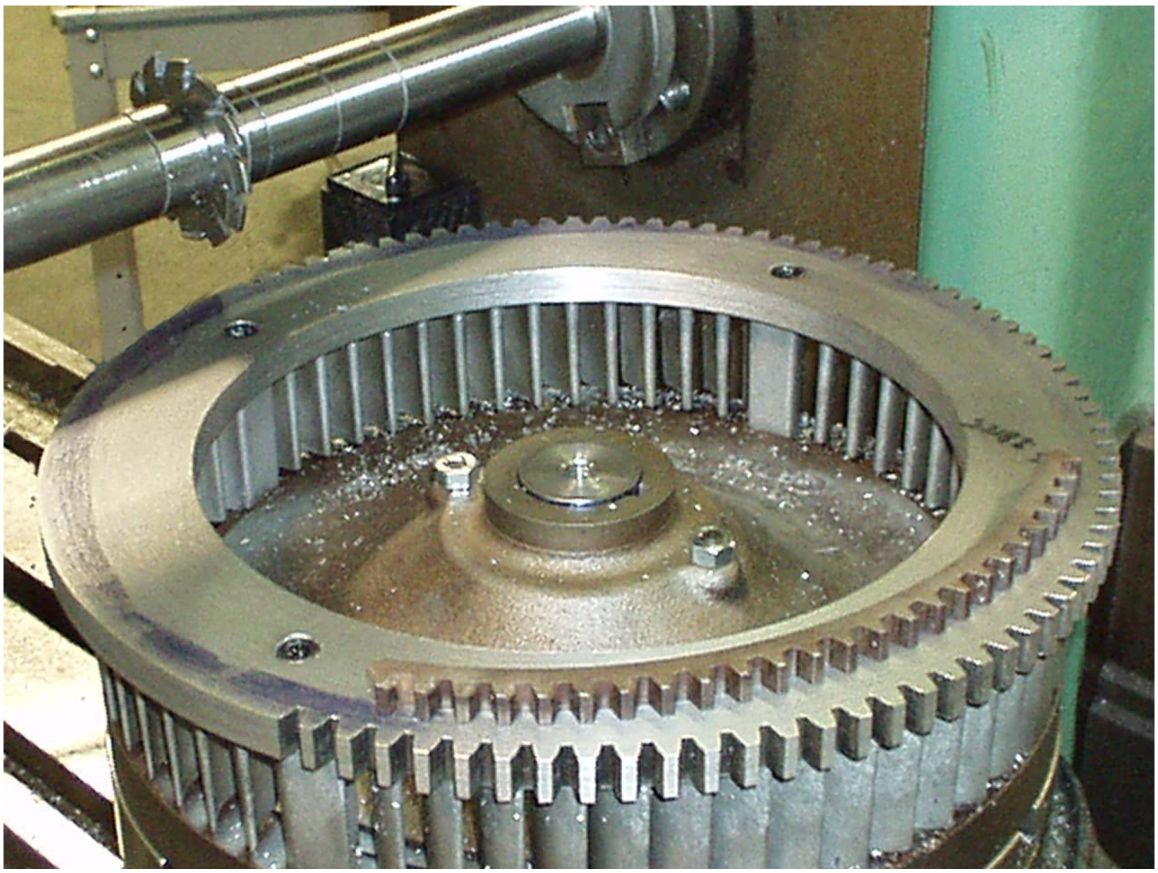
The Gear Project

Metal Machining IV

A Service Learning Exercise



By

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Service learning projects are designed to integrate a students' academic curriculum to provide a service to local communities. Service learning gives the student experience in his or hers field of study and applies it to real life situations, and enhances the knowledge gained in the classroom.

There are many requirements to meet for Metal Machining classes these include, drilling and tapping holes to reading and understanding measuring tools. Beginning machining classes you are taught the basics. You begin with running vertical milling centers, radial arm drills, lathes, saws, reading micrometers, horizontal mills, rotary tables, indexing heads, electromagnetic discharge machines (EDM), and computer measuring machines (CMM).


