Design and Simulation of New Skewering Part in Satay Industries

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Abstract
Nowadays, satay is sliced and skewed manually by workers. Due to high demand in satay industries, the industry is facing a pressure to produce more skew of boneless meats. Hence, the manual method to skew boneless meats is no longer practical, tedious, not economical and ergonomically not feasible to workers and financially unsustainable to company. Because of the customer need is very high, the satay industries need to expand in term of production, space, and marketing. Due to the growing demand for satay product on the market, the effectiveness of the satay processing machine must be improved. This is also to help the industries in terms of time savings and thus will increase product sales. The benchmarking of existing machine is considering the movement of the cutting and skewing process. Many of the machines for skewering are not in automation which the skewering process is done manually. The research is focus on the time constraint between manual and automation skewering process. Instead of the cost, work force, sales, market, time, productivity, and etc. the results and benefit for the industries is the speed of production will increase per day compared to manually skewering method. The numbers of sticks is the main constraint to be designed. The strength of the new skewering part is very suitable with the boneless meat at 0°C or maximum value tensile strength of thawed meat. All the design and analysis are done by using CATIA V5R21 software. The maximum motor pressure will be below than the highest tensile strength that can be accommodated by the new skewering part.
Keywords: skewering satay, satay industries, motor pressure, rod skewer

1.0 Introduction

1.1 Research Background

This research focuses on the satay skewering process in satay industries that basically using boneless meat as their main product. Because of the customer need for satay is very high especially in Malaysia, many company needs to expand in term of production, space, and marketing. Due to the growing demand for satay product on the market, the effectiveness of the satay processing machine must be improved. This also helps the companies in terms of time savings and thus will increase product sales. The research will help the satay industries to realize their mission and target in the future.

In satay production, skewering process is the most time constraint that many of companies taking too much times in the processes. This is because in manual production, the workers need to skewer each of meats and they need to hold the skew and meats using their hands. The workers also need to carefully manually skewering the skew into the meats to make it perfect.

1.2 Satay Industries Background

There are different characters and different ways for different country and region in serving food (Stanley et. al, 2017). Satay (written as sate in Malay) is one of Malaysia's most popular foods which is made from marinated beef and chicken pieces skewered with wooden sticks and cooked on a charcoal grill. It is typically served with compressed rice cut onions, cucumber, and a spiced peanut gravy for dipping. Kajang, Selangor is one of the famous satay called Sate Kajang. The specialty of Sate Kajang is in term for a style of the satay are the meat chunks is bigger than that of a typical satay and the sweet peanut sauce is served along with a portion of fried chili paste.

1.3 Problem Statement

Nowadays, most of the satay processing was made manually. There are several companies that have innovated to simplify the process of cutting and poke a stick of satay. Most of the products on the market processing satay skewer poke machine automatically but cutting process is still done manually. Currently slicing the satay meats is done manually and needs a long time to finish hundreds of satay in a certain time. The size was also not in uniformity of each skewer. Because of the product is done manually, its take a several time to done each sticks of satay. The workers also need to wait the boneless meats from frozen becomes soft for cutting and skewering processes.

1.4 Objective

The objectives of the research are:

i. Skewering 36 satays in one process.
ii. Comparing between manual skewering methods with new skewering part productivity.
iii. Design and simulate the new skewering parts.

2.0 Literature Review

Nowadays satay machine concept is separately with the cutting and skewering process. Many of the machines are not totally in automation which the cutting or skewering process is done manually.

2.1 Satay Skewering Machine

Product: Satay Skewering Machine
Model: SM-1200
Voltage: 240V/50Hz
Power: 100W
Dimension: 1310 x 700 x 350mm
Weight: 50Kgs
Capacity:15 sticks p/tray, 6 pieces p/stick, Maximum 1200 sticks/hour

Figure 1: Satay Skewering Machine (Satay Skewering Machine, 2017)

2.2 Meat Slicing Machine

Figure 2: X13-PLUS Series Slicers (X13-PLUS Series Slicers, 2018)

Some of the meats is fed manually on the machine track for cutting process. Although the cutting process is using machine, but the skewering process is still in manually. Because of the feeding meats inside the machine is manually, the operator would expose in danger if the operator or user do not operate the machine properly. This will make the time for the satay process being slow and workers need to divide the work of cutting and skewering satay at different times.

