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Development of an Innovative Mango's Wrapper Tool

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Abstract: This paper presents a new design and development of an innovative tool for wrapping mango fruit by using a mechanism of compression spring. This innovative mango's wrapper tool is capable to solve the problem faced by mango farmers or entrepreneurs during traditionally wrapping process. Previously, the wrapping process is handled manually by using paper wrapper and rope while ladder is sometimes used for tall trees. 30 mango fruits are picked for size sampling. The diameter for the mature mango fruits is within the range of 5.8cm to 7.9cm. The suitable casing size is determined to be 10cm in which 3.1 cm is the tolerance. The innovative mango's wrapper tool is designed by using SolidWork 2016. Later, tool fabrication process is carried out including cutting and joining the parts such as steel compression spring, paddle, cable and PVC pipes. The analysis is focused on the compression spring and the maximum force of 45.117N is applied on the pedal to pull the jaws while releasing the rubber band. Meanwhile, the tool is highly efficient and the time for the tool to wrap one mango fruit is 65 seconds compared to 190 seconds by way of traditional method. Significant saving in term of labor workforce is as much as 67% and the ratio of manpower requirements is reduced to 3: 1. Among the factors contributing to the saving are the used of 210cm long pole which eliminate the need of use a ladder. Lastly the tool is lightweight, convenience to use with minimum maintenance.

Keywords: Mango, Wrapper, Tool, Innovative, Time

1. Introduction

Nowadays, mango cultivation is gaining popularity while demand has steadily increased every year. In global, it is an important crop in tropical regions throughout South America, Hawaii, Central America, Asia, the Caribbean, and Africa. Mango farmers often practice grafting in order to ensure fruit production [1]. In Malaysia, the contribution factor is due to food producer has becoming innovative in introducing new tool into the market. This is in line with National Agro food Policy (NAP) 2011 – 2020, which focus towards improving the food industry to be productive, competitive and knowledge-based industry [2]. It is estimated with the improvement; fruit production will increase

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from 9.6 to 12.9 tones metric per hectare from 2010 until 2020. The expansion of agriculture land bank for commercialization of fruit farming is led by the government and the private sector to fulfill the increasing demand from exporter for oversea market [3]. One of the main ideas in supporting the transformation of agro food industry is the modernization of agricultural activities through research and development (R&D). Technology and innovation used to design an innovative tool to help the agriculture industry in improving the efficiency of the farming process. As can be seen from the mango farming industry, the trend has shown an increase in the farming activities in more than 90 countries and at the same time various type of mango such as Tommy Atkins, Keith, Kent, Osteen, Haden and Valencia Pride are produced. Worldwide, mango production has increased to 35 million tons, a significant improvement for the last 30 years [4]. Indirectly, farming activities has greatly been affected and one of the areas is the wrapping process of the mango fruits. It is an important process to protect the crops form pest insects. The wrapping process, through the use of mechanical wrapping tool, is able to save huge amount of time. The mango's wrapper is also user-friendly tool, it requires mini-mum maintenance, able reducing labor cost and injury. The tool is developing from the principle of compression spring for the wrapping method while long pole is helpful in reaching the highest point of the tall mango trees.

2. Technical Development

The main problem encountered by the mango producer is the time consumed in the wrapping process using traditional method. Besides, the wrapping process is limited to mango trees up to 1-meter height. Therefore, ladder is necessary for trees with height of more than 1.8 meter as shown in Fig.1. Due to this, farmers find it difficult to achieve high productivity. To overcome the problem, a fully mechanical wrapping tool is designed to help farmers with the wrapping process.

Fig. 1- Traditional method for wrapping mango fruit.

3. Innovative Mango's Wrapper Tool Development Process

Tool development process begins with taking the sample size of the mango fruit to determine the right size of the casing. The next step is tool specifications and fabrication process.