Figure 1

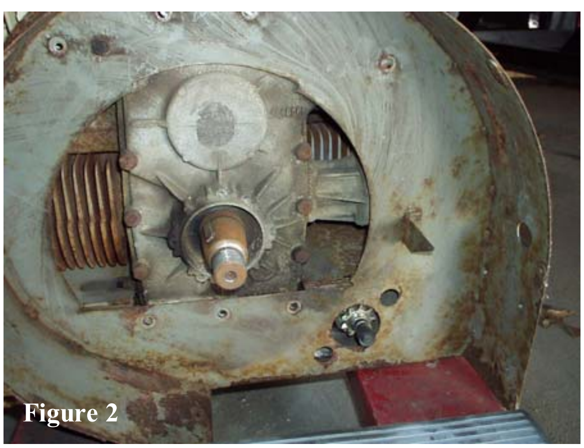


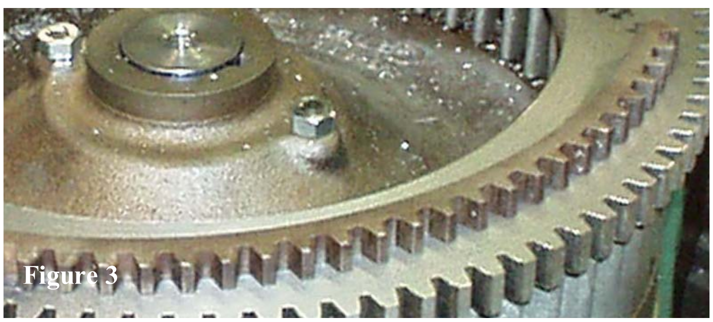
Figure 2

Metal Machining I, II, and III are introductory classes that prepare you for the advanced class. Metal Machining IV, you're given the requirements for the class, and using the skills learned in the prior classes, set free to accomplish the tasks that you set for yourself while meeting the requirements of the class. A portion of the class is customer contact. Customer contact consists of completing a job for a local industrial business. This allows a student to use the skills learned in the classroom and apply them to an actual industrial job. The student is required to stay in contact with the customer, report on his or her progress, while providing a service to the customer.

Gerrish Township Fire Department requested a service of replacing a broken ring gear. The ring gear is part of a 7 kilowatt Kohler model RV generator. Figure one and two are pictures of the generator. This generator is particularly important to the fire department because it supplies backup power to their fire truck and powers their floodlights. Mark Brown, who is part owner of Emergency Apparatus (EA) of Grayling Michigan, and a member of the Gerrish Township Fire Department, has been our contact for this job. Although Emergency Apparatus builds and repairs fire trucks, they will not be profiting from this particular job. Service learning projects are not meant to help local business profit from the services in which students provide. Both EA and Gerrish Township Fire Department understood and agreed to these terms.

Creating a Gear

The first step in creating a gear is to figure out everything you can about the gear, the more information you have the better. In this case the only item we could pull information from was a broken piece of gear (figure 3). This gear is the old ring gear



from the generator's flywheel. The generators starter engages the ring gear and flywheel to start the generator. Without a properly designed ring gear the generator will not start. The old ring gear provided us with the total number of teeth, and the diametral pitch. The diametral pitch is a ratio equal to number of teeth on the gear per inch of the pitch diameter. The pitch diameter is an imaginary circle on which the gear tooth is designed.

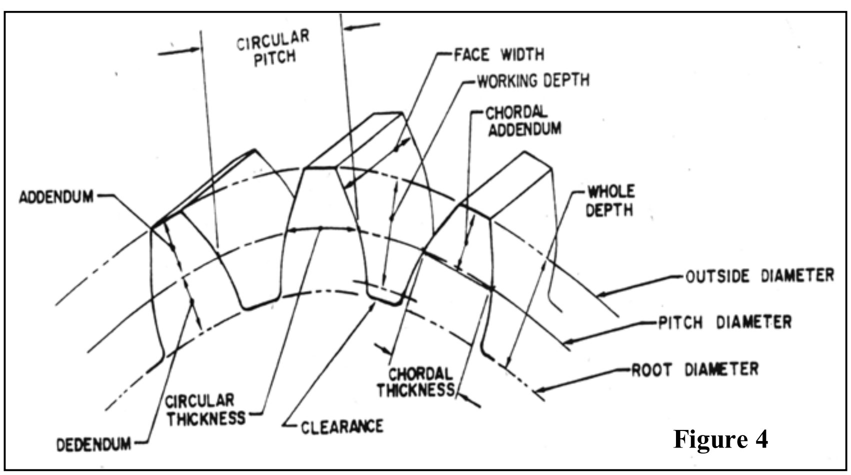


Figure 4

The pitch diameter also cuts through the center of the tooth, and represents the centerline of the teeth. Figure 4 will indicate where the pitch diameter, and the outside diameter are located in reference to a gear along with other significant gear terminology.

