

Manufacturing of Gas Sampling Chamber Components

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Abstract

Creating a useable product from an engineering design requires a special skill set and knowledge of machining tools. Using an engineering drawing, dimensions are noted and then stenciled onto the raw materials using a variety of measurement tools. Assortments of cutting tools are employed to create a dimensionally accurate component, and the components are assembled to create a usable device. Each operation requires a specific knowledge of the machine being used and calls for various techniques to manufacture accurate components.

Keywords

PVC Sheet – Polyvinyl Chloride, a thermoplastic polymer with a density of 1380 kg/m^3 . Extremely weather resistant.

Square – Measurement tool comprised of two rulers joined at an exact 90° angle. Used to draw straight lines and check component alignment.

Caliper – Measurement tool used to determine distance between two symmetrical sides. Display is either digital or manual, and can accurately display a measurement to the ten-thousandth on an inch (hundredth of a millimeter)

Bandsaw – Powered machine used for cutting. Blade consists of a toothed band of metal riding on two wheels that rotate in the same plane.

Mill – Powered machine used for component shaping. The mill utilizes a vertical or horizontal rotating spindle that holds the cutting tools. May be used for cutting, planing, drilling, rebating, and routing.

Introduction

It is one thing to design a product on paper, but often engineers have difficulty bringing their design to life in a useable form. Through the use of machining tools, a user can turn raw materials into a functional device. These tools require specific knowledge of the machine being used, and calls for various techniques to manufacture accurate components.

Objective

The objective of this paper is to guide the reader through the steps required to manufacture a gas sampling chamber comprised of sheet PVC components. The machining tools required will be introduced, as well as tips and techniques to accurately reproduce the dimensions of a paper design.

Machining Operations

Measurement

The first and most critical step of manufacturing the sampling chamber is accurately measuring the dimensions of the various components. When dealing with gas or any other fluid containment device, the slightest inaccuracy can lead to leakage and the failure of the device. The device was designed using the UniGraphics software, and

dimensions can be easily obtained from the program. The tolerance of all dimensions is ± 0.25 mm.

Accurate measurements can be obtained using the following tools: a square, rulers, and a caliper. The square is essentially two rulers connected at one end at an exact 90° angle. By taking the sheet PVC and aligning the corner at the 90° angle of the square, a square component can be obtained. Depending on the length of the component, a ruler or caliper may be used to determine length and width. Digital calipers can accurately display a measurement to the ten-thousandth of an inch (hundredth of a millimeter), however most have a maximum length of only 6 inches (152.4 mm). For longer components, a ruler should be used. Using a pencil, mark the appropriate length. Next, take the square and align its bottom edge with the bottom edge of the PVC sheet, and align its vertical edge with the pencil mark. Using the pencil, mark the entire length along the vertical edge of the square. This method will ensure that straight line at exactly 90° is drawn to guide cutting. Proper measurements will ensure that components will fit together properly. If the line guiding the cut is even slightly angled, the components will not fit exactly and gas will be able to escape.

Cutting with the Bandsaw

After measurements, the component needs to be cut from the raw material sheet, and this is achieved using a bandsaw. The bandsaw is a variable speed machine, and it is important to set the speed according to the material being cut. In this case, PVC sheet is a soft material, so it is cut at a high speed, around 2200 ft/s. Harder materials, such as steel and aluminum, cannot be cut at such a high speed as the material would grind the teeth of the saw down, dulling the blade. These materials should be run around 150 ft/s and 1000 ft/s, respectively.

The first step is to turn the machine on. After being powered, the speed can then be set using a dial on the machine. It is important not to adjust the speed while the device is not running as this will upset the gearing of the machine. Place the measured sheet on the cutting table of the machine and align the marked length with the blade. The blade has a thickness of 2.0 mm, and this must be accounted for. Align the sheet such that the blade is just outside of the marked length that is to be cut. Positioning the blade exactly on the measured line will cause excess material to be removed, and the component will be shorter than its tolerance limit and unusable. On the cutting table is a steel bar with a tightening knob at its end. Once the part is aligned, move this bar to the edge of the PVC sheet and tighten the knob. This bar acts as the square did during measurement, and will ensure a straight cut. Feed the sheet through the blade at a steady pace, using your hands to keep pressure both vertically against the blade and horizontally against the steel square. Cutting creates friction, which leads to heat. It is thus important to keep a steady cutting pace and not allow the part to sit against the moving blade. This can cause discoloration and warping in the component.

After the component is removed, use the square to check that the component is perfectly square, and the ruler to check that the appropriate length was cut. The blade does not leave a perfectly smooth surface, so it will be necessary to remove large frayings with your finger nail, and refine the surface with fine grit sandpaper.

Milling

The sampling chamber design includes a door running on ball bearings. These bearings run in channels on both the top and bottom of the chamber, and the channels are created using a mill. A mill operates similar to a drill, rotating a spindle vertically with a cutting bit at the end. In addition to drilling holes, mills are also capable of planing, routing, and channeling. The platform of the mill has various hand cranks, which allow the user three dimensions of freedom, allowing the user to move the part horizontally and vertically, while also controlling the depth of cutting.

In this case, a 5 mm end bit was used to create the channel. Insert the bit into the appropriate chuck, and insert the chuck into the spindle of the machine taking time to align the key in the spindle with the groove on the chuck. Using a wrench, tighten the bolt at the top of the machine to secure the chuck in place. The mill displays vertical and horizontal position on a digital display to the ten-thousandth on an inch. The cutting depth is control using a calibrated hand crank. One rotation of the crank is equal to a depth of 0.1 inches. From the engineering drawings, determine your reference point. This point will be used to control the cutting dimensions. Turn on the machine, and set the cutting speed. High speeds are recommended with PVC, around 18000 RPM. Using the hand cranks, move the component through the cutting bit, keeping on eye on the digital display to ensure that you create the proper dimensions. This operation will require multiple passes to create the correct geometry. Using this setup, three passes should be standard.



Figure 1. Milling of the Bearing Channels



Figure 2. Machined Sampling Chamber Components

References

- Machine Shop Trade Secrets: A Guide to Manufacturing Machine Shop Practices

Harvey, James, Industrial Press © 2005

- "A Rough Guide to Better Milling"

<http://www.americanmachinist.com/304/Issue/Article/False/21630/Issue>