3.1 Mango Size Determination

It is necessary to wrap the mango between 40 to 45 days after maturity. This is to protect the crops from fruit flies. For an effective wrapping tool, the diameter of the mango fruit is one of the important factors in deciding the suitable diameter size of the casing. For this reason, 30 pieces mango fruits had picked randomly from the farm. Each of the mango fruit's diameters is measured and segregated according to the range as shown in Table 1. The data is analyzed to determine the size, average, frequency, minimum and maximum of the mature mango fruit [5]. Research has shown the diameter of mature mango fruit is between 5.8 cm and 7.9cm. The highest number of diameter is within the range of (6.5 ≥ 6.9), which is 12. Meanwhile, 9 mango fruits have the range of (7 ≥ 7.4). Next, 3 and 4 mango fruits are within the range of (6.0 ≥ 6.4) and (5.5 ≥ 5.9) respectively. Lastly, 2 pieces mango fruits are within the range of (7.5 ≥ 7.7). Fig. 2 shows the range for the entire mango fruits sample.

Based on the parameters:

(a) Average diameter = $\frac{\sum fx}{\sum f} = \frac{202}{30} = 6.73cm$

(b) Minimum diameter = 5.8 cm

(c) Maximum diameter =7.9cm

The most suitable size for the housing is 10cm. Tolerance of 3.1cm is required to cater for a slightly different shape of the fruits, besides taking into consideration the standard size of the PVC pipe available in the market

Table 1- Mango size analysis data

30 pieces mango fruits for sampling diameter size	**Range Diameter**	**Median**	**Frequency**	**Cumulative Frequency**	
(cm)	*(cm)*	*(x)*	*(f)*	*(F)*	*fx*
6.5 7.0 7.2 6.8 6.8 6.5 7.1 6.4 6.6 6.8 7.5 7.0 7.1 6.5 7.2 6.9 6.2 6.7 5.6 6.9 7.3 5.9 6.3 6.6 7.4 5.9 5.8 7.9 7.3 6.7	5.0 ≥5.4	5.2	0	0	0
	5.5 ≥5.9	5.7	4	4	22.8
	6.0 ≥ 6.4	6.2	3	7	18.6
	6.5 ≥ 6.9	6.7	12	19	80.4
	7.0 ≥7.4	7.2	9	28	64.8
	7.5 ≥7.9	7.7	2	30	15.4
Minimum Size = 5.8 cm Maximum size = 7.9 cm			Σ*f*=30		Σ*fx*=202

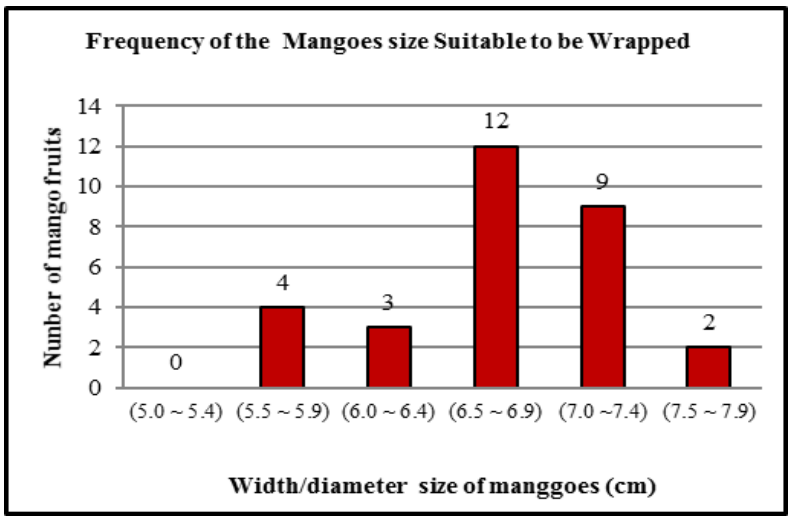

Fig. 2 - Frequency of mango fruits size.

3.2 Virtual in 3D design

Design is a visual representation of a plan or proposal. A good design process needs to take into consideration the process of fabrication while conforming to tool specification. Figure 3 shows the SolidWork 3D modeling of the tool. The 3D modeling requires details such as dimension, materials and mass. It is achievable by producing the Solid Parts and Assembly Models as shown in Fig.3 (a-f). This virtual design result has been used as a reference during the fabrication process. Each part designed including casing, connector, pole, spring, pin lock as jaw. Then all the parts have been assembly to become a mango's wrapper tool.

