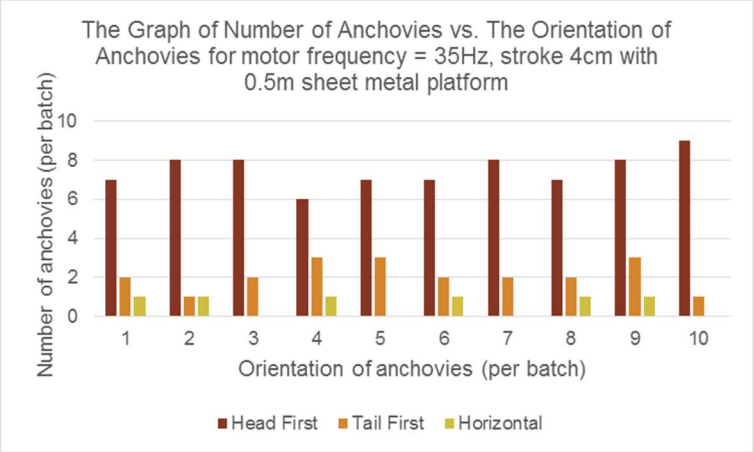


**Figure 5**: Graph of *Number of Anchovies* vs *Orientation of Anchovies* for a motor frequency of 35 Hz, stroke of 4 cm and with a sheet metal platform

The third parameter is the length of the stroke. From the experiments, it is found that the mechanism that used the 4 cm stroke produced better result compared to the one with 8 cm stroke. This is because the longer the stroke for the reciprocating motion, the bigger the range of movement of the anchovies has to react on the platform which causes the anchovies to experience some difficulties in orientating itself during the period.

The last parameter is the length of the platform. The longer the platform results in the longer time it takes for the anchovies to orientate according to the head-first position. However, this situation has an effect to sacrifice the productivity of the feeder as the longer platform will consume more time for the anchovies to 'flow' from the platform into the machine. The yoke mechanism as explained in [14] was employed in connecting the driver and platform, thereby making the platform to be as short as possible in order to set the anchovy in the required orientation. The detailed design of the sorting and yoke mechanisms for this work can be seen in [15].

Figure 6 shows the results of experiment when the anchovies were randomly drained onto two different types of platforms, i.e., plywood and sheet metal. The less friction platform (metal) has a tendency to increase the head-first orientation that feed the anchovies into the splitting inflow chute of the machine than the rival counterpart (plywood).

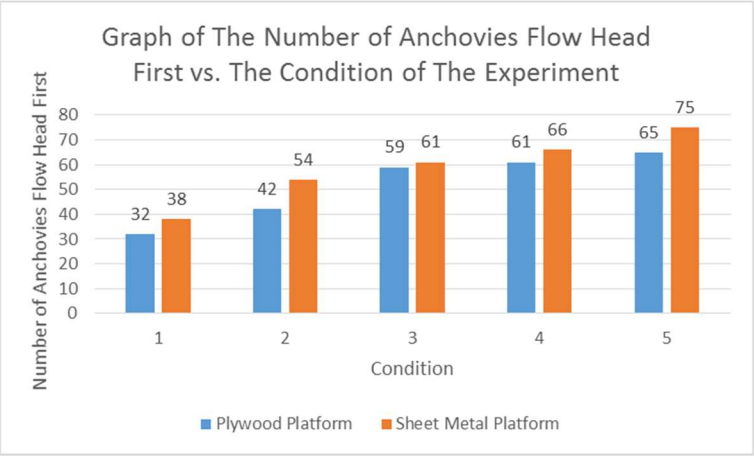


**Figure 6**: Graph of *Number of Anchovies Flow Head First* vs *Condition of The Experiments*

## 4.0 CONCLUSION

There are several conclusions that can be drawn from the experiments in order to find the most suitable type of surface, motor frequency and length of stroke of the mechanism to implement for anchovy processing. They are mostly related to the possible orientation of the anchovies and are as follows:

- The smoother the surface, the higher the probability for the anchovies to have proper orientation because of friction.
- The higher the frequency of the motor rotation, the more effective it is to orientate the anchovies.
- The longer the stroke, the lower the ability of the mechanism to orientate the anchovies due to the movement of the anchovies on the platform.
- The longer the platform, the higher the tendency of the anchovies to orientate properly due to longer traveling distance.

The platform inclination angle also plays a role to ensure the anchovies rotate and flow appropriately. However, if the inclination angle exceeds its optimum angular position, the unwanted or undesirable results were observed.

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## REFERENCES

1. Loeb M.V., 2012. A New Species of Anchoviella Fowler, 1911 (Clupeiformes: Engraulidae) from The Amazon Basin, Brazil, *Neotropical Ichthyology*, 10(1): 13–18.
2. Food Standards Agency, *Fish and shellfish*, https://webarchive.nationalarchives.gov.uk/20060802132803/http://www.eatwell.gov.uk/healthydiet/nutritionessentials/fishandshellfish/, [Accessed: 24 June 2004].
3. Chisholm H. (Ed.), 1911. *Anchovy*, Encyclopædia Britannica (11th Edition), Cambridge University Press.
4. Sandi B., 2017. *What Are the Health Benefits of Anchovies*?, Healthy Eating | SF Gate, http://healthyeating.sfgate.com/health-benefits-anchovies-2748.html, [Accessed: 11 December 2017].
5. Roizman T., *Vitamins that help balance cortisol*, https://www.livestrong.com/article/497824-vitamins-that-help-with-cortisol/, [Accessed: 3 October 2017].
6. Lac K., *What are B6 & B122 good for*? https://healthyeating.sfgate.com/b6-b12-good-for-6084.html, [Accessed: 19 November 2018].
7. Staughton J., *14 Surprising anchovies benefits*, https://www.organicfacts.net/health-benefits/animal-product/health-benefits-of-anchovies.html, [Accessed: 23 October 2018].
8. Selamat A.M., Chelamuthu M.R. and Suhaili M.S., 2016. The Impact of Tourism on The Marine Environment of Small Islands: The Case of Pangkor Island, Malaysia, *Journal of Modern Education Review*, 6(9): 639 – 647.
9. Satyendra K.S., *Feeders and their type*, http://ispatguru.com/feeders-and-their-types, [Accessed: 26 September 2015].
10. Singh S.P., Ghosh S., Anju and Khanna P., 2009. Mathematical Performance Analysis of A Reciprocating-Fork Hopper Feeder, *IEEE Student Conference on Research and Development (SCOReD)*, 11227003.
11. Bian Y., Ma Y. and Zhang Z., 2007. Reciprocating Feeder Applied to Precision Seed-grain Sowing Machines, Alliance of crop, soil, and environment science society, *Transactions from The Chinese Society of Agricultural Engineering*, 2: 122-127.

12. Daniel R.V., Siddhappa S.A., Gajanan S.B., Philip S.V. and Paul P.S., 2017. Effect of Bearings on Vibration in Rotating Machinery, *IOP Conference Series: Materials Science and Engineering*, 225, 012264.
13. Zakaria M.H., 2010. *Semi Centrifugal Technique for Small Casting Manufacturing*, BEng. Thesis, Universiti Teknologi Malaysia.
14. Arakelian V., Le Baron J-P. and Manuk M., 2015. Design of Scotch Yoke Mechanisms with Improved Driving Dynamics, *Proceedings of The Institution of Mechanical Engineers, Part K: Journal of Multi-body Dynamics*, 230(4): 379-386.
15. Muhamad Haikal M.N., 2018. *Development of Anchovy Processing Machine*, BEng Thesis, Universiti Teknologi Malaysia.