Development of Balloon Forming Machine Andit's Control using Plc

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Abstract— Balloon forming is the fundamental processes by which the stents are manufactured that are utilized for angioplasty to cure critical heart diseases. Careful selection of various parameters such as pressure, temperature, along with the time duration, etc. affects the balloon quality and plays vital role in effectiveness of critical care of the patient. The proposed system converts the microprocessor controlled balloon forming unit to GUI based computer controlled balloon forming unit. Keeping most of the important variables of the balloon forming process same, and hence utilizing the same transducers, some new sensors are also introduced to avail more information on the operator station. The proposed system is comparatively not only more user-friendly and accurate, it also results into easy to expand and modify type simple but reliable as well as cost-effective solution.

Key words: PLC, balloon forming machine, stent

I. INTRODUCTION

Balloon forming is designed to produce a variety of high strength polymer balloons using a stretch, blow molding process. These balloons are almost exclusively used in medical procedures, such as Angioplasty, stent delivery and many other dilation and occlusion application.

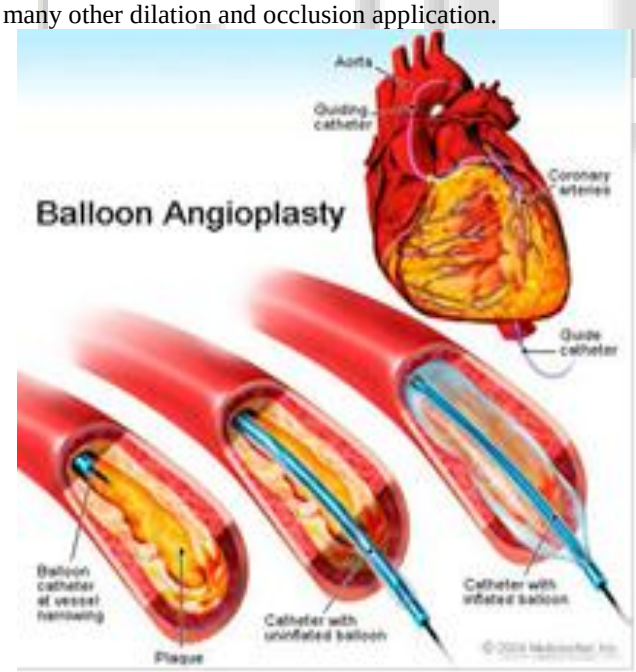

Fig. 1. Balloon Angioplasty [2].

An angioplasty balloon is a medical device that is inserted into a clogged artery and inflated to clear blockage and allows blood to flow. The full medical name for the angioplasty procedure is percutaneous transluminal coronary angioplasty.

With extensive use in the United States since 1980, it can relieve angina (chest pain) and prevent heart attacks in people with coronary artery disease. Before angioplasty, bypass surgery was the only option for people with clogged arteries. In bypass surgery, doctors must open the patient's chest to reroute blood vessels to the heart. Angioplasty is less invasive, as the balloon is fed in through the blood vessels, and the chest remains closed. Patient recovery time is also generally faster with angioplasty, than with bypass surgery.

Angioplasty is performed under local anesthetic, and the patient is kept awake so the doctor can ask if he or she feels any pain during the procedure. The surgeon opens the femoral artery at the top of the leg, and passes a catheter threaded on a thin guide wire into the blood vessel. The catheter, which is a tubular medical device, is about 3ft (91 cm) long. The surgeon feeds the catheter through the blood vessels into the coronary artery. The catheter releases dye, so its precise position can be seen on a fluoroscope, which is an instrument used for observing the internal structure by means of x-ray. When the first catheter is in place at the clogged artery, the surgeon feeds a smaller, balloon-tipped catheter through it.

This catheter is about the width of a pencil lead, and the length of the balloon itself corresponds to the length of the affected section of artery—usually less than an inch. The surgeon guides the balloon-tipped catheter into the narrowed artery. The doctor inflates the balloon for a few seconds. It reaches a diameter of about an eighth of an inch (0.3 cm). If the patient does not feel any pain, then the doctor proceeds to inflate the balloon for a full minute. This clears the arterial blockage, and then the catheters are removed. The patient is treated with prescription drugs to thin the blood and prevent clots, and should recover from the operation within weeks.

