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Design and Model Fabrication of Meat Chopper Machine

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A B S T R A C T

Meat is one of the most consumed foodstuff in our country as well as globally. In our society, cutting meat is one of the tiresome and boring activities dealt by individuals as well as masses. In addition to this the chopped meat is not of equal size and safety of the cutting hand is always at risk. Hence, the main goal of this research is to overcome the limitations listed above and others. The purpose of this research was to design a meat dicer machine which can efficiently cut the meat into perfect cubic shape within short period of time. The design of this machine includes different mechanical as well as electrical tools which help accomplish the required movements. This paper also elaborates on the design of each part of the machine which includes selecting the component materials and transmission system, kinematic arrangement of forces, material selection on the machine and proportion of parts to ensure the maximum strength and functionality of the machine. Further, the design of the various parts of the machine in 3D model and machine fabrication are discussed, along with different test measures of the machine. The boneless meat is initially pushed by a pressing action and is then cut by different types of blades to finally attain the desired cubic shape. This machine can be effectively applied in any places particularly in places where meat is consumed heavily like college cafeteria, military camps, and ceremonies.

Keywords: Meat, 3D Model, Cutting blades, Modelling, Fabrication

1. Introduction

Meat science and the research studies conducted both independently and in conjunction with many industry stakeholders over the last 50 years have provided greater understanding of the relationships between animal handling techniques prior to harvesting (slaughter) and the quality of the meat produced [1]. As well, improved practices during and after harvesting of animals, especially in large processing and large processing plants, have contributed to progress in meat industry. These includes improvements to refrigeration and storage, aging of meats (mainly beef and lamb carcasses), and transportation [2-4]. Additionally, the slaughter process itself has changed over time, and now beef and veal animals are usually stunned with a captive bolt gun (with a retractable bolt penetrating the brain), rendering the animals unconscious prior to bleeding. The consumption of meat along with other food is very important because it enriches both the nutritional content of the food and also acts as important delicacies. It is a nutritious food containing some quantities of essential amino acids, in the form of proteins and also contains group of vitamins [5, 6]. Animal meat is composed of muscles, bones, fats and connective tissues, and the main edible and nutritional part of the meat is the muscle or lean meat.

Chopping is a stage in the meat production process. It consists in mechanical comminution of meat to achieve homogenous consistency and to bind all ingredients added. Chopping results in considerable comminution of the raw material, the hydration of proteins with water added during processing and the emulsification of fats [7-11]. Mixing and homogenization are results in alignment of the spatial dispersion of all ingredients. These operations lead to the formation of a multi-component and multi-phase physical system known as meat batter, where the initial physical structure of all the chopped raw materials has been changed considerably. It is mostly manifested by changes in the properties of meat proteins and the fatty material [12-15]. Sodium chloride plays an important role in the extraction of myofibrillar proteins. Myofibrillar proteins are responsible for the development of functional properties of emulsified meat products, such as gel formation, water-holding capacity and emulsification. The addition of fat to meat products affects their rheological and structural properties and provides a unique taste profile. Fat affects the texture, flavor, mouth feel, and overall sensation of lubricity and

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appearance of meat products. The structure and physicochemical properties of proteins and lipids influence the formation and stability of emulsions by forming an interfacial protein film around fat globules in finely comminuted meat products and thus they affect the texture of many food products.

1.1. Background of this research

The design and the production of a machinery as part of the technological progress of a country requires the accomplishment of the technology and development of capacity in the three activities of design, fabrication or production and engineering research and development. Engineering development and analysis of machinery and equipment is a compliment to any design and manufacturing process. It is through such testing and subsequent advance that operational complications of the machines produced locally can be examined and cracked and the quality of product maintained.

The slicing technology can be dated back to the 1900's, with a number of authors studying the ideologies of slicing and slicing machines. The first slicing machine was designed by an American in 1873 (Hardin, 2001), the machine made use of an oblique knife in a vertical slicing frame for slicing dry beef and it worked the frame holding the meat while slicing against the cutting blade (Odior and others, 2009). Otto Rohwedder designed and manufactured the first slicing machine that would slice and wrap bread in 1925 (Frank, 2004). The machine made use of an oblique knife in a vertical sliding frame for slicing dry beef and it worked with the frame holding the meat while slicing it against the cutting blade. The conventional slicing machine was originally designed to slice meat into pieces of uniform thickness. It was also used for slicing cheese, vegetables, ham, onions, green peppers and sandwich ingredients.