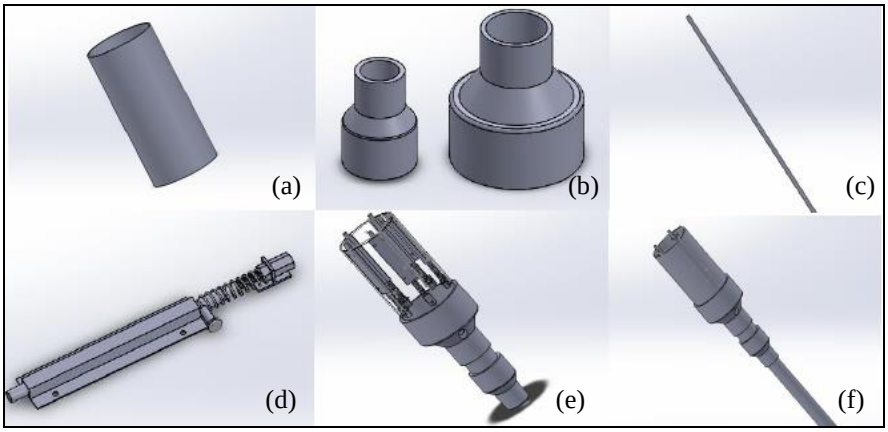

Fig. 3- Part and assembly design by using SolidWork 2016 (a) casing; (b) Connector; (c) Pole; (d) Assembly pin and spring; (e) Assembly five Jaws; (f) complete assembly all the part.

3.3 Components and Fabrication step.

Product fabrication divided into several parts. The material for the construction of structure is consisting of mild steel, compression spring and PVC pipe. Based on the 3D modeling, the dimension is measured before continuing with the cutting process. Adhesive is used for the most of the joining process. Rivet used to join the latches with the PVC pipe while the compression spring inserts into the sliding bolt.

Fig. 4 shows several components and fabrication steps. A PVC pipe with a diameter of 100mm and 210mm length is used as a casing to wrap the mango fruit as shown in fig.4 (a) The door latch are used as jaws and screwed together with the casing. The jaws are used to hold the rubber band at the tip of sliding bolt as shown in figure 4 (b) Fig. 4(c) shows all the five jaws. Fig. 4(d) shows the compression spring with a diameter of 40mm. During the wrapping process, the spring will pull the jaws downward while releasing the rubber band hinged at the tip of the sliding bolt. A pipe diffuser with diameter of 100mm and a length of 50mm is joint together to a PVC pipe of the same diameter by using adhesive as shown in fig. 4(e).

Fig. 4(f) shows two pipe reducers each with a diameter of 50mm and 100mm are joining by using adhesive. The most critical process is to connect each of the jaw to a brake clamper using cable. Five cables for each of the five jaws are required while a main cable is introduced to connect the pedal with the five cables. Lastly, a PVC pipe with a diameter of 25mm and a length of 200mm is joining with a pipe reducer with a diameter of 30mm and a length of 50mm to produce a pole as shown in fig. 4(h). Fig. 5 shows the actual and virtual design of Innovative Mango's Wrapper Tool after complete fabrication and assembly process.

