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# Prototyping the Novel Machine for Continuous Divesting and Laying Rubber Gloves of the Rubber Glove Process

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***Abstract***

The rubber glove process is performed by coating the hand-shape formers with coagulants and dipping them into the latex to coat with a thin latex film. The coagulants will convert the liquid latex film into a wet-gel on the formers. The formers are continuously passed through a warm oven and will be dried in the oven before heading for stripping. In the present day, the dipping lines are the semi automation with the partial stripping capability, thus the lines enable to run at speed that is impossible for the conventional dipping line. Unfortunately, the rubber gloves are not completely removed from the formers in one step, and then at this situation more than two operators are required for divesting gloves catch up with the speed of dipping line. Consequently, the machine has ability to divest rubber gloves is necessary to solve this problem. This research had prototyped the novel machine to divest the rubber gloves from formers. The machine was designed using Computer Aided Design (CAD) and Computer Aided Engineering (CAE) which comprised a gripper set which could continuously divest rubber gloves from the hand-shape formers. The gripper components had a close ability for divesting and an open ability for laying gloves. Particularly, the machine was built and tested with an artificial divesting line to divest and to lay rubber gloves. The novel machine could completely remove and lay gloves. This innovation will be developed to use in the rubber glove production line, compensate the glove divesting operators to reduce the expensive labor cost and time.

***Keywords****:* Prototyping, Novel Machine, Divesting, Laying, Rubber Gloves.

## 1. Introduction

The natural rubber latex is prepared for producing the rubber gloves by concentration and compounding with chemicals. The hand-shape formers are coated and dipped into the latex to coat them with a thin film of latex. The coagulant converts the liquid latex film into a wet-gel on the formers. The formers are continuously passed through and will be dried in the vulcanization oven before heading for stripping [1, 2]. The schematic of the rubber glove process are shown in Fig. 1. The complex techniques were invented to strip the rubber gloves using the fingers to clamp onto cuff and pull the rubber gloves away from molds [3]. In the present day, the dipping lines are now semi automated with partial stripping capability using the film article release machine [4] as shown in Fig. 2. Unfortunately, rubber gloves are not completely removed from the formers in one step. At this situation, the operators are required for divesting gloves. More than two operators may be hired to divest rubber gloves from formers to catch up with the speed of a dipping line (Fig. 3). The removed gloves are stored in the baskets and taken to pack. The rubber gloves are laying and 50-200 pairs of gloves are determined by balancing of the rubber glove weights for packing. Fig. 4 shows the balancing method of 100 pairs of rubber gloves by an operator. These steps of process have to use many operators which have experience of divesting, laying and weighting rubber gloves. The consuming of labor cost and time then usually

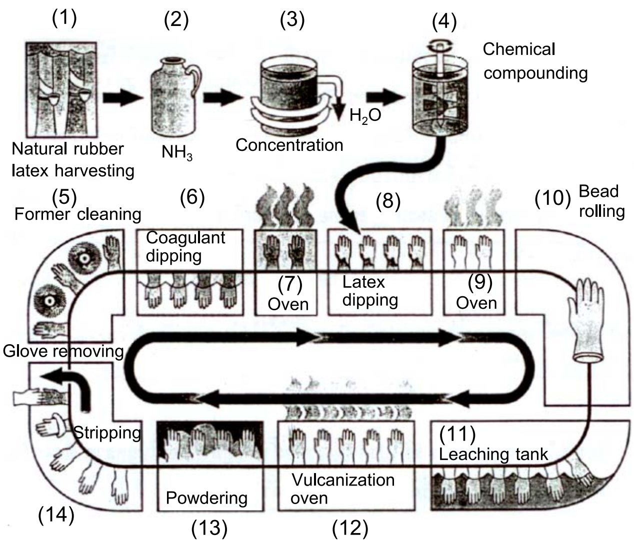


Fig. 1 Schematic of the rubber glove process

Fig. 2 Glove stripping process

Fig. 3 Removing gloves from the hand shape formers by operators

Fig. 4 Balancing 100 pairs of gloves after laying

occurs from these steps in the processing lines. The machine that has abilities to divest, count and lay rubber gloves are necessary to solve these problems.