Slicing technology has already been developed advanced in the western world in 1970s, in the mid-eighties most of the slicers can process mono crystal with large diameter up to 125 mm (5 inches), like the horizontal inside diameter slicing machine manufactured by Mayer Byu Geyer company in Switzerland which sliced parts with the maximum diameter up to 304.8 mm (12 inches). During the age of industrialization, automatic machines have confirmed to lessen the time needed to do a specific task; hence they are vital part of human life. Nowadays, human life becomes more competitive and faster than before. Slicing meat is a risky and time-consuming task in our busy life.

Its advantage are to cause less kerf, small deviation, even cut surface, big quality and less cost. Its application in the market created a new chapter for the cutting technology in the 21 century (Huang and others, 1996). The function of the slicer has been very complete, complete, and the way of slicing is diverse. The comb shape cutting machine in 1980s is not new anymore. It has been replaced by the cutting and rotating one, surface grinding one and the one with an air cushion which can prevent the blade from bending and distorting, which can repair and maintain the blade automatically (Jiang, 2011). The chip material can roll and grind by itself while cutting, which can reduce the bending of the monocrystal. Figure 1 shows the manual chopping process in COET and the blade edges.

Fig. 1 Manual Chopping of Meat in MCOET cafeteria

1.2. Problem statement

The main motive for this senior research paper under the topic design and fabrication of meat dicer is mainly because of the significance of meat in our country. Meat as we know all is one of the most familiar diets in our country. But, the problem arises when it comes to cutting the meat prior to consuming it as a diet. Many people suffer of this tedious activity daily especially when it comes to large quantity of meat for mass use. The main reason for the design and fabrication of this meat dicer machine is because our cafeteria in MCOET College consumes a large quantity of meat. The chopping of this meat manually involves large number of people mostly old women which suffer of this activity whenever it is required. It usually takes more than three hours to finish cutting the meat that is to be served only for lunch. So to solve this problem we designed this meat dicing machine that will chop 2kg of meat per minute with low cost of fabrication and operation.

1.3. Aim and objectives

The aim of this project is to design and fabricate a meat dicing machine with low cost. The aim is achieved through the following objectives.

- Reduction of human labor in the process of meat cutting, because the machine is designed to operate with less human interference using a motor and mechanisms enabling power/torque to be transmitted to the meat to be diced.
- Ensuring the level of safety of the user by employing standard design requirement.
- Ensuring that a level of hygiene is maintained and meat is safe for consumption through proper selection of material.
- Saves time that will be wasted in cutting the meat manually.
- Reduction of fabrication and operating cost
- Producing cubic shaped meat.

1.4. Methodology

Figure 2 shows the methodology followed in this research work,

- Formulation of the research problem: These include peeking out the problem that we want to study. In our case the problem is the difficulties facing in chopping meat .The best way of understanding the problem is to discuss it with one's own colleagues or with those having some expertise in the matter. So we discussed and got supportive ideas .also we studied the feasibility and clearly state our objectives because it determines the data which are to be collected, the choice of techniques to be used in these explorations and the form of the final report.
- Literature survey: Once the problem is formulated, a brief summary of it should was written down. At this juncture we undertook extensive literature survey connected with the problem .For this purpose, the abstracting and indexing journals and published Academic journals are the place that we searched depending upon our problem.
- Design process: once the problem and literature survey have been formulated in clear cut terms, then we prepared a research design .This includes the design calculations and design structure of the machine. the function of research design is to provide for the collection of relevant evidence with minimal expenditure of effort, time and money. The design would cover some essential components of the machine which will be explained further as Machine frame, Cutting blades(horizontal, vertical, and detaching blades), Duct, Pulleys, Ac motor, Pressing rod, Belt, Bearings.
- Fabrication of the model: after the design process what follows is the fabrication process. The fabrication process is based upon the design.
- Experimental testing: after fabrication process experimental testing applied to know whether the machine meets the design requirements.
- Final product: after testing the fabricated model if the product meets the designed requirements it will be ready for mass production.
- Preparation of the report or thesis: finally, we prepared the report of what we have done.