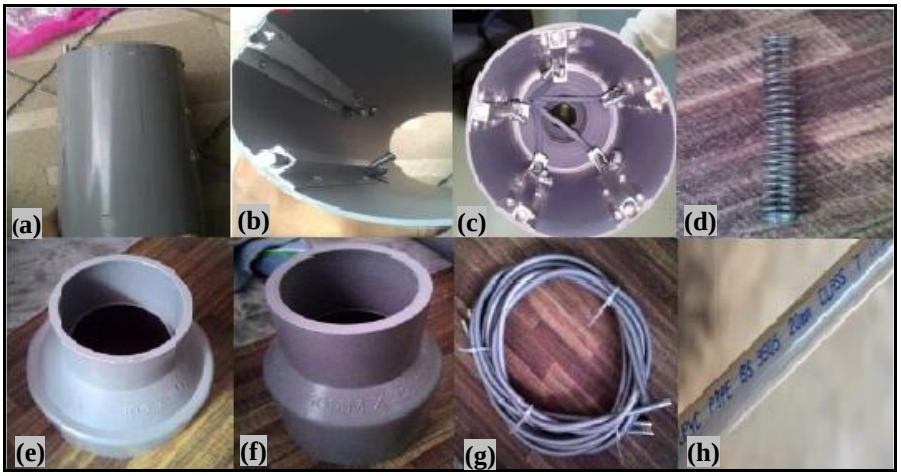

Fig. 4- Components and Fabrication steps. (a) PVC pipe cutting for casing; (b) door latch installation as jaws; (c) complete latch installation; (d) compression spring installation; (e) reducer installation; (f) pipe PVC connector; (h) connecting jaws and pedal using cable; (g) Installation of pole

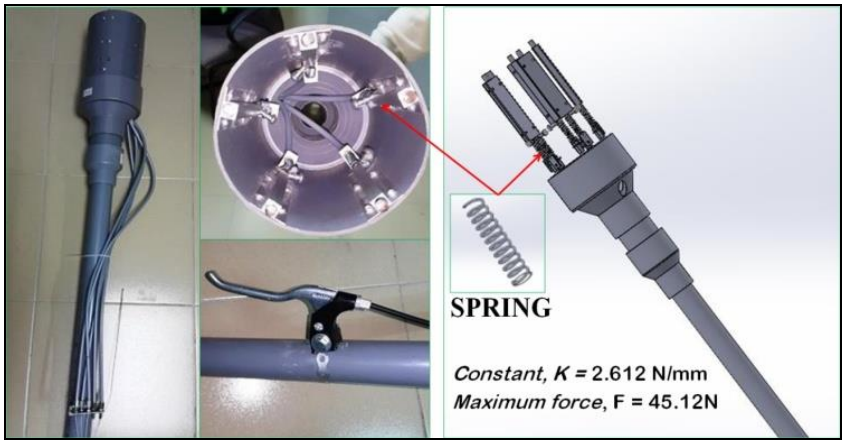

Fig. 5 - Actual design after complete fabrication process.

4. Tool characteristic and specification

The wrapping process by the innovative mango's wrapper tool can be handle by manually. Three main components of the wrapping process consist of the wrapping tool, rubber band and a 30cm x 40cm plastic wrapper. Initially, the rubber band is stretched by placing it at the tip of the five sliding bolts. The plastic wrapper is placed inside the casing. Aiming the casing toward the mango fruit and by pressing the pedal the sliding bolt will move downward and simultaneously releasing the rubber from the tip of the sliding bolt. The plastic wrapper is tied around the fruit's stalk by the rubber band. Analysis is focused to determine the performance of product in particularly the spring, time and operational cost.

4.1.Spring force analysis

Force analysis on the spring is done to determine the correct spring's size. The spring is made from "music wire ASTM A228"and of the "closed and squared" type. Following are the results from the analysis [6];

(a) Wire diameter, d: 1.000 mm
(b) Outside wire diameter, D_{outer} : 8.500 mm
(c) Internal wire diameter, D_{inner}: 6.500 mm
(d) Free length, L_{free}: 40.000 mm
(e) Total active coils, n_a : 9
(f) Total coils, n_t : 11
(g) Spring indexs, C: 7.5
(h) Coils distance, $coil_{pic}$: 4.111 mm

From the above data, the True maximum load "True F_{max}" and Maximum Load Considering Solid Height, "Solid Height F_{max}" of the spring is 45.117 N. The value of the spring constant, *k* is 2.162 N/mm. The spring stress value τ is 1.031×103 MPa. This value is based on the spring shear modulus, G which is 79.3×103 MPa and the Wahl correction factor, W is 1.197.

