

Pressure analysis of a water hydraulics system in an automatic food processing machine

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ABSTRACT – This study focuses on the effect of pressure to the application of water hydraulics system in a food processing machine. Water is used as a pressure medium to control the movement of double acting cylinders inside a customized food processor machine. Automatic cyclic movement is used to press the dough out of the extrusion cylinder. In this paper, analysis on pressure fluctuation during the process is presented.

1. INTRODUCTION

The aim of this project is to develop a water hydraulic system for a sustainable food processor system. This is an effort to make water hydraulic system available for local industrial and domestic application. Tap water is used as the medium to transfer energy and pressure from pump to the cylinder. Water is cheap, environmentally friendly and can be easily integrated into the food industries. [1]-[4]. Simultaneously, pressurised fluid can be integrated into the system, and with the help of suitable controller, can be used to control the operation of the machine. Thus, a study on the changes of the pressure in the water, or pressure transient, is important [5]. This will certainly affect the quality of the produced food itself.

A test rig for an automatic food processing machine has been fabricated. The controller can be used interchangeably by using a relay system [6], a programmable logic controller [7] or even embedded system such as Arduino [8] and Raspberry Pi. Nevertheless, the controller will be used to control a 24 VDC four-way spool valve, with extrusion and batch cylinders used in the experiment. Measurement of pressure is taken from the extrusion cylinder, which also control the thickness of the produced products. The specification of the cylinders can be found in Table 1.

Table 1 Properties of hydraulic cylinder.

Properties	Data
Bore size	63 mm
Rod size	20 mm
Stroke length	500 mm

2. METHODOLOGY

Figure 1 shows the arrangement of a test rig for an automatic food processing machine comprises of pump, inverter, controller, valve, sensor and cylinder used in the experiment. In this system, tap water is utilized as the medium to provide force and pressure in the cylinders. Fluid pressure that is entering the system will be provided by the water pump. The pump transfers a deliberate amount of pressurized water into the system, with control from the inverter system, that controls the speed of the electric motor. The cyclic stroke movement from the extrusion cylinder, will produce extruded cookies in batches. The pressure that is provided by pump is measured at the extrusion cylinder inlet, using a pressure sensor. This system have pressure relieve valve in order to maintain input pressure at 3.0 Bar.

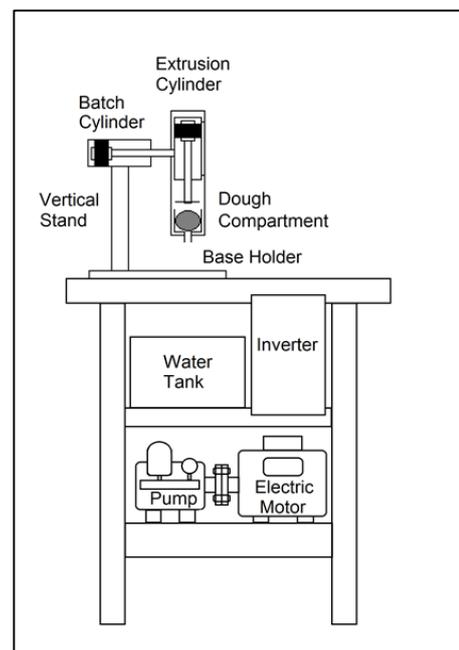


Figure 1 Automatic Traditional Cookies machine.

3. RESULTS AND DISCUSSION

Figure 2 shows the result of the pressure analysis from the test rig. Pressure input for the system is set at 3.0 bar. At the beginning of the experiment, the unbalanced pressure happens during first and second peak of the graph because of there is a gap between the cylinder and dough as shown in the small circle in the figure. However, after the third peak until the end of the graph, the pattern of pressure transient is uniform until the end.

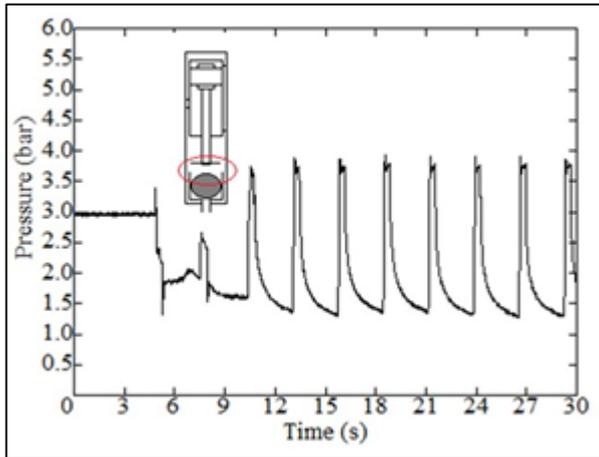


Figure 2 Pressure analysis.

During the pressing process of the dough, the valve is opened to let the pressurized water flows into the cylinder. The pressure in the system decreases proportional during that process. This system requires an average pressure of 1.40 bar to push the dough through the mold. A sudden increasing of pressure is recorded during the process, when the cylinder stops. This is due to the condition of the directional control valve in close mode. The highest-pressure peak of the graph is 3.93 bar at 18.5 s. During the closure of the valve, it can be seen a water hammer effect can be observe in every peak. It is concluded the hammering is related to the effect of intense water pressure due to the sudden closure of the valve.

4. CONCLUSION

In this paper, the relationship between stroke movement and pressures has been analyzed. Based on the result, during the making of every single of cookies, the pressure will rise in the system. This phenomenon happen due to compression by the stroke to the cookies dough. However, the rise of the pressure is small, and within the safety limit of 3 Bar pressure. Such condition will have no negative effect on the cylinder and piping system of the machine.

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