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Efficiency Optimization of Continuous Motion Vertical Form Fill and Seal Machine

Sachin M[1], Sree Rajendra[2]

[1]*PG student, Industrial Automation and Robotics, Dept. of Mechanical Engineering, Malnad College of Engineering Hassan, Karnataka, India*
[2]*Associate Professor, Dept. of Mechanical Engineering, Malnad College of Engineering Hassan, Karnataka, India*

Abstract – *we live in a world surrounded by automation in various forms, a manufacturing which automatically fills the raw material and packs it is called a From Fill and Seal Machine (FFS). The FFS machine increases the production rate of an industry, as these machines are automated and reduces the human intervention, it is widely used in food and pharmaceutical industries where contamination should be avoided. The machine currently available is not economical for short production and the maximum operating speed of the machine is capped at 120 bags per minute. This paper proposes a new design of the sealing mechanism to increases the production rate of the machine and it also can handle wide range bag width. This paper discusses the design and fabrication of the new design. The proposed design increases the production rate and reduces the setup time at an optimum cost.*

Key Words: Eccentric Wheel, High-speed, Packaging, Vertical Form Fill and Seal.

1.INTRODUCTION

Packing the product produces is one of the important steps in any production system. Packing can be of several types like kitting, wrapping, cartoning, filling the product inside a glass or plastic jars, filling inside tin cans etc. one of he most commonly used technique in consumer goods is filling the product inside the thin film plastic pouch.[2] This type of packing is generally known as Form Fill and Seal (FFS) method and the machine used to pack in this fashion is called FFS machine. The Vertical Form Fill and Seal (VFFS) machine is a kind of FFS machine in which the flow of material is vertical in direction from top to bottom due to gravity. The other variant is the Horizontal Form Fill and Seal machine in which the flow of material is horizontal direction which is out of the scope of this paper.

1.1 Intermittent Motion Machine

Intermittent motion machine is a type of VFFS where there is a small pause or stoppage of the machine in the process. In this type of machine, the horizontal sealer is fixed at a definite position and the film stops for the filling and sealing process. This pause/stoppage of machine is necessary because of the inertia of the sealing mechanism, since the horizontal sealing jaw uses double acting pneumatic cylinder as an actuator, the horizontal sealing mechanism have to overcome the inertial force while changing from extension stroke (sealing position) to retraction stroke (open position). The time required by the cylinder to change direction is proportional to the stroke of the cylinder and it limits the operating speed of the sealing mechanism.

1.2 Continuous Motion Machine

Continuous Motion machine are machines in which there is no need for the film to be stopped in order to seal it. Such machines use a sealing mechanism which doesn't have to overcome inertia like continuous rotation or revolution. Hence, they are faster compared to the intermittent type.

2. Methodology

The method followed in the success of this project includes but not limited to the following modules.

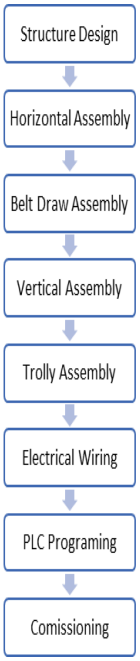

Fig -1: Methodology

2.1 Structure Design: The structure of the machine was built using cold drawn mild steel square tube of **size** 50X50X1mm**.** The structure was built with a factor safety of 2 and was tested for the induced stress and strain using Ansys 16 analysis software and it was found that the max stress was 37Mpa and max strain was 0.000188 which is within the permissible limit.

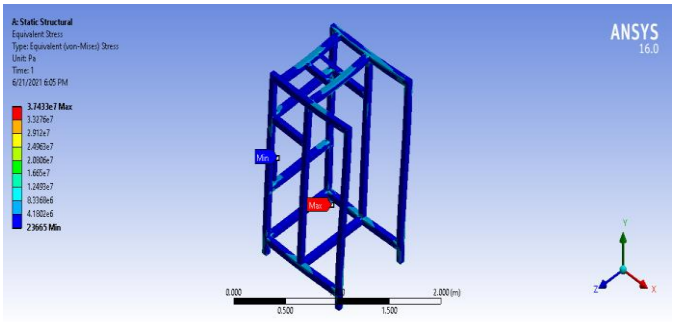

Fig -1: Stress-Strain Analysis of Structure

2.2 Horizontal Sealer Assembly: Based on the previous studies and observation the seal jaw with elliptical motion was chosen. It was decided to use Fixed eccentric wheel system which consists of a gear driven by a servomotor and the gear is fitted to a flange to which the entire sealing mechanism is assembled, this flange provides the needed eccentricity to the seal jaw and converts the rotation of the gear into elliptical motion of the seal jaw. The same was designed with the help of Solid Works 2018. The Horizontal Assembly consists two black coated mild steel seal jaw with heater and a cutter mechanism.