2.3 Satay Cutting Box

Figure 3: Janolia 36 Hole Skewers Food Slicer (Janolia 36 Hole Skewers Food Slicer, 2018)

There is some futuristic design of satay production which some of manufacturer or satay supplier design a new concept of cutting and skewering satay called satay cutting box. The concept of this satay cutting box is totally manual without any electrical supply. Both skewering and cutting process made according to the rules set to finish the process. The rules of this design is begin with insert the meats inside the box, then the user will skewered the sticks each of the hole on top of the box. After that, the user will press manually 3 sticks for each process and finally the cutting process. As a result, meat has been cut will be the same size. The skewering process is done when the boneless meats is in thawed meat conditions maybe over than 0˚C.

2.4 Meats Product

For satay preparation, most of the companies in satay industries are using frozen meats because of the meats is easy to stored and long-term preservation. Frozen meat should be cut using a band saw machine because of the hardness of the meat. There are several tensile test to study the mechanical properties of whole meat which is called as breaking strength (BS) and energy to fracture (EF). Breaking strength and energy to fracture from commercial food meat product are the accesses to the quality and

behaviour of sliced meat products. M. Dolores et. al (2014) derived from the tensile test which if the BS is less than the superficial adhesion force between the product and the surface line of the processing equipment, the meat products could break and leading to problems that will cause the processing line being stopped.

According to Munro (1983), the tensile strengths for beef were topside, -10˚C is 6.22 Mega Pascal (MPa) with a Standard Deviation (SD) of 0.65 and commercial grade beef, -20˚C is 5.58 MPa (SD 0.92). Munro also mention that there is no significant difference was noticed between the tensile strengths of different muscles from within a given topside joint or from different topside joints, but this factor was not extensively investigated. Munro (1983) also mention that the maximum value of tensile strength of thawed meats is 0.53 MPa.

2.5 Design Stages of New Skewering Parts

Nizam et al. (2014), there are design stages that consist of compliance minimization, eigenvalue maximization, and detailed design. For new skewering parts, the design parameters include mass, compliance, natural frequency, Frequency Response Function (FRF), stress, displacement, buckling, and fatigue life. The three-stage design was implemented on the synthesis of a new skewering part. The mechanical part obtained by using such a design strategy was compared to the suitable temperature of the meats for skewering process. It was found that the new skewering part, using the proposed design approach, will get the right temperature of the meats based upon static and dynamic performance.

3.0 Methodology

3.1 Description of methodology

The research is to design the new skewering parts when to replace manual method by workers. The research is estimate capable to skewers maximum 36 sticks in one process of boneless chicken or beef satay. The automatic method will increased the productivity up to maximum 36 times compare to manual skewering method. The mechanism of new skewering parts is consists materials of stainless steel which have 36 hollow rod to be filled with skewers.

3.2 Hypothesis

This research will be conducted by according to a study on the efficiency and effectiveness of the machinery for the product to be produced. The results are based on time savings and the total number of products to be produced by a new skewering part through an established process. From this theoretical framework, there are 3 factors that influence to find the best processes of the skewering part which is number of skewers, rod strength, and maximum motor pressure. All the design and analysis are done by using CATIA V5R21 software.

3.3 Theoretical Framework

In Malaysia, satay industries are still performed on a small scale because the demand is still at a small scale among Malaysians. Most employers manage their own meat cutting process and skewering stick of satay. To demand requires speed in the production process and thus will be able to produce a standard size to avoid wasting raw material costs.