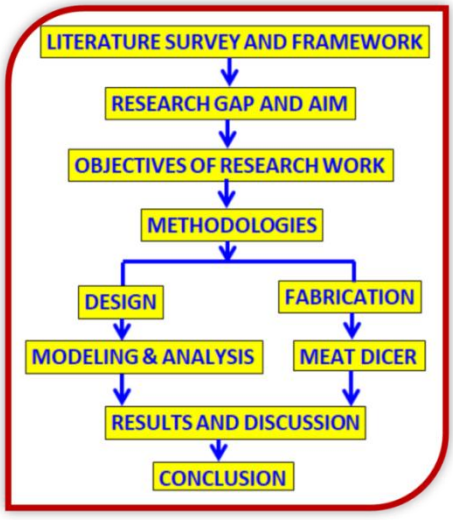

Fig. 2 Flow chart of this research

1.5. Fabrication of Machine

First we bring a large black sheet plate with a thickness of 4mm. then we cut this sheet into 50cm*50cm dimension according to the designed dimension with a cutting machine. After this we cut a square hole in the sheet by using a nibbling. The horizontal and vertical blades are similar in their construction their difference lies only in the way they work. They are manufactured with stainless steel plates. In constructing these blades, we cut four equal 15cm*4cm stainless steel plate then we cut two holes of 2cm in vertical blade and 1.2 cm in horizontal blade for positioning of shafts. These two blades will be held rigidly by these shafts which are fastened with a nut. Three sharp blades in one side of 22cm length are welded in between the plates. Finally, we fixed a positon of 2.2 cm at the back of the plate for the eccentric shaft in which it converts rotary motion of the motor into reciprocating motion. Rotating blade is the final blade that is used to cut/chop the meat in length wise. The material used to fabricate it is stainless steel. It has a length of 24cm. The duct is the path the meat passes from the hopper. It is also fabricated from stainless steel of 40cm*32cm which is bent into a shape of rectangular prism duct. It is welded in the hole on the front surface of the machine. The pressing rod is used to push the meat toward the blades. It is manually operated. The first surface is stainless steel since it pushes the meat and it is welded with tube iron to help it with pressing. The closing plate as its name suggests is used for closing and opening entrance of the meat. It is made by bending sheet metal plate into a structure shown in the figure. Two AC electric motors are used on the two sides of base surface. The first motor is used to drive the vertical blade pulley and the second motor is used to drive the rotating blade and from rotating blade to horizontal blade pulley. The motion is transferred from driver pulley to driven pulley by the belt. And the pulley of each blade is supported in the bearings. Figure 3 shows the image of individual component of machine.

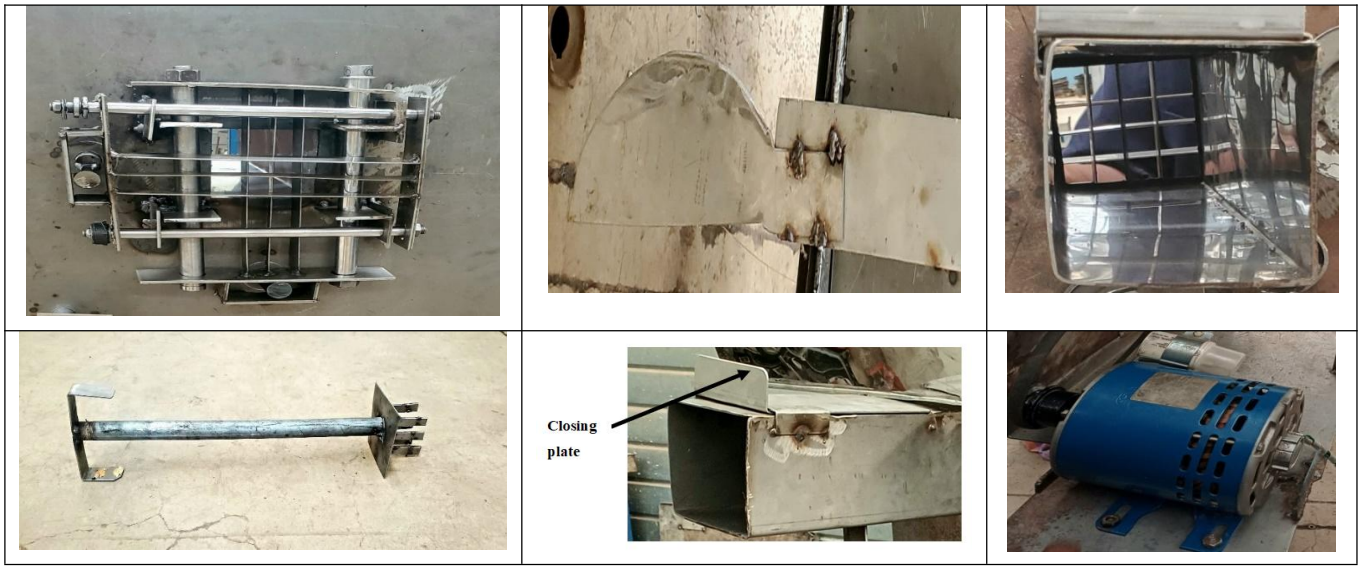

Fig. 3 – Individual components of Machine.