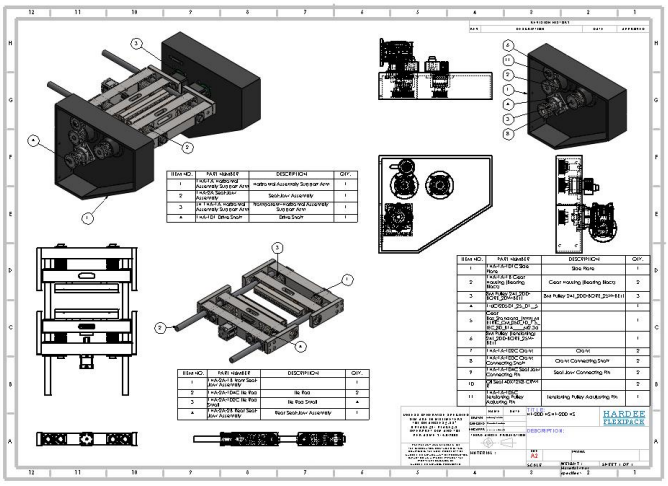

Fig -2: Horizontal Assembly Drawing

2.3 Vertical Sealer Assembly: The vertical sealer seals the two seams of flat plastic film forming a tube. A tapered Aluminum bar with heater was used as a vertical seal jaw. The seal jaw was mounted on aluminum arm pivoted at one end and actuated by a pneumatic pencil cylinder at another end.

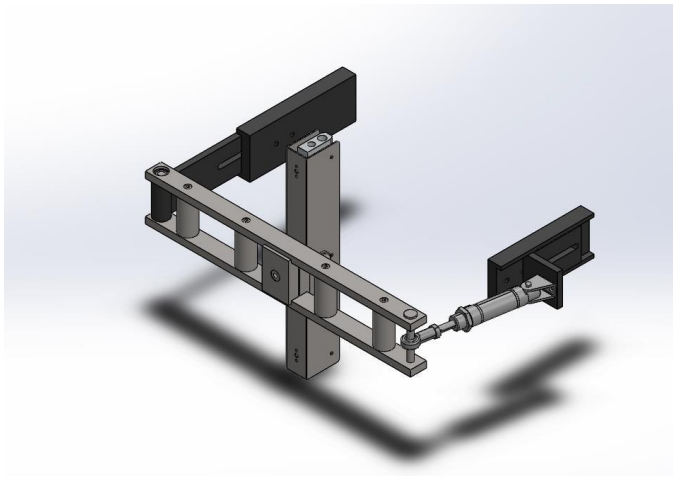

Fig -3: Vertical Sealer Assembly

2.4 Paper Puller Assembly: paper puller mechanism which draws the paper through the forming collar, the forming collar folds the flat sheet of paper into cylindrical form with two seams of paper touching each other which is sealed by the Vertical sealer creating a tubular paper stream inside which product can be dumped. A servo driven belt drawn mechanism was used for paper puller.

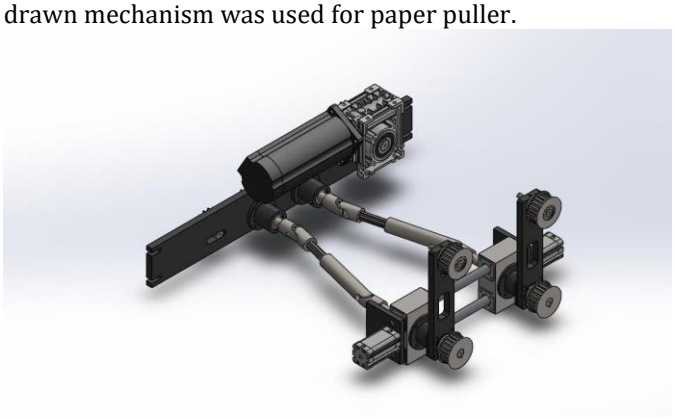

Fig -4: Paper Puller Assembly

2.5 Electrical Circuit: The project utilizes 3 phase 50hz AC power supply, The machine consists of five motors out of which three are Schneider's 1.5 HP BCH16HM10230A6C AC servo motor which are driven by Schneider electric's Lexium 16 servo Drives (one for horizontal sealer, one for paper puller, one for auger filler[optional]) and the remaining two are 1HP AC squirrel cage motor(one for Agitator, one for screw conveyor[optional]).Schneider electric's modicon TM200CE40T PLC was chosen as a controller and Autonics TCN4s temperature controller was used to regulate the horizontal and vertical heater temperature. An HMI HMIGXU3500 was used to facilitate the interaction between the machine and the operator.