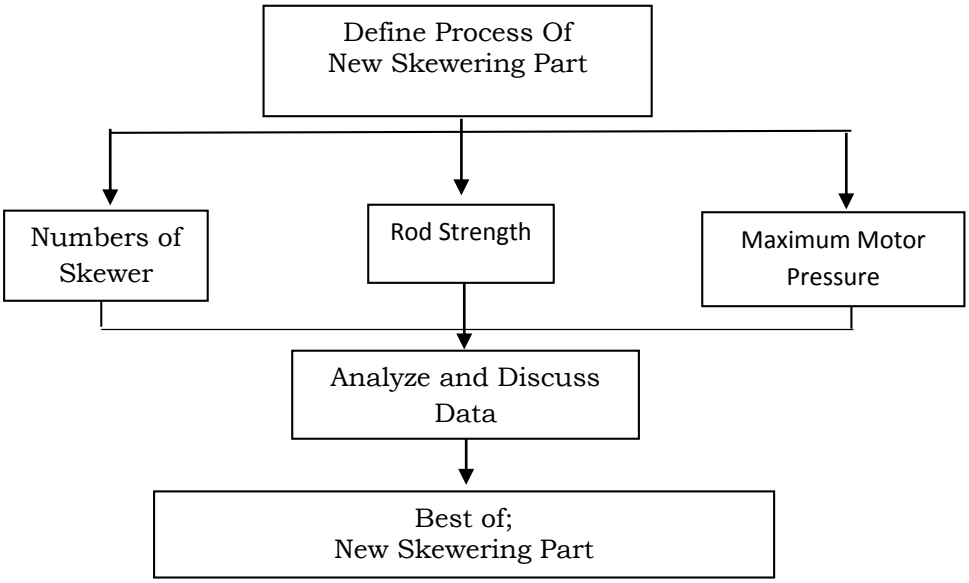

Figure 4: Framework for Action on New Skewering Part

4.0 Data Analysis and Discussion

4.1 Design Stage

According to Nizam et al. (2014), there are three design stages which consist of compliance minimization, eigenvalue maximization, and detailed design. The capability of new skewer design is maximum 36 sticks in one cycle process of skewering boneless chicken or beef satay. The method has increased the productivity up to 36 times compared to manual skewering method.

All 36 hollow sticks are in vertical position which it's depends on the linear motors to press the new skewer into the boneless meats. The materials of new skewer were using stainless steel. The analysis of the design is to check the strength of rod to pierce into the meats. All these 36 hollow rods are function as a guide for the satay sticks to skewer into the meats. So the satay sticks will skewered inside the meats without tilts of its position.