4.2.Time consumption analysis and product cost

The time analysis is done to compare between manual wrapping and the mechanical wrapping tool. Figure.6 shows the wrapping process from the beginning until the mango fruit is secured inside the plastic wrapper. The plastic wrapper is used because it is not easily damaged and robust [7]. Fig. 6 shows the steps how to use the Innovative Mango's Wrapper Tool. The used of rubber band instead of rope is to facilitate the wrapping process. The 5 jaws together with the rubber band and plastic wrapper are used to help the wrapping process. The jaws are required to hold the rubber band and the plastic wrapper. Once the jaws are released, the mango fruit will be secured in the plastic wrapper and sealed by the rubber band. A cable is used to connect the jaws and the pedal. The wrapping process to secure one mango fruit takes 65 second from start to finish.

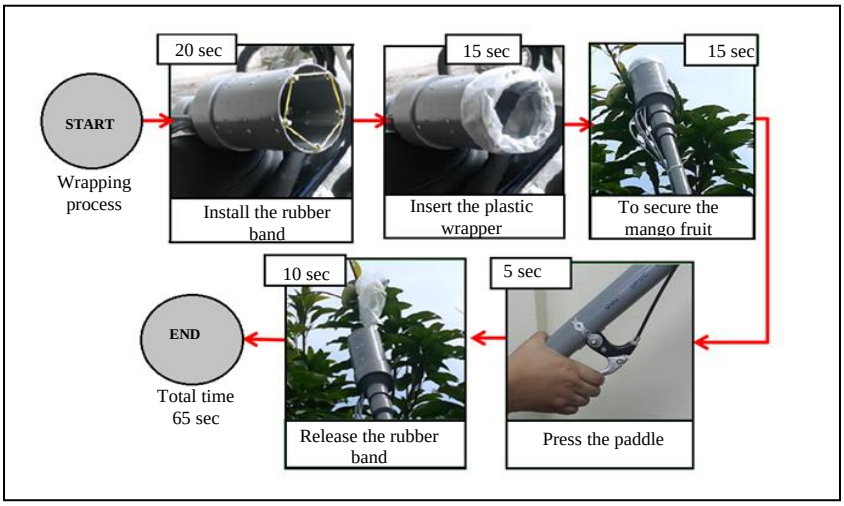

Fig. 6 - Period of wrapping a mango fruit

To determine the effectiveness of mango wrapping tool compare to the traditional method, an analysis had conducted and the result is shown in Table 3. For each of the method, 100 mango fruits are used. From the table, traditional method requires 19000 second to complete the task while mango's wrapper tool requires only 6500 second. The analysis shows a significant saving of 12500 second. On the operation cost, traditional method requires 3 workers and a ladder to complete the job. It is also shows the comparison in term of time and cost. A reduction of 67% in labor cost clearly shows the effectiveness of the mango wrapping tool.

Table 3 - Comparison of mango packaging time, cost and characteristic

		Traditional	**IMW-T**
Time	Duration time for 100 pieces	19,000 second	6,500 second
	Save time	12,500 second (ratio 3:1)	
Labor cost	Worker	3 person	1 person
	Salary/ 8 hour	3x RM50 = RM 150	RM 50
Characteristic	At high position	ladder (climb)	lever (2m)
	Mechanism	Manual	Spring
	Produce Cost/unit	Ladder Price (RM 200)	Prototype RM 70 Real RM 50
	Market Price		RM 120

4.3. Product advantages

The following are the advantages of the innovative mango-wrapping tool;

- Improving the efficiency of the wrapping process in term of time and operational cost
- Having a pole with a length of 2 meters, the product is capable of reaching the tree's highest point without ladder.
- Only require a minimum force to complete the wrapping process.
- The construction materials are lightweight and it enhances the product mobility.
- Spare parts such as springs and cable are readily available in the market

5. Conclusions

The innovative mango's wrapper tool designed based on the principle of mechanical compression spring. The maximum force of 45.117N is required to operate it as manually by human. The product is highly capable to wrap a mango fruit in 65 seconds compared to 190 seconds using the traditional method. Due to the shortening time, the ratio of labor had reduced to 3:1. The main factor contributing to the time saving is the exclusion of ladder. Instead, the product with it long pole manages to complete the wrapping process in shorter time. In addition, it is lightweight and

the operation is straightforward. Lastly, the product offers tremendous benefits in term of improving the efficiency and reducing the operational cost.

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