Knowing as much as you can about a gear is important, just knowing the pitch diameter and the diametral pitch you will be able to solve for the rest of the gear. In our case the only information we had was the number of teeth and the diametral pitch. Using gear formulas from text manuals and internet resources, we were able to calculate for the unknowns of the gear. Our first calculation is the outside diameter of the gear. Dividing the number of teeth, plus two, by the diametral pitch will produce the outside diameter. In our case the number of teeth is 100 and the diametral pitch is eight, this produced an outside diameter of 12.75 inches. The 12.75-inch diameter will be the diameter of the gear blank. The gear blank is a round circular piece of steel where the tooth profile will be cut from. Figure 5-G is a picture of the gear blank before it is turned down to size, and figure 5-H is the old ring gear.

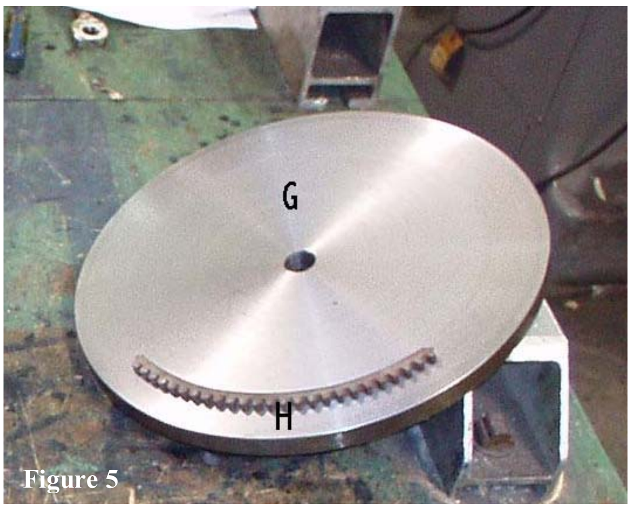


Figure 5

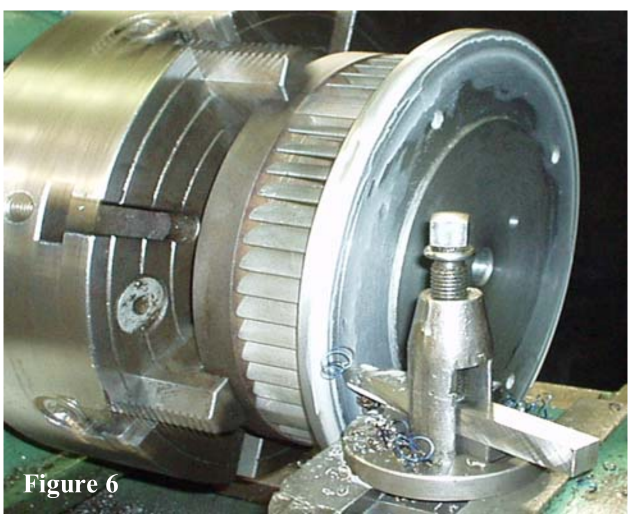


Figure 6

Using a lathe we were able to turn the outside diameter and face the gear blank. Figure 6 shows the gear blank and the flywheel on the lathe. This is where we turned, and faced the gear blank. Facing is an operation where material is removed from the face of an object, or turning the thickness down to a specific size. In this operation we are facing to a thickness of .500 inch. After we finished turning the outside diameter to 12.75 inch and faced the thickness down to .500 inch. We removed the stock from the center of the gear blank using a cut off tool. It is a simple tool that is sent straight into the material about three inches from the center of the gear blank to remove one solid piece of round stock.

This project included, reengineering a product that had some flaws in the previous ring gear, and to come up with ways of securing the flywheel and maintaining its center.