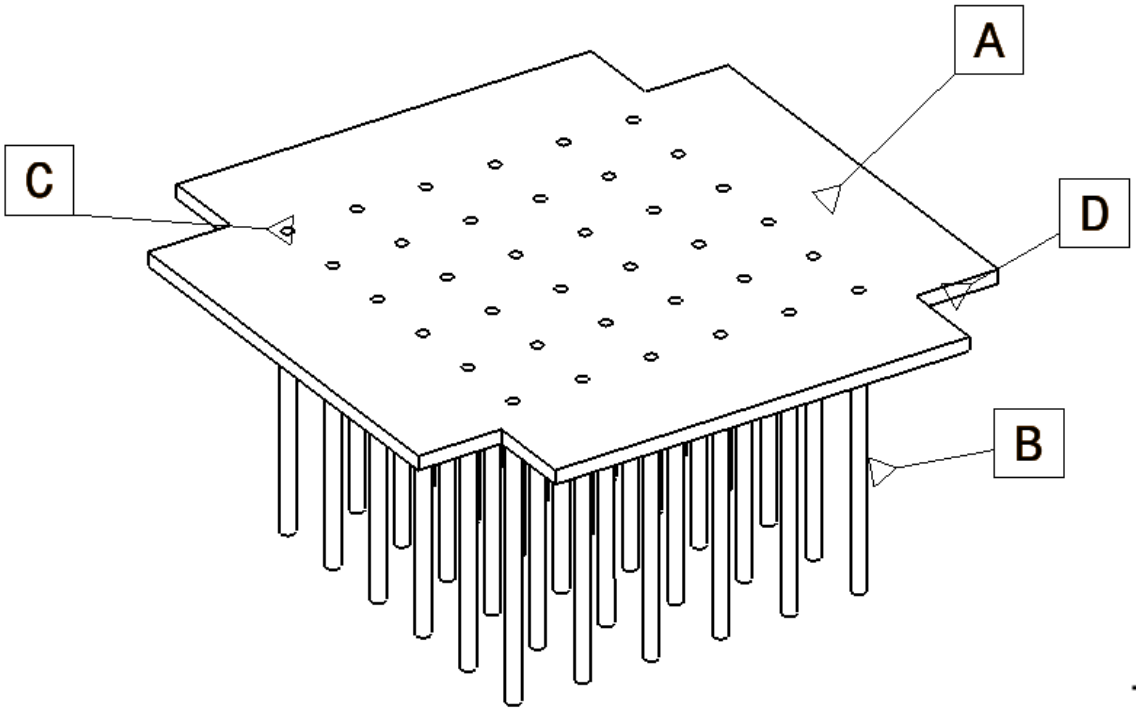

Figure 5: New Skewering Part Design

Table 1: Part Descriptions

Parts	Descriptions
A	Platform Holder
B	Hands Holder
C	Rods
D	Skewer Hole

The materials of the new skewering part are made from stainless steel because of the hygiene of foods. All 36 hollow rods are designed by following the thickness of 36 holes on the meats box and skewer sizes as shown in Figure 6. The holes of the skewer need to be calculated and design properly because want to prevent the waste of the materials. The hands holder design is to ease the user holding the new skewering part.

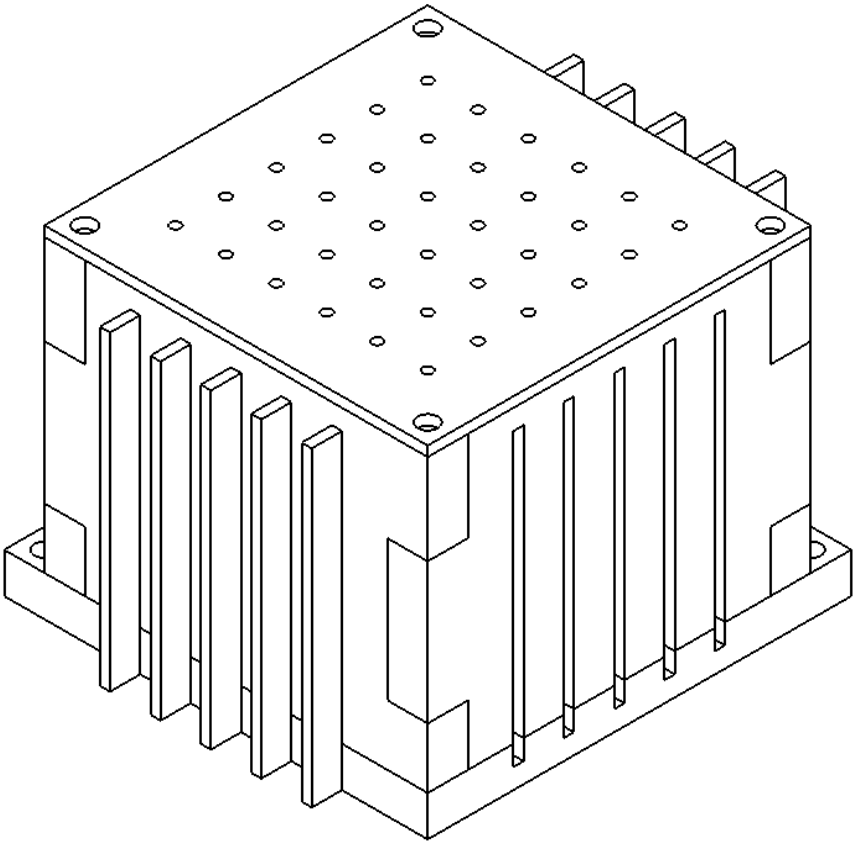

Figure 6: Meats Box

4.2 Analysis Phase

In analysis phase, there are a few main analysis parts involved, which is the strength of rod, maximum motor pressure, and the effectiveness of 36 rod pierce into the meats by following the meats box guider.

4.2.1 Effectiveness of the New Skewering Part Design

Base on figure 7, the clash analysis between new skewering part and meats box is 'clear'. The effectiveness of all 36 hollow rods is can pierce into the meat inside the meats box without any clash between these two parts. The new skewering part will be press by using linear motor which located on top of the new skewering part through the meat box cover. This showed that the skewering process is stable and not missed from the meats position.

