

Spur gear manufacturing using conventional machine tools

Manufactura de engrane recto utilizando maquinas herramientas convencionales

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Abstract	Resumen
<p>The objective of this writing is to develop a methodology for the manufacture of a spur gear prototype using conventional machine tools. The purpose of this article is to help scientists and engineering students who need a guide to manufacture this type of elements that are part of a mechanical system for the transmission of movement and force. This study intends a comprehensive analysis of each step used for the manufacture of a spur gear, which allows in an objective way to determine the cutting tools and equipment necessary to carry out its manufacture, starting from the design of the element in question and applying the technical formulas necessary to adjust the parameters in the machining of the part. The methodological approach for this study has been determined based on the practical skills and experience that are paramount in the use of conventional machines. As a contribution we can say that with this methodology it will be possible to eliminate many previous problems in terms of planning and the lack of experience in handling conventional tools.</p>	<p>El objetivo de esta escrito es desarrollar una metodología para la manufactura de un prototipo de engrane recto mediante el uso de máquinas herramientas convencionales. El propósito de este artículo es ayudar a científicos y estudiantes de ingeniería que necesitan una guía para manufacturar este tipo de elementos que forman parte de un sistema mecánico para la transmisión del movimiento y fuerza. Este estudio pretende un análisis comprensivo de cada paso utilizado para la fabricación de un engrane recto, que permita de manera objetiva determinar las herramientas de corte y equipos necesarios para llevar a cabo su manufactura, partiendo del diseño del elemento en cuestión y aplicando las fórmulas técnicas necesarias para ajustar los parámetros en el maquinado de la pieza. El enfoque metodológico para este estudio se ha determinado en base a las habilidades prácticas y experiencia que son primordiales en el uso de máquinas convencionales. Como contribución podemos decir que con esta metodología se podrán eliminar muchos problemas previos en cuanto a la planeación y la falta de experiencia en el manejo de herramientas convencionales.</p>
Spur gear, Manufacturing, Conventional machines	Engrane recto, Manufacturar, Maquinas convencionales

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Introduction

Gears are extremely common components used in many machines. In general, the function of a gear is to transmit motion from one rotating shaft to another. In addition to transmitting motion, gears are often used to increase or decrease speed, or to change the direction of motion from one shaft to another.

They are extremely common in the output of mechanical power sources, such as electric motors and internal combustion engines, which rotate at much higher speeds than the application requires.

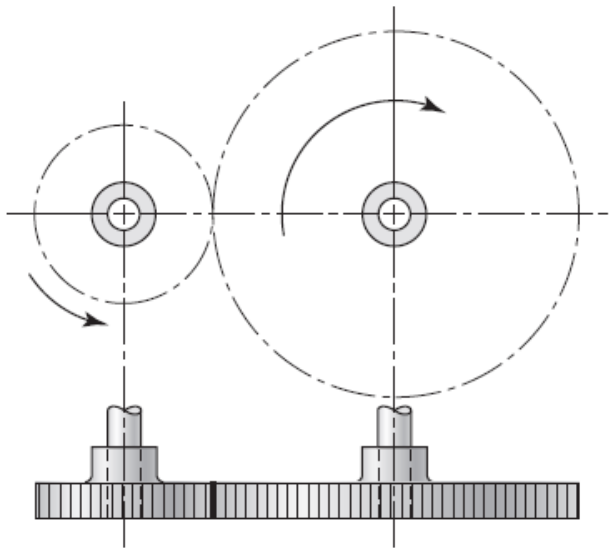


Figure 1 Spur gear

Spur gears are used to transmit rotational motion between parallel axes as shown in Figure 1 (Shigley's mechanical engineering design, 2011).

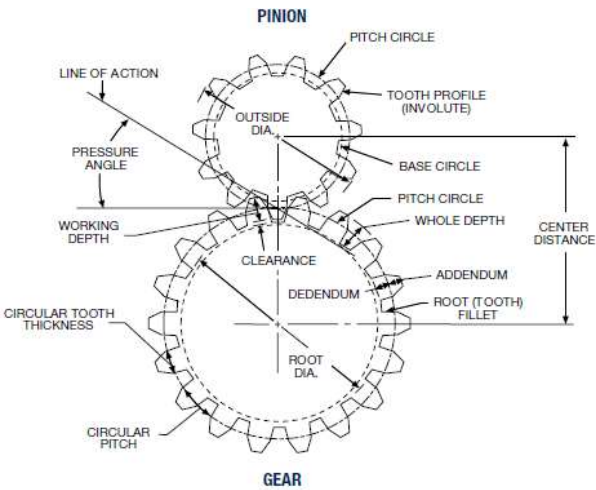


Figure 2 Parts of a spur gear

Although there are currently various techniques for manufacturing gears on a large scale, it is still important to manufacture them using conventional machine tools, which bring into play the skills and abilities in the training of engineers, which will facilitate their entry into the professional world.

In this case, a prototype of a spur gear is manufactured by identifying its main parts in Figure 2 (Edward G. Hoffman, 2006) and using a cutter as shown in Figure 3.



Figure 3 Spur gear cutter

The most important data we need to take into account for the manufacture of a spur gear are: Diametral Pitch (DP), Cutter Number (#8), Number of gear teeth that can be manufactured using this cutter (12 to 13 teeth), and the pressure angle which is 14.5°. This information is printed on the surface of the cutter Figure 3.

Tooth range	Cutter number
134 - greater	1
55 - 134	2
35 - 54	3
26 - 34	4
21 - 25	5
17 - 20	6
14 - 16	7
12 - 13	8

Table 1 Tooth range for each cutter number

Table 1 presents each cutter number with its respective range of gear teeth that can be made, so depending on the number of teeth that need to be manufactured we choose the cutter number.