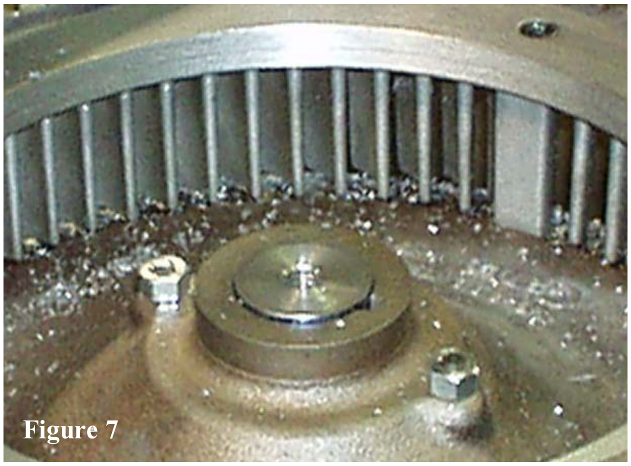


Figure 7


Figure 8

Figure 7 is a picture of the flywheel with a center-locating device called a snarbore. A snarbore is a made up name for an arbor with a shaft on the end of it. We needed a way to center the flywheel to the rotary table (figure 8). The rotary table has a precision hole of one inch in the center of it, and the flywheel's center has a 3.6-degree taper. We were able to use those two features to our advantage by creating the snarbore. The snarbore has a 3.6-degree taper at one end and the shaft is slightly smaller than one inch. The snarbore also has a 5/8-11 tapped hole on the shaft side. We used the tapped hole and a cap screw to bolt the snarbore to the bottom of the rotary table. This allowed the snarbore's outside taper to press against the flywheels inside taper to secure the flywheel to the rotary table. We also utilized the holes in the flywheel, by inserting two bolts with t-slots. Using the flywheels features, we were able to decrease set up time and increase rigidity of our setups.

Cutting the Gears

The gears were the last operation we had to complete. Because of the size of the gear and the amount of precision involved, we opted to use an indexing rotary table with a horizontal mill. An indexing rotary table allows the operator to turn an object precisely with a desired angle of movement. The total amount of teeth in the gear is 100, and there are 360 degrees in a circle. By dividing 360 by 100 equals 3.6 degrees per tooth. The rotary table that we used is a 90=360, 90 turns of the crank equals 360 degrees of the rotary table. One turn of the crank equals 4 degrees on the rotary table and dividing 3.6 by 4 will produce a fraction of 9/10. 9/10 of one turn of the crank will rotate the rotary table 3.6 degrees. Each rotary table has a metal disk with a certain number of holes on it. Those holes are equally spaced, and using the right disk with the right number of holes you are able to rotate the crank handle to appropriate hole. For example, because we have to rotate the crank 9/10 of a full turn, choosing a disk with 10 equally spaced holes then rotating around to the 9th hole for every turn will rotate the rotary table 3.6 degrees.

The horizontal milling machine (figure 9) is where the spindle is primarily in the horizontal axis. This will allow the gear cutter (figure 10) to cut down on the gear blank while the flywheel is bolted flat to the rotary table.

Calculating for spindle speeds and table feeds. Using cutting speed charts for medium alloy steel and a formula of, cutting speed multiplied by 4 then divided by the diameter of the cutter will


Figure 9

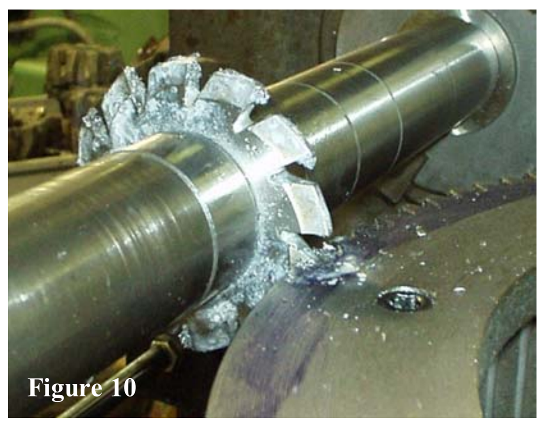


Figure 10

produce an appropriate spindle speed for the gear cutter. With a cut speed of 50 multiplied by 4 then divided by 3, for a 3 inch cutter equals about 66 revolutions per minute. For the feed, in inches per minute, multiply (feed/tooth) which is .002 by number of teeth in the cutter 12, then by rpm 66, equates to about 1.5 inches per minute. We repeated the process of cutting a tooth then rotating the rotary table 3.6 degrees 100 times to produce a 100-tooth gear with an eight-diametral pitch.

Although this project was challenging, we gained valuable experience by using brainstorming techniques and good communications skills learned in previous classes to solve problems. There was little or no guidance from the instructor, which increased our confidence in our ability to think, plan, do and assess a project. The customer contact portion of Metal Machining IV has been a very valuable learning experience. We would urge anyone interested in Manufacturing Technologies to use this resource to their advantage. We would like to thank Mark Brown and the Gerrish Township Fire Department for giving us an opportunity to apply our skills as machinist. We also would like to thank our instructor, Leonard Miller, for teaching us the skills needed to become competitive machinists.

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