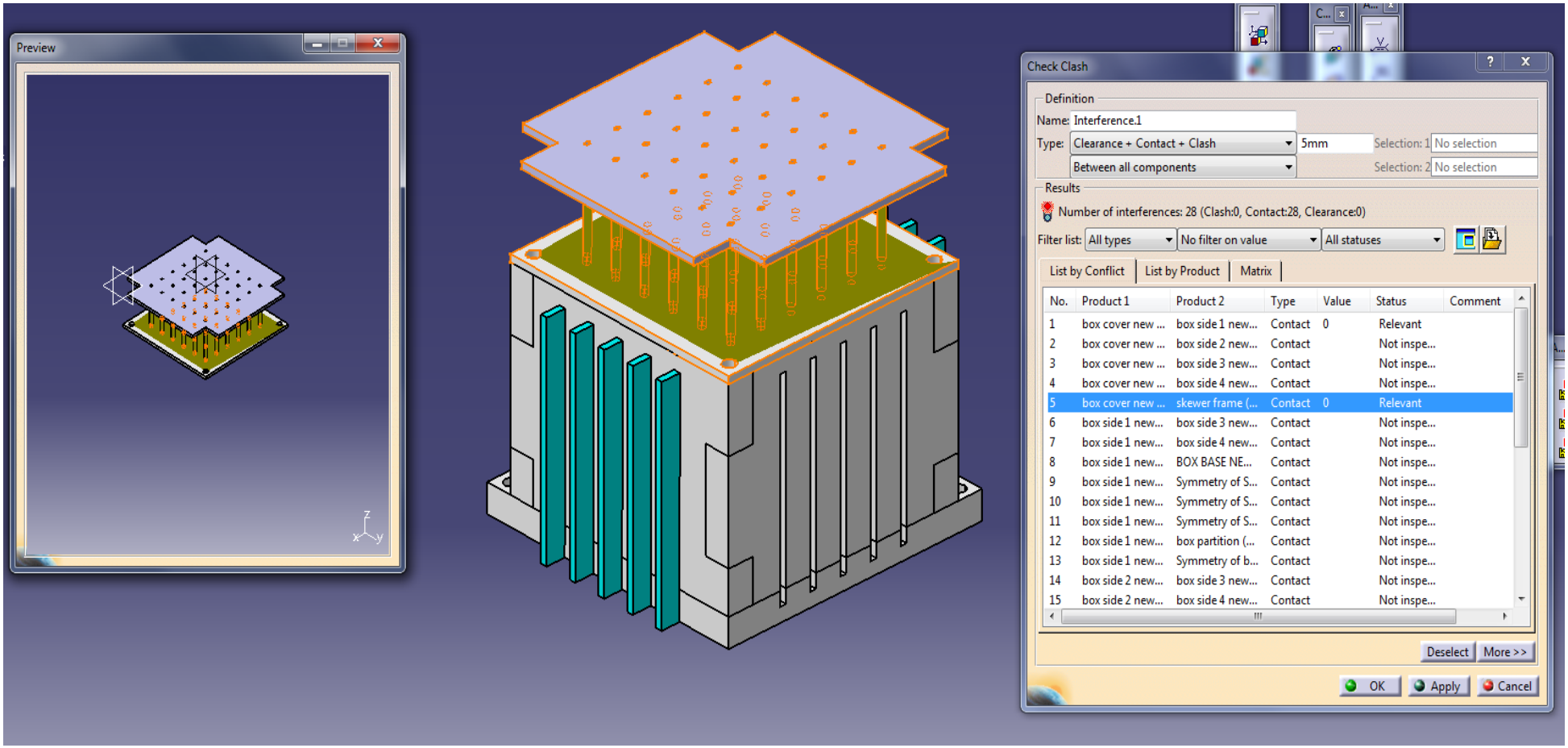

Figure 7: Clash Analysis between Skewering Part and Meats Box

4.2.2 Static Analysis New Skewering Part Optimizer

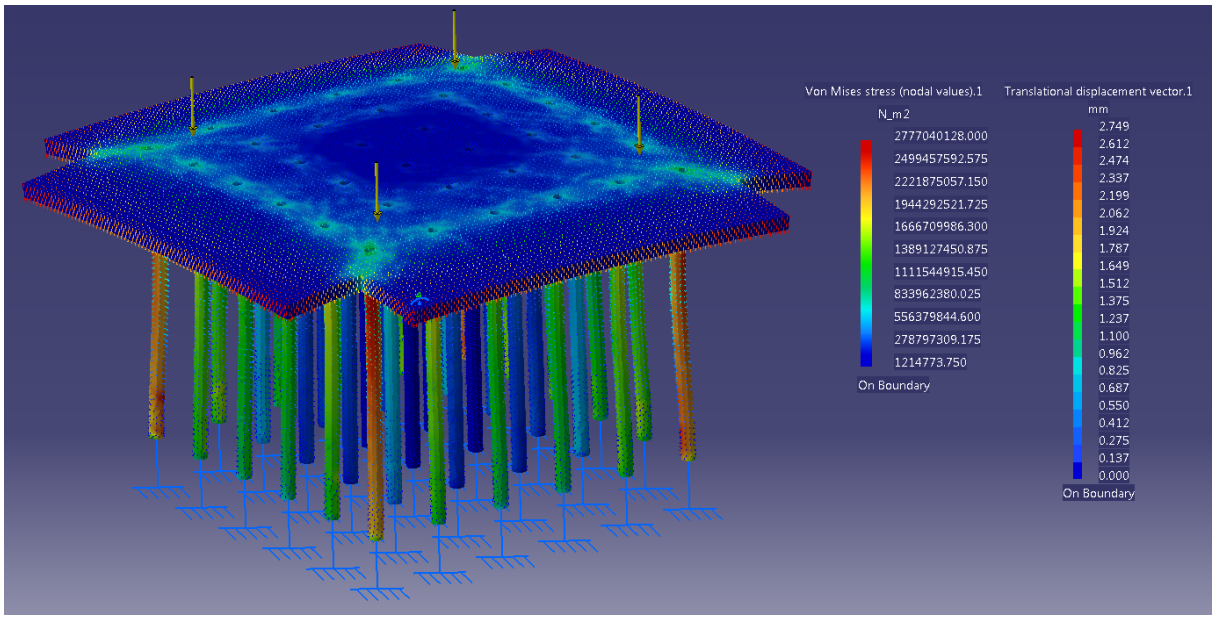

Figure 8: Static Analysis of New Skewering Part for -10˚C

By applying the strength of the top beef in frozen condition -10˚C, the analysis showed that the maximum value could apply to the new skewering part when the meat strength, 6.22 MPa is 278 MPa. After the maximum stress applied to the new skewering part, figure 8 shows that some area of the platform holder and hollow rods are bending because of the pressure. Finite element results above give safety factor 1.85. This showed that the new skewering part is not suitable to be use when the boneless meats is in frozen condition of below than -10°C.