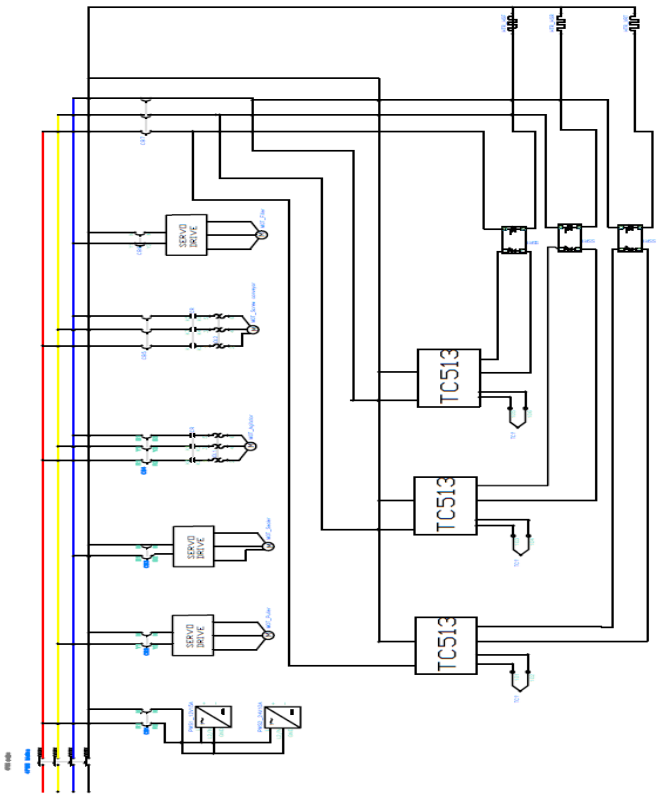

Fig -5:AC Electrical Circuit

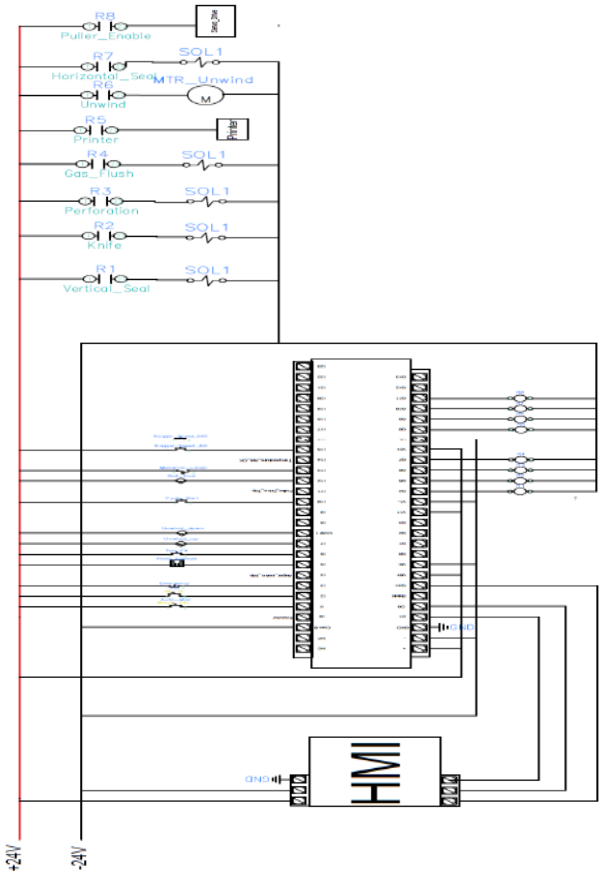

Fig -6: DC Electrical Circuit

2.6 Programing and Commissioning

The controller was programmed using Ladder logic using Echostruxure Machine Expert V1.2. Vijeo Designer V1.2 was used to Design HMI Layout. All the machine operating parameters were set by trial and error method.

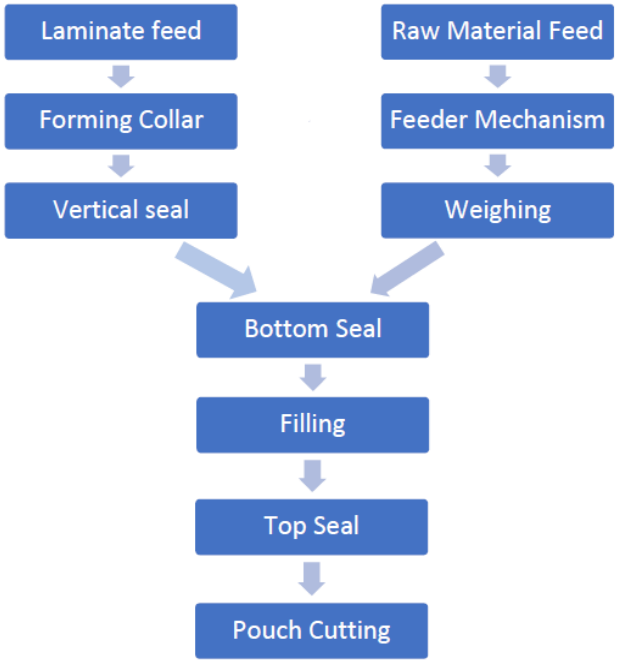

Fig -7: VFFS Process Flow

3. CONCLUSIONS

A high-speed continuous motion VFFS machine with eccentric wheel type sealing mechanism was designed, fabricated and tested aiming at increasing the efficiency of the machine. The new design increased the production rate of the machine by 25% and it increases the overall efficiency of the machine by 25-27%. The new design is cost effective as it doesn't consist any complicated mechanism. Incorporation of such an efficient machinery in small scale industry can help them increase their business and in a developing country like India where MSME sector contribute 6.1% of manufacturing GDP and 24.63% of GDP from services.[6] a technology like this can help country grow economically.

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