Abstract

The purpose of this poster is to develop an automated production layout along with its design for above mentioned subject. The research work includes designing the fixture for holding the bottle while capping and three-finger self-centering gripper for placing and moving the bottle to and fro from guideways to the bottle bottom holder and vice versa. Suggesting an automated system and technology for checking the water level in bottle and effectively removing such bottles from assembly line would also be one of the objectives of this poster. Tools like automated torque wrench, precision indexing conveyor belts, three-finger self-centering grippers, three-jaw chuck (bottle holding fixture), infrared level detection sensors have been used in this system. FEA analysis of three-finger gripper and three-jaw chuck is done to verify their design. The components of this system are designed using Creo Parametric 2.0. Designed components are analyzed using ANSYS Workbench 16.0.

KEYWORDS: Automated production layout, Pneumatic Torque Wrench, Precision Indexing Conveyor Belt, Spring Loaded Cap Dispenser, Infrared level Detection Sensor, Three Finger Self Centering Gripper.

Introduction

Clean water is an essential basic human need. Packaged drinking water is a solution for getting pure and germ free water when clean drinking water isn’t available. Due to the high demand for packaged drinking water there are lot of companies providing it. Recycling and washing the bottles, proper orientation of bottles and caps, filling the bottle with required quantity of water, capping of bottles, labelling the capped bottles, inspecting them & packaging the inspecting bottles are the processes of bottling in any bottling plant. Except few, mostly these companies are small-scale and local industries due to market availability. The companies with large turnover mostly have all their systems automated. Moreover, the cost of installation of a fully automated bottling plant is quite high with respect to total budget of company. So most of the small industries have some systems automated but not all. For example, capping of water bottle would be done by the torque wrench, but there is a possibility that either the water bottle is manually fed to it or the torque wrench is manually operated. In countries where labor is cheap these is large turnover mostly have all their systems automated. The research work includes designing the system for above mentioned subject. The research work includes designing the fixture for holding the bottle while capping and three-finger self-centering gripper for placing and moving the bottle to and fro from guideways to the bottle bottom holder and vice versa. Suggesting an automated system and technology for checking the water level in bottle and effectively removing such bottles from assembly line would also be one of the objectives of this poster. Tools like automated torque wrench, precision indexing conveyor belts, three-finger self-centering grippers, three-jaw chuck (bottle holding fixture), infrared level detection sensors have been used in this system. FEA analysis of three-finger gripper and three-jaw chuck is done to verify their design. The components of this system are designed using Creo Parametric 2.0. Designed components are analyzed using ANSYS Workbench 16.0.

AUTOMED WATER BOTTLE FEEDING, CAPPING AND INSPECTING SYSTEM

The total assembly prototype of the automated system is shown in fig 1. For convenience we can divide the whole system into different sections depending upon the components they use. The system is designed for a bottle of height 10.23 in and base diameter 2.75 in with neck radius of 0.8 in and bottle head of 1.1 in. The bottle is already filled with measured quantity of water in the earlier stage and is ready for capping.

1. Precision Indexing Conveyor Belt

All the conveyor belt used in this system are precision indexing conveyors. These conveyors are used for carrying the water filled bottles from filling station to capping station. These conveyors have long dwell time and short index period and can be integrated with pneumatic, cam-controlled or servomotor actuated operations.

2. Spring Loaded Cap Dispenser

The dispenser is located directly over the path of the bottles traveling on the conveyor belt. Two rollers support the bottle head, just enough to let it pass while the cap is being dropped down. When bottle hits the flap at entrance of dispenser, the flap moves in actuating the stopper at the end chute to move down through a spring mechanism. As the stopper moves down cap drops on the bottle head as it moves ahead.

3. Three Finger Self Centering Gripper

This gripper is used to pick the bottle from conveyor and placing it in the three-jaw chuck for capping and another gripper places the capped bottle again on the conveyor for further process. These grippers are mounted on rod less pneumatic cylinders with three degrees of freedom. The fingers of grippers are equally placed to support and grip bottle. The three fingers are actually pneumatic actuators having converging and diverging motion.

4. Bottle Bottom Holder

The bottle bottom holder is basically a three-jaw chuck which clamps the bottle during the capping process. The chuck has motion to move in and move out through the guideways. So they can be used for bottles with different base diameters too.

5. Pneumatic Torque Wrench

As the cap has diameter 1.22 in and material is PE plastic the standard capping torque required is 16-20 lb/in and removal torque is 10-14 lb/in. The apt working pressures for this operation are 25-30 psi. The torque wrench is fixed to an upper plate by bolts and has motion in upward and downward direction.

6. Bottle Removal System

This system is located on the conveyor for removing insufficiently filled bottles. When an incompletely filled bottle is detected by the sensor it actuates the actuator to move forward. The actuator has a fixture to hold and carry bottle forward out from the conveyor. This sensor uses a beam of infrared light of 15 mm in diameter and a wavelength of 1450 nm. It has a transmitter to emit light and a receiver to detect the emitted light. The clear PET plastic bottle attenuates about 5% of the light emitted, while the water attenuates about 95% of the light, allowing for precise liquid detection.

ANALYSIS

1. Analysis of Three-Finger Gripper

The material selected for gripper structural steel. The top face of finger is fixed and a stopper moves down cap drops on the bottle head as it moves ahead. The pro-e models of different components of assembly system are discussed below.

1. Precision Indexing Conveyor Belt

All the conveyor belt used in this system are precision indexing conveyors. These conveyors are used for carrying the water filled bottles from filling station to capping station. These conveyors have long dwell time and short index period and can be integrated with pneumatic, cam-controlled or servomotor actuated operations.

2. Spring Loaded Cap Dispenser

The dispenser is located directly over the path of the bottles traveling on the conveyor belt. Two rollers support the bottle head, just enough to let it pass while the cap is being dropped down. When bottle hits the flap at entrance of dispenser, the flap moves in actuating the stopper at the end chute to move down through a spring mechanism. As the stopper moves down cap drops on the bottle head as it moves ahead.

The maximum stress acting is 6848.3 psi. Which would act on the vertical faces of all three chucks. So the force acting on a single jaw is 100lb. The results for total deformation and equivalent stress are shown in the fig 9. The maximum stress acting is 6848.3 psi. F.O.S = 36529/6848.3 = 5.30 Thus of factor of safety is 5.30 which verifies that designed component is safe.

2. Analysis of Chuck of Bottom Holder

The jaws of chuck have to withstand the torque of the torque wrench. The value of this torque is almost 20 lb/in. Now this torque would produce a force of 20* 15 ~ 300 lb which would act on the vertical faces of all three chucks. So the force acting on a single jaw is 100lb. The results for total deformation and equivalent stress are shown in the fig 9. The maximum stress acting is 6848.3 psi. F.O.S = 36529/6848.3 = 5.30 Thus of factor of safety is 5.30 which verifies that designed component is safe.

Conclusion

The poster proposes a cheap, effective and automated model for capping the bottles as well as detecting and removing insufficiently filled bottles. The various components discussed in the model are cheap and aptly suitable for the function which they are intended to perform. Stress analysis and deformation analysis of fingers of three-finger gripper and jaw of bottle bottom holder were done by ANSYS workbench 16.0. Factor of safety for both the components were found well above two. Thus this system would be very beneficial to small scale bottling plants with low cost of installation and setup.