Many inventors had created the automatic machines to remove the film articles such as balloons of the molds [5, 6]. Rodrigues and Pike [7] invented the discharge conveyor to receive gloves from the stripped heads. The stripping apparatus had been invented using brushes to remove gloves from formers [8]. Howe and Alexander [9] had invented the shell molded article stripping machine using blast of air to reverse cuff of gloves for covering the mechanical fingers. The fingers were away from the formers and the cuff of rubber gloves free to be removed with a final set of rotating brushes into a moving conveyor. These inventions could remove the rubber glove from the formers but it has not fully supported the present rubber glove process. Finally, the novel machine which completely removes, counts and lays rubber gloves is the necessary innovation. This research proposes the automatic machine which has the divesting, counting and laying ability. This machine will compensate the glove divesting and weighting operators. Particularly, this novel machine will reduce the expensive labor cost of the rubber glove process in the nearly future.

## 2. Critical Factors for Machine Design

The first ability to design the novel machine is the divesting rubber gloves from the formers. The second is the counting numbers of gloves and the third is the rubber glove laying for packing. Before advancing into the design and implementation according to the machine abilities, the critical factors of the automatic machine must be evaluated.

### 2.1 Machine Types

Batch and continuous chain are primary types of the dipping units [10]. The dipping unit types are a factor to design the divesting glove machine. A technique uses for automatic divesting will differ in accordance with the general overall type or machine employed.

### 2.2 Former Shapes and Sizing

Unless employing proper techniques, the orienting or protruding thumb on a surgical glove former can make for a stubborn divesting. A more tapered former shank from cuff to wrist area is another function for certain divesting gloves. Particularly, the employed techniques must be able to apply with different former sizes.

### 2.3 Glove Properties

The materials to form gloves have a rupture limit. The divesting techniques must avoid glove tearing.

## 3. Machine Design using CAD/CAE

### 3.1 Computer Aided Design

CAD (Computer-Aided Design) is the using of computer systems (computer and software) to create the geometric models [11]. CAD helps the designer to visualize the product and its components and creates the database to manufacture [12]. This research had used SolidWorks software to create the 3D-model of the prototype machine.

### 3.2. Computer Aided Engineering

CAE (Computer-Aided Engineering) include stress analysis on components and assemblies using FEA (Finite Element Analysis) [13, 14], Multi-body Dynamic (MBD) and Kinematics [15]. The strength of the components of the prototype machine had used SolidWorks Simulation to analysis based on FEA before fabrication. The SolidWorks Motion is an add-in option of software which had used to analysis MBD and kinematic of machine.

## 4. Result and Discussions

The critical factors were considered to design the divesting apparatuses of a prototype machine. Grippers were designed to divest latex rubber gloves from the formers. Chains were design to move grippers for counting and laying rubber gloves in a box. The model and analysis of prototype machine are described as following.

**4.1 The 3D-Model of the Prototype Machine**

The 3D-model of the novel machine comprised the major sets as grippers, chain, transmission and frame (Fig. 5). The numbers of components of each set of the model are described in Table 1. The 14 grippers of machine continuously moved by fixed with chain. The fingers of grippers would be closed and opened when the rollers under grippers rolled on a guide rail. Fig. 6 shows the close and open positions of fingers which are controlled by a guide rail. When a gripper closed, it held a glove of a former. The