1.6. Working of Machine

First the meat is put into the hopper, and then the pressing action happens through a pressing rod manually. The rotation of the pulley mounted in the shaft of the first motor transfers the motion to the pulley of vertical blade pulley. Then this rotation is converted into reciprocating motion of vertical blade pulley by eccentric shaft. After this the rotation of the pulley mounted in the shaft of the second motor is transferred to rotating blade pulley and from rotating blade pulley to horizontal blade pulley. This is how the machine operates. Figure 4 shows the modeling and steps involved in this research work.

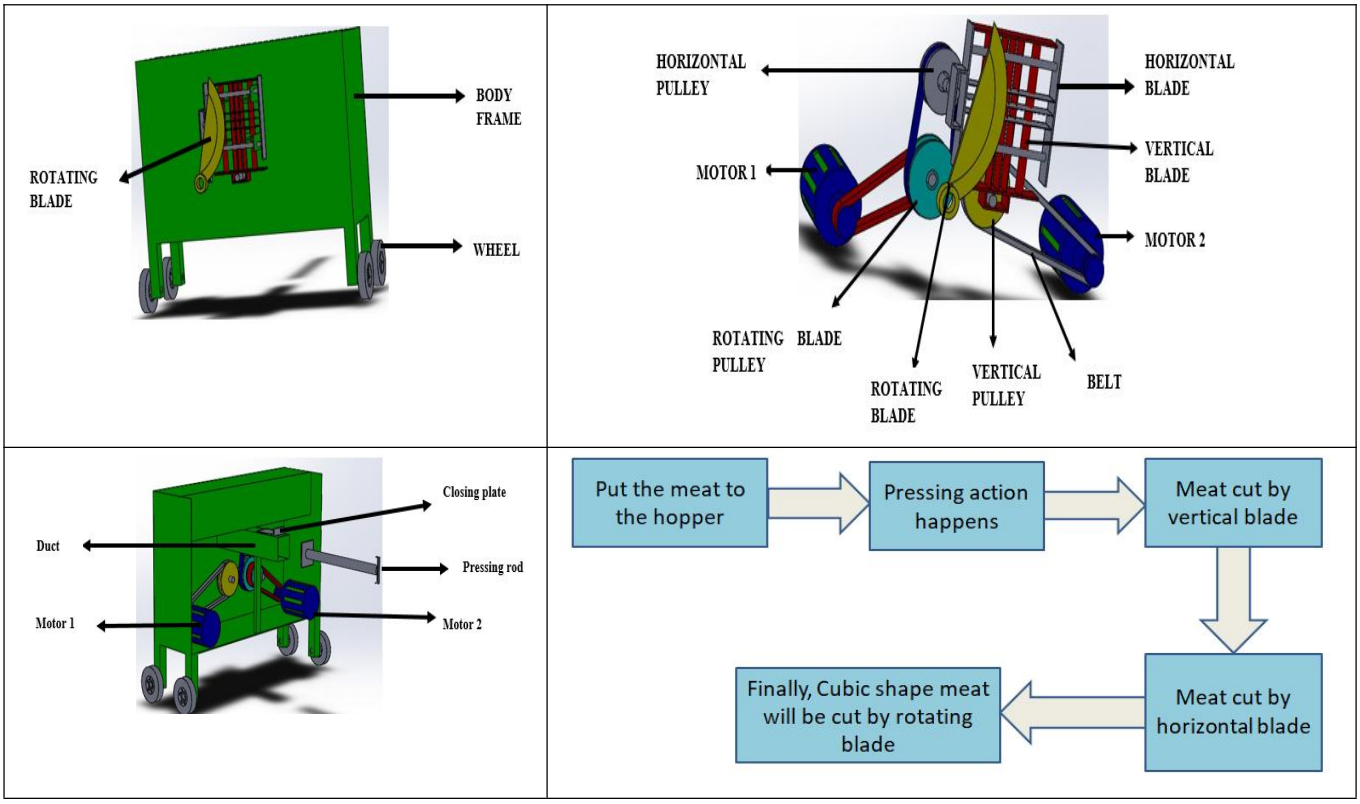

Fig. 4 – Modeling and Working of Machine

1.7. Advantages and disadvantages

The advantages of meat chopper machine

- ✓ Large amount of meat can be chopped in short period of time.
- ✓ Shape of the chopped meat is of equal shape and size.
- ✓ Eliminates the use of bare hands which eliminate the risk of injury
- ✓ Reduces number of people being involved.
- ✓ The process is hygienic
- ✓ Reduce labor and work load on the workers.

