

### Objectives

The main objective of these projects is to calculate rectangular coordinates (XY points) of various hole patterns. All patterns share some order - randomly spaced series of holes do not qualify as true patterns. The most common hole patterns are linear and circular.

### Overview and Applications

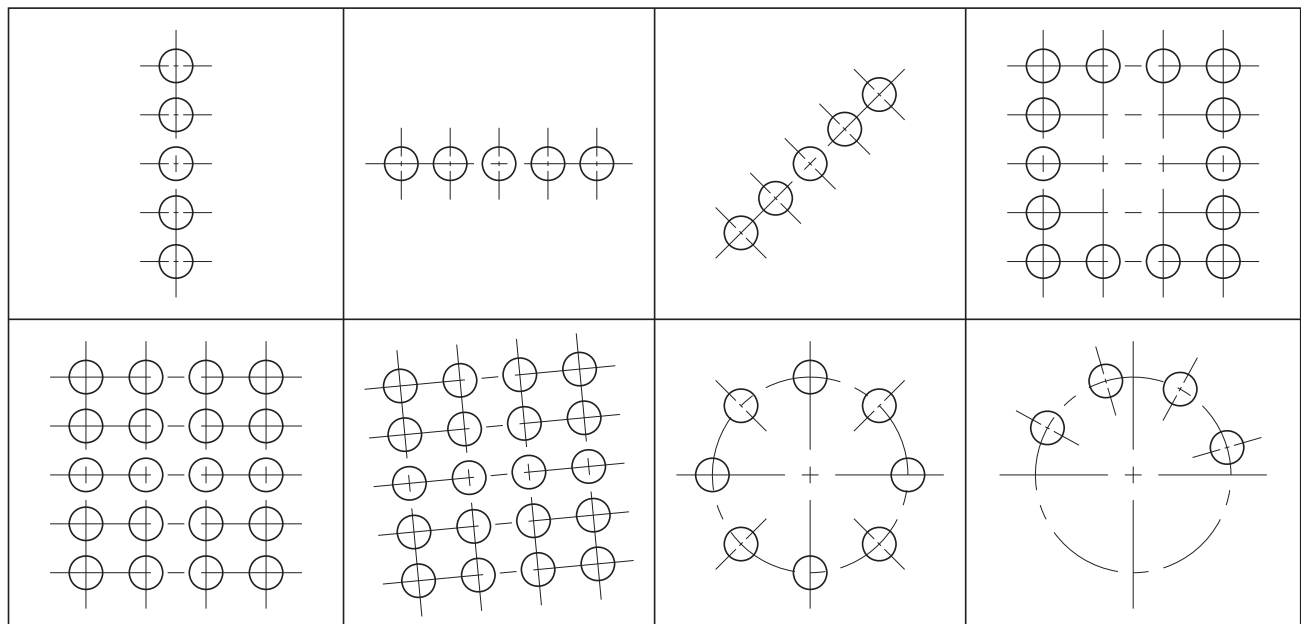
A pattern of holes is an *orderly* arrangement of holes located on a part, typically equally spaced. Typical patterns are linear (horizontal, vertical and angular) and circular - those arranged along an arc (arc and bolt hole patterns). The holes in such patterns may be used for a wide variety of industrial purposes.

One of the most common applications of hole patterns are those used for fastening two parts together, for example flanges. In such cases, the patterns of both parts must be identical. Flanges commonly use an even number of equally spaced holes (6, 8, 12, for example), arranged on a bolt circle diameter. Odd number of equally spaced holes can be found on flanges where the pattern orientation is important. Arc patterns share many characteristics of bolt hole pattern, but are contained within a certain angle that is smaller than 360 degrees. Holes in such patterns are also equally spaced.

Another common pattern is an octagonal series of holes (in rows within an octagon) that is used for holding pipes in heat exchangers. An example of such a pattern is one of the projects in this series of project (27-05).

Hole patterns arranged in a linear direction could be single horizontal or vertical rows, frames (two horizontal and two vertical holes combined) or a full matrix (array of rows and columns).

Many modern CNC lathes support the third axis (milling axis or live tooling), which also can be used for machining various patterns. These are some common patterns of holes that are machined on CNC machining centers:



## **Programming Methods**

Programming methods vary for each pattern, and there could be a number of variations. The longest programs are the result of programming *XY* coordinates individually, for each hole and each tool. Typical programming methods used for shortening the program length include incremental mode G91, subprograms, and even macros (this subject is not covered here). Combining one programming method with another, for example, an incremental mode and subprograms, results in even shorter programs. Keep in mind, however, that a short program developed at all costs just to be short, is not always the best approach.

Many circular array holes (arc and bolt circle) have a defined center at a location other than *X0Y0* (part zero). The required program can be simplified by using the *Local Coordinate System*, identified by the G52 command. Also, a datum shift command G10 can be used, if the control system supports it.

Using polar coordinates for circular patterns can save a great amount of time, but the majority of CNC systems do not have this feature available as a standard specification. If such a feature is available, polar coordinates can be defined by the pattern center point and the arc radius.

## **References**



*CNC Programming Handbook* - Chapter 27 *Pattern of Holes*  
Chapter 27 *Bolt Circle Formula (explanation)*  
Chapter 27 *Polar Coordinates*  
Chapter 26 *Machining Holes*  
Chapter 40 *Local Coordinate System (G52)*  
Chapter 40 *Data Setting (G10)*  
Chapter 53 *Polygon calculations*