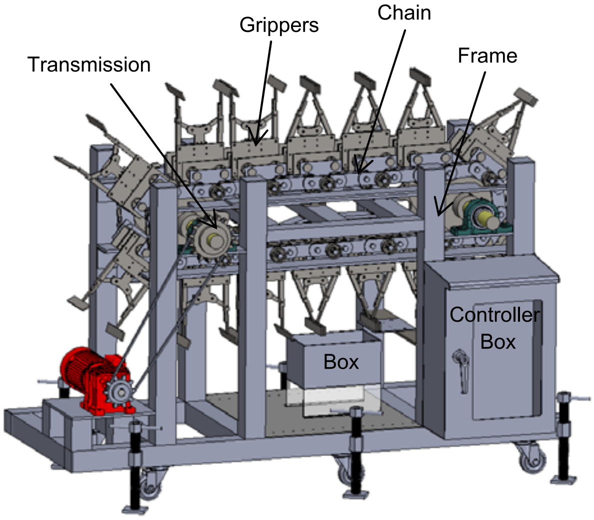


Fig. 5 The 3D-model of a prototype machine

Table. 1 Total components of prototype machine

| Set | Repeated Components | Inclusive Components |
|---|---|---|
| 1. Grippers | 15 | 336 |
| 2. Chain | 6 | 336 |
| 3. Transmission | 5 | 12 |
| 4. Frame | 25 | 74 |
| Overall | 51 | 758 |

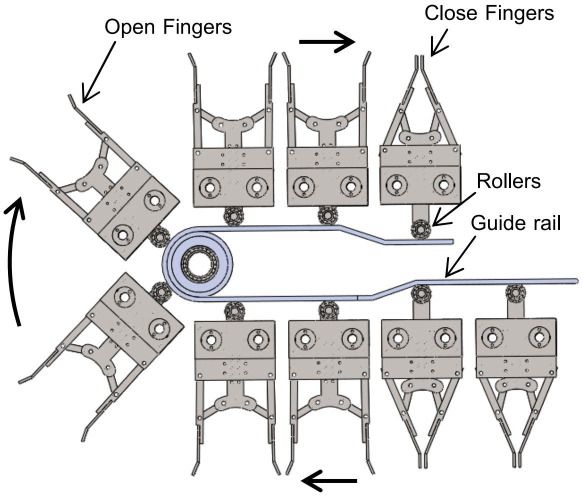


Fig. 6 The gripper models on a guide rail

rubber glove would be divested after fingers gripped a rubber glove and a gripper was away from a dipping line. The fingers would be opened again under a guide rail then a glove would be released to lay in a box.

**4.2 Strength of Machine Components**

The gears of the transmission set would be pulled by chain under load of 1,800 N. The frame set supported weight of 253.62 kg from gripper, chain and transmission set. The FEA was used to check strength of gears and a frame. The materials of gears and a frame set were AISI-4340 and AISI-C 1030 steel, respectively. The mechanical properties of material are shown in Table 2. The FEA results are shown by color contour of Von Mises stress in Figs. 7 and 8.

Table. 2 Mechanical properties of materials [16]

| Type | Elastic Modulus (GPa) | Yield Stress (MPa) | Poisson ratio |
|---|---|---|---|
| AISI-4340 | 200.00 | 860 | 0.29 |
| AISI-C 1030 | 200.00 | 340 | 0.29 |