The disadvantages of meat chopper machine

- ✓ Electricity is required for the operation.
- ✓ Noise and vibration as the metals contact to each other
- ✓ The machine is relatively heavy in size.
- ✓ Sanitation is greatly required as the meat directly contacts with metal.

2. Results and Discussion

This research work explains about the project that has successfully completed in about 1 month. Beside that there were some problems that we have to face along our process to fabricate and test our product. Therefore there have some suggestions to improve our project in the project in the future that will give benefits to the user. In this chapter the decision has been made based on the overall decision that we got from the research and discussion in the previous chapter. Besides, this chapter also addressed the objective and the suggestion from the researcher that we have made. With that, the conclusion has been made to our research.

Our product has successfully achieved the objectives that we have set. Among them is, our product can chop more than 2kg of meat per minute. With the help of the three blade which are the vertical blade, horizontal blade and rotating blade our machine can chop different type of meat with minimum time, which is more effective than the traditional chopping of meat using knife that unhygienic and risky.

Besides that, our product can also reduce the work load on workers. This is because the workers don't need to waste their energy in chopping the meat manually because they only need to put the meat in the duct and push it through the duct which requires less energy and the rest of the chopping will be done by the machine. After running this project, we found that our project can greatly help the users because this product can reduce the work load of the workers compared to the manual chopping of meat by hand using knife. Besides that, our product is neater, robust and productive compared to the manual chopping of meat.

To improve this project, several suggestions have been made:

- Use motor with high torque
- Use highly sharpened stainless steel cutting and rotating blades
- Making the entire body of the product made of stainless steel
- It would be better if we could use chain drive system instead of belt drive system as per expertise in the ERI-SOC because in our fabricated model we suffered from belt slippage. The chain drive also ensures perfect velocity ratio.

3. Conclusions

Currently, the world is being transformed at a faster rate than any other time to date due to the effect of technology. Life is being simplified and human effort is diminishing as automatic machine has been applied in every part of our lives. Cutting meat is one of the common activities in our society at personal kitchens, butchery, restaurants and cafeterias. The traditional process of cutting meat has always been very tedious, time consuming, risky and unhygienic. We came up with an idea that can eliminate most of the human labor required to cut the meat and also minimize time required. When we come to our college cafeteria, the meat dicer machine is not available yet. Hence, designing and fabricating a machine that is capable of dicing/chopping meat which will mechanize the dicing/chopping process for both domestic and commercial consumption becomes essential. The design proves that simple member elements can be assembled to make a functional engineering device. Rust free engineering materials were selected. During the design process the equations that were involved were cutting force, torque and shear force equations. The result and fabrication of this project has shown the possibility of manufacturing a relatively cheap, easy to use and reliable machine for dicing/chopping meat which reduce human effort, safe and hygienic. It's flexible and has wide range of application. This design is environmental friendly as it does not use an internal combustion engine, but it is driven by an electric motor eliminating the production and emission of fumes. Almost every home in Eritrea eats meat and also meat is consumed in large amount in cafeteria of colleges and different social ceremonies like marriage, festivals, and religious ceremonies. So this meat dicing/chopping machine would serve perfectly in dicing/chopping this bulk meat in to edible size.

Lastly, we hope this project can be fully utilized, accepted and can be applied and suitable with technological development nowadays. Besides that, we also hope that this product will give the best result to the users and it can fulfil the requirement of all users.

4. Future Recommendations

The design of this project can be improved in the future. One way of improving this design is by using a single motor strong enough to rotate all the pulleys. Other way is to replace all parts of the machine with stainless steel. It is an alloy of steel which has special features that is practically immune to rusting and ordinary corrosion. Hence, it can provide the best criterion which can boost the machines performance. In addition to this, the pressing action of the meat input which is currently manual can be substituted by an automatic system which can elevate the efficiency of the machine. Moreover, the machine can be more digital by implementing special types of software which can assist the machine in controlling the movement of the blades and timing of them.

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