II. BALLOON FORMING MACHINE

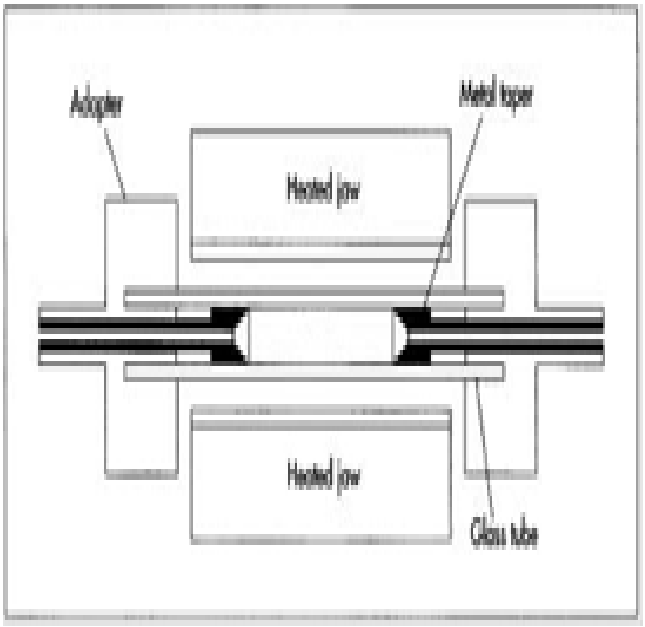

Fig. 2. Architecture of balloon forming [3].

Angioplasty balloons are made by extruding material into a tube shape, and then forming the tube into a balloon through a process known as blow molding. The balloon is formed through blow molding. Though many tubes are cut, blow molding takes place one piece at a time. A worker inserts the pre-form into a device called a glass form. The manufacturer may have various glass forms that correspond to different finished diameters of the product. Next, one end of the tube is welded shut. The open end is connected to a supply of compressed air. Then two heated jaws close around the part. The compressed air is switched on, and it keeps the pre-form at a constant inner pressure. The heated jaws warm the piece. This warm up time prepares the plastic for the next step. The blow molding process is controlled by a computer with sensors that determine when the material has reached the optimum temperature for the next step of pressure forming.

After the warm up, the computer signals the compressed air machine to switch to a high-pressure mode. The balloon is inflated at this high pressure for a specified amount of time. Shortly after the high-pressure stage begins, the heated jaws stretch the material. Then the formed balloon is cooled, again with compressed air. Now it is ready for removal from the glass form, inspection, and packaging.

III. ANGIOPLASTY BALLOO

Fig. 3. Different Size of Balloon [3].

A patented coating eliminates the chance of an angioplasty balloon being punctured or damaged during stent delivery and post-stent dilation. It increases the coefficient of friction between stent and balloon surface so there is no movement or slippage. The coating can be produced from a variety of polymers.

Angioplasty balloon catheters come in a wide range of lengths and diameters, and are made from a variety of materials, but the major shared characteristic is that the balloon can inflate to a certain diameter and not beyond, thus allowing a predictable opening. Balloons can be produced in a range of sizes, configurations, lengths and burst pressures. Wall thickness is typically 5 to 50. Balloons are available with 0.5 to 50-mm diameters and sizes from 2 to 12 mm.

A. Extrusion

The raw materials for the balloon arrive at the manufacturing facility in granulated form. Workers empty the raw materials into a heated, barrel-shaped vat. As the granules melt and liquefy, a rotating screw mixes the materials into a homogeneous blend. The liquid plastic is then pumped through an extrusion device. This is a nozzle with one hole cut in it. The liquid comes out the extruder as a long tube. The tube is pulled by a mechanical puller through a cooling bath, which freezes the tubing so that it is solidified. Next, a mechanical cutter chops the tubing to its specified length. At this point, the tubing is called a pre-form.

B. Raw Materials

The key requirements of angioplasty balloons are strength and flexibility. A variety of plastics has been used that combine these traits. The first angioplasty balloons in use in Gruentzig's time were made of flexible PVC (polyvinyl chloride). The next generation of balloon technology used a polymer known as cross-linked polyethylene. The materials typically used in the twenty-first century are PET or nylon. PET is the kind of plastic commonly used in plastic soda bottles. It is somewhat stronger than nylon, but nylon is more flexible. So either material is used, depending on the manufacturer's preference. Some angioplasty balloons are coated for lubrication, for abrasion resistance, or to deliver an anticoagulatory drug. In these cases, an additional raw material is required.

Angioplasty balloons are composed of polyethylene, polyethylene terephthalate (Dacron), nylon, or other low-compliance polymers. Burst pressure, which is the specific inflation pressure at which 1% of tested balloons burst, is rated by the manufacturer. Most polyethylene balloons are rated to 10-12 atm, whereas Dacron and other polyester balloons are rated up to 15 atm. The Blue Max Balloon (Boston Scientific Corp.) and similar products are notable for their reinforced high-pressure polymer construction and ability to be pressurized to 20 atm. Occlusion balloons are manufactured of compliant polymers such as polyurethane, latex, or silicone. Burst pressures in occlusion balloons (usually ~ 5 atm) are of less consequence because these balloons are not meant to exert large amounts of force, making inflation to high pressures unnecessary. Here Balloon tube is made up from Pabax + Grilamid TR (70+30 %).