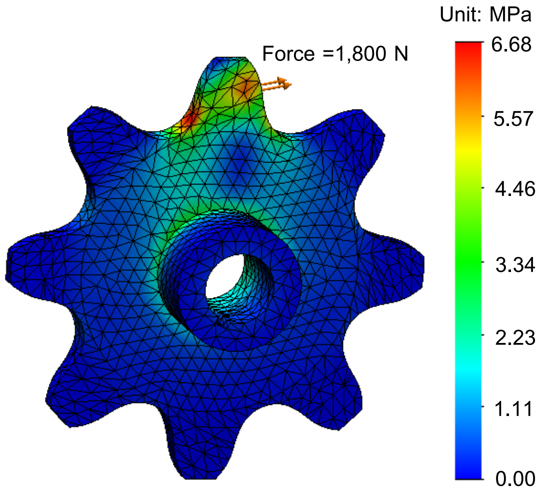


Fig. 7 Von Mises stress occurring on a gear

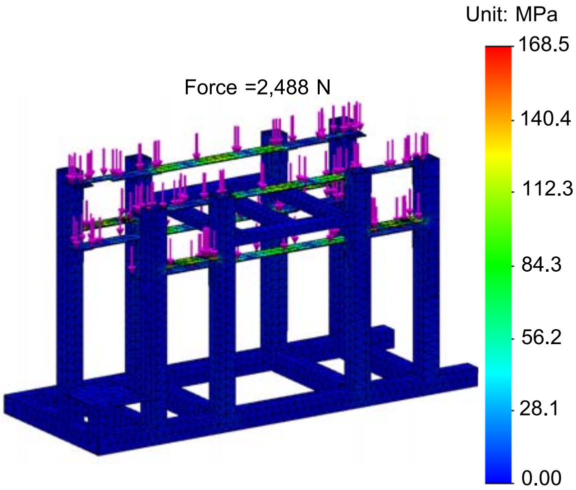


Fig. 8 Von Mises stress occurring on a frame

Factor of safeties for gears and a frame were determined and had the values of 127.64 and 2.02, respectively. Consequently, these components could withstand the applied loads and safe to fabricate.

### 4.3 Fabrication of the Prototype Machine

The prototype machine was fabricated according to a 3D-model. The gripper and chain components were combined before installed on the frame of machine. The novel machine for divesting and laying gloves is shown in Fig. 9. An infrared sensor was fixed at the frame legs of a machine to count gloves which passed with grippers under the machine (Fig. 10).

### 4.4 Implementation of the Prototype Machine

The abilities of a prototype machine were verified using an artificial glove process. The rubber gloves were hanged with acrylic hand-shape formers and conveyed using a chain which was run above the machine (Fig. 11). The grippers of a machine gripped and divested gloves from formers as shown in Fig. 12a. The gloves were pulled on the acrylic flat plate and released in a box. The rubber gloves were released continuously, and then made them