Diametral Pitch	Circular Pitch	Thickness of tooth on Pitch Line	Depth to be Cut in Gear	Addendum
3	1.0472	.5236	.7190	.3333
4	.7854	.3927	.5393	.2500
5	.6283	.3142	.4314	.200
6	.5236	.2618	.3565	.1667
8	.3927	.1963	.2696	.1250
10	.3142	.1571	.2157	.1000
12	.2618	.1309	.1798	.0833
16	.1963	.0982	.1348	.0625
20	.1571	.0785	.1120	.0500
24	.1309	.0654	.0937	.0417
32	.0982	.0491	.0708	.0312
48	.0654	.0327	.0478	.0208
64	.0491	.0245	.0364	.0156

Table 2 Standard diametral pitches for spur gears

Table 2 shows the standardised Diametral Pitch values with their respective values that define the geometry of the gearing using the diametral pitch system. Taking into account that the diametral pitch in a gear is the number of teeth per inch of the pitch circle, see figure 2.

The lack of a methodology for manufacturing spur gears has remained a problem in the formative stages of the engineering stage. This project highlights the importance of explaining in detail the steps involved in manufacturing a spur gear using conventional machines.

Methodology

The methodological approach adopted in the manufacture of this prototype spur gear is based on the characteristics required to be achieved and these are as follows:

To machine a spur gear with an outside diameter of 3.25" and having 24 teeth, as shown in Figure 4. First, a drawing was made using SolidWorks software, with the necessary technical parameters based on the ASA B6.1-1932 standard.

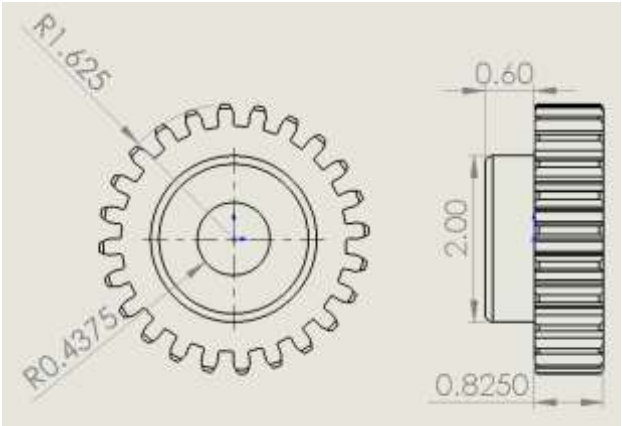


Figure 4 Spur gear dimensions

The values and formula used for the gear design are given in Table 3 and are based on the diametral pitch system (ERIK OBERG, 2016).

Variable	Value/equation	Result	Remarks
OD	3.25 in		Outsi of diameter
NT	24		Number of tooth
PA	14.5 deg		Pressure angle
PD	$OD \cdot NT / NT + 2$	3 in	Pitch diameter
DP	$NT / PD$	8	Diametral pitch
DB	$PD \cdot \cos (PA)$	2.9044 in	Base circle diam
WD	$2.157 / DP$	0.2696 in	Whole depth
AD	$PD / NT$	0.125 in	Addendum
DD	$1.157 / DP$	0.1446 in	Dedendum
CT	$1.5708 / DP$	0.1963 in	Circular thickness
DR	$PD - (2 \cdot DD)$	2.7108	Root diameter
INV	$0.125 \cdot PD$	0.375 in	Involute radius
CTA	$(360 / NT) \cdot 0.5$	7.5 deg	Circular thickness angle

Table 3 Technical characteristics of spur gears



Figure 5 Facing and roughing operations

After defining the dimensions, the first machining operations are carried out, in this case facing and roughing as well as drilling in 6061 aluminium material, using a carbide burin on a conventional lathe.



**Figure 6** Placing the part on the indexer

After what was done on the conventional lathe, the next step is to clamp the part on the table of the conventional milling machine using the indexing head with its respective counterpoint, it is worth mentioning that the alignment of the part with the spindle is very important, otherwise the teeth of the spur gear will be out of position.



**Figure 7** Definition of the chuck on the indexer

To determine the chuck with the appropriate number of points for a 24-tooth gear, we use the following formula (Steve F. Krar, 2013).

$$X = V / T \quad (1)$$

Where:

X= Turns of the crank.

V= Ratio of the dividing head and the crank.

T= Number of divisions to be cut.

By means of the operations carried out, it is obtained that it is necessary to turn the indexer crank plus twelve points of the plate containing 18 points by one complete turn, this is done to cut the appropriate number of teeth based on the characteristics shown in Table 3.

Figure 7 shows the indexer chuck with a different number of points, allowing the workpiece to be rotated the appropriate degrees for cutting each gear tooth.



**Figure 8** Cutting of each of the gear teeth

In order to continue with the manufacturing process, the cutting stage is carried out at depths of .090 in for each one of them until reaching 0.2696 in (Hole depth), as indicated in Table 3 and illustrated in Figure 8.

## Results

Figure 9 shows the finished spur gear, where the teeth of the gear can be seen, it can also be seen that a chamfer cut was made on both sides of the tooth to remove the cutting edge of this, the cutting marks of the tool are present at the ends of the tooth.





**Figure 9** Finished gear

## Conclusions

To clearly explain the results obtained and the possibilities for improvement.

In this work we have proposed and explained the steps to follow in order to manufacture a spur gear using conventional machines and applying the technical formulas for its design, as the results show. It should be pointed out that practice and experience play a fundamental factor in the machining process, as well as the safety and skills of the person during the manipulation of the conventional lathe and milling machine.

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