IV. HARDWARE

- PLC
- Halogen Lamp
- Halogen Lamp Intensity Controller
- Temperature Sensor
- Pressure Control Valve
- Proximity Switch
- Clamp
- Solenoid Valves
- Alignment Tools

V. SOFTWARE

- RSLogix 500

VI. HARDWARE IMPLEMENTATION

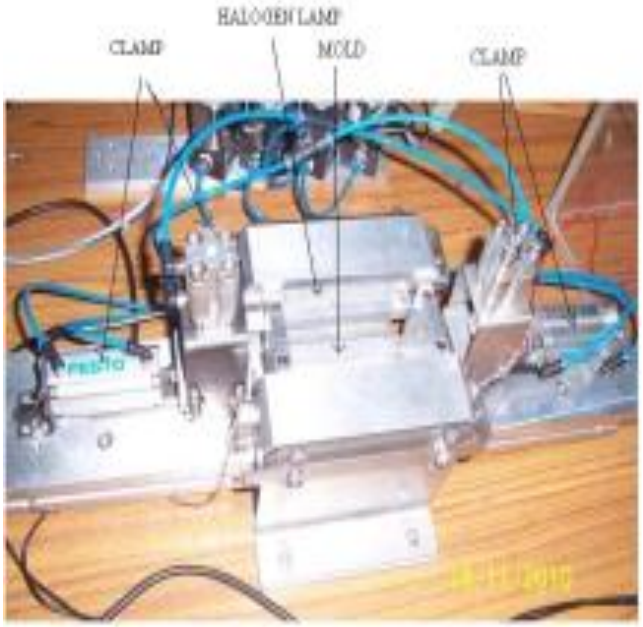

Fig. 4. Hardware of balloon forming machine.

In this machine control when power supply is on halogen lamp is on. Due to its intensity heat will be generated and temperature will increase. It is heating mold and balloon tube become soft. Balloon tube is put inside mold. At the same time pressure valve will becomes on and given pre pressure to the tube. After predefined time temperature will maintain and forming pressure is given to the tube for some time. After then for the stretching application, we have to give the supply to the solenoid valve and it gives pneumatic pressure to the clamp and clamp will be on. And balloon is form. Then cooling will be on and temperature decrease.

This unit in figure 5 is Halogen lamp intensity control unit, which is PAC-2(Phase Angle Control). According to change the phase angle, change intensity of the Halogen lamp. And according to changing intensity temperature will be change. So this unit controls the temperature of Balloon Forming Machine.

Fig. 5. PAC-2.

In figure 6 Pressure control valve (Proportion-Air (QB3)) is given. It is operated at 0-10 volts and controls 0-30 bar pressure. I have scaling 0-30 bar pressure at 0-10 volts. So we will vary pressure according to variation of 0-10 volts. There is no requirement of any type Pressure sensor for the feedback. In Proportion-Air (QB3) valves there is inbuilt facility of feedback the temperature.

Fig. 6. Pressure Control Valve.

In figure 7 Solenoid valve is given. It is normally open and normally close valve. It is operated at 24 volts. And it controls the pneumatic pressure for the operation of the clamp.

Fig. 7. Solenoid valve.

VII. CONCLUSIONS

Balloon forming is one of the basic processes by which the stents are manufactured that are utilized for angioplasty to cure critical heart diseases. The proposed system converts the presently microprocessor controlled balloon forming unit to GUI based computer controlled balloon forming unit. Almost all the important variables of the balloon forming process have been kept same, but some new parameters have been added by introducing some new sensors to avail more information on the operator station. The proposed system is comparatively not only more user-friendly and accurate, it also results into easy to expand and modify type simple but reliable as well as cost-effective solution. Local operation is provided using ladder logic based client running on workstation installed with the application developed. Majority of the functionalities proposed are validated by laboratory implementation. Working model of the proposed solution has been designed, implemented, tested and validated by trial runs.

VIII. FUTURE SCOPE

This project is for given type of balloon forming unit only. There are various other types of such balloon forming units available in the market. This project can be further developed to suit customization in order to make it configurable for almost any type of balloon forming unit. More intelligence and functionalities can be added into the GUI. Wireless module can also be attached to add wireless monitoring and control features. Client server type application can be created so this software application will be available to other computer terminals connected through LAN. This application can be modified in order to monitor the same system via web based GUIs.

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