Fig. 9 A prototype machine

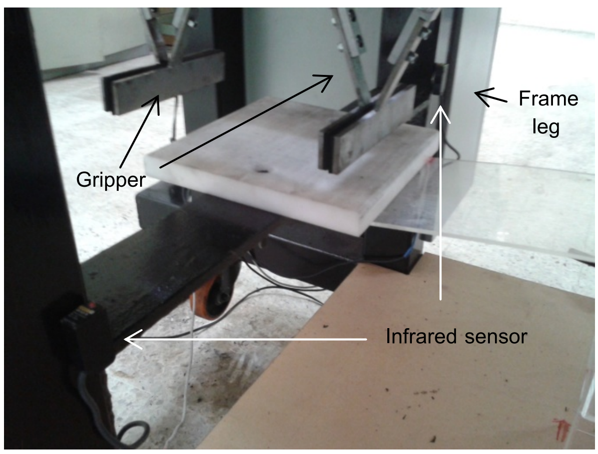


Fig. 10 An infrared sensor for counting gloves

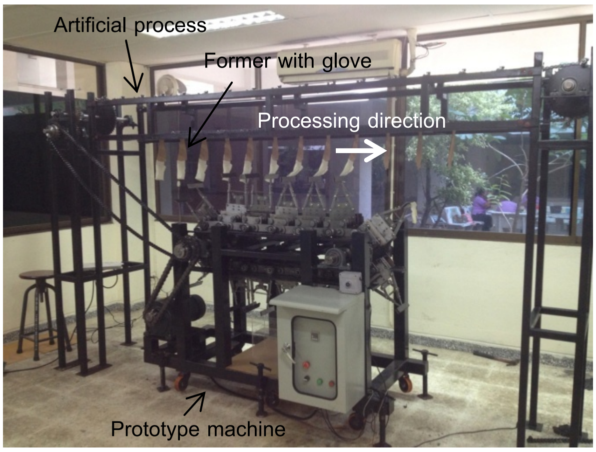


Fig. 11 A prototype machine testing with an artificial gloves process

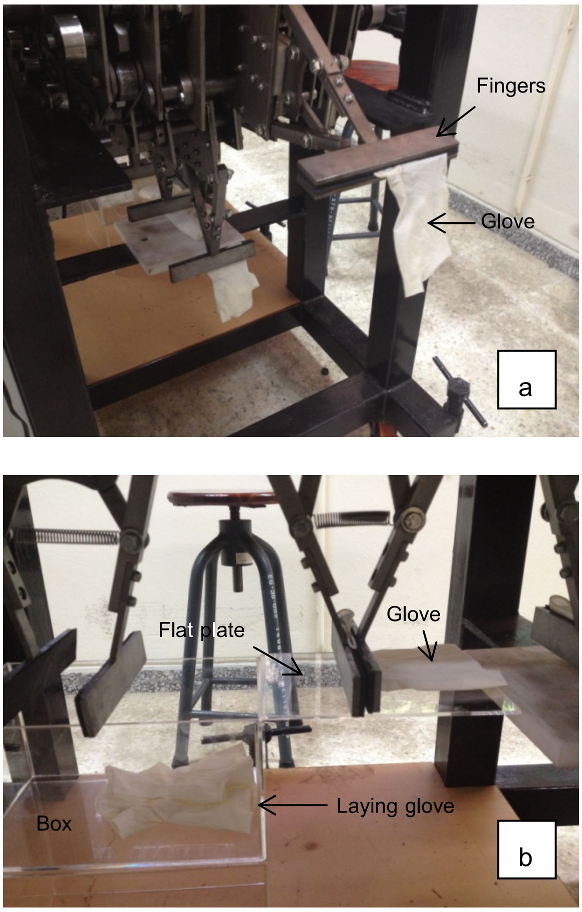


Fig. 12 Testing results of: (a) divesting and (b) laying gloves

overlapping in a box (Fig. 12b). The 10 formers with gloves per one round were verified the abilities of a prototype machine. The numbers of gloves which were divested from formers and could been laid in a box are shown by a bar graph in Fig. 13. The machine efficiency was more than 96% when tested with the total gloves of 50 pieces. The error of gripping and divesting of gloves was occurred cause of some distances between the acrylic formers were not equal to distances between the machine grippers.

## 5. Conclusion

Design of a novel machine for continuously divesting, counting and laying gloves concerned the critical factors which comprised a type of machine in glove processes, former sizes, former shapes and glove properties. The fabrication of the novel machine was performed without a trial and error method because it used CAD/CAE for pre-study. A novel machine was fabricated and verified its capacities. The good efficiency of a machine was expressed after tested with an artificial gloves processing line. The completely divesting, counting and laying gloves were the performance of a machine. The automatic divesting, counting and laying rubber gloves will

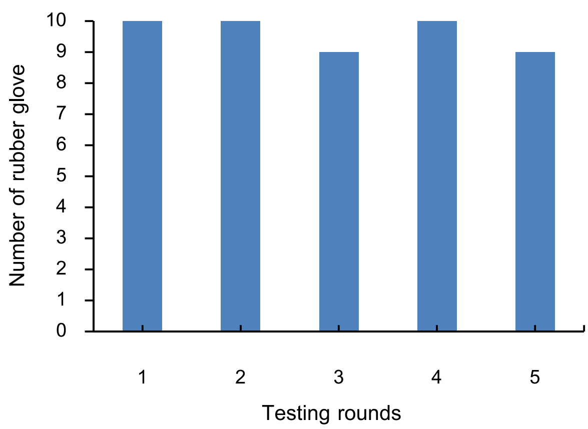


Fig. 13 The testing results of a novel machine with an artificial gloves process

be the excellent options of the dipping lines which will compensate many operators in the nearly future. The latex glove products will be increased while the expensive labor and time costs will be reduced by the automatic machines. Subsequently, the operators will be safe from the noise pollution in the rubber glove factories.

### 6. Acknowledgement

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