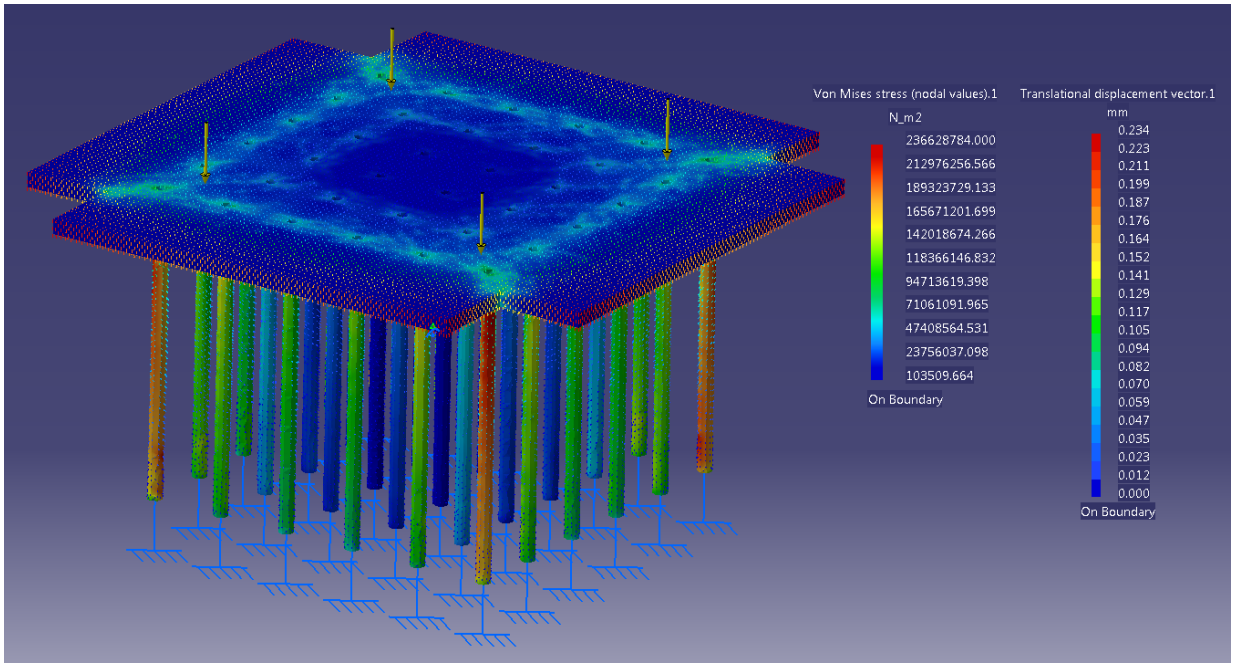

Figure 9: Static Analysis of New Skewering Part for 0˚C

After applying stress levels 0.53 MPa in Figure 9, there does not appear to be severe stress concentrations that would indicate faulty design. This also shows that, the skewering process need to wait until the meats thawed until 0˚C to avoid the new skewering part being bent. The location of the linear motor is on top of the new skewering part. The value of the maximum motor pressure will be below than 237 MPa because of the highest strength that can be accommodated by the new skewering part. From the stress levels, 237 MPa and material tensile strength, 515 MPa, that give safety factor roughly 2.17.

Table 2: Results Meats at -10˚C and 0˚C

	Mass (kg)	Maximum Deflection (mm)	Von Misses Stress (MPa)	Safety Factor
Meats at -10˚C	1.77	2.749	277	1.85
Meats at 0˚C	1.77	0.234	237	2.17

5.0 Conclusion

The research is focus on the new design, strength of hollow rod and maximum motor pressure to be applied to the new skewering part. Base of the analysis, the result shows that the new design of new skewering parts is very useful for satay industries if their looking at the time constraint for a large production. 36 sticks in one process for new skewering part compared to single stick by manual process. There are several things that will give a higher impact to the satay industries.

Instead of the cost, work force, sales, market, time, productivity, and etc. the results and benefit for the industries is the speed of production will increase per day compared to manually skewering method. Any company can produced in larger quantities within short period of time and less labour cost. Workers tiredness and exhaustive due to long period of skewering works can be reduced due to combination in one process.

The strength of the new skewering part is very suitable with the boneless meat at 0ºC or maximum value tensile strength of thawed meats, 0.53 MPa or less. By applying the maximum value tensile strength of thawed meats to the new skewering part, the conditions of the new skewering part is still in good condition and no bending appeared on the surface of the platform holder and hollow rod. These mean that the design of the platform holder and hollow rod is accepted.

The maximum motor pressure also can be determined according to the maximum value of the tensile strength, 237 MPa of the new skewering part with safety factor 2.17. The linear motor will be placed on top of the new skewering part and push horizontally when skewering process.

Acknowledgement

This research was conducted on research and teaching methods at Politeknik Sultan Azlan Shah, Behrang, Perak. The authors wish special thanks to;

i. Mr. Azrul Fakhri b. Azali, Manager of Hazal Enterprise for the information of the frozen satay industries.
ii. Politeknik Sultan Azlan Shah and Jabatan Pendidikan Politeknik Malaysia for permission to publish this work.

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