Helical Milling Operation
Helical milling produces helical flutes or grooves on the periphery of a cylindrical or conical workpiece. This is performed by swiveling the table to the required helix angle, then rotating and feeding the workpiece against revolving cutting edges of milling cutter. Helical gears and drills and reamers are made by this operation.

Cam Milling Operation
The operation cam milling is used to produce the cam on milling machine. In this operation cam blank is mounted at the end of the dividing head spindle and the end mill is held in the vertical milling attachment.

Thread Milling Operation
The operation thread milling produces threads using thread milling centres. This operation needs three simultaneous movements revolving movement of cutter, simultaneous longitudinal movement of cutter, feed movement to the workpiece through table. For each thread, the revolving cutter is fed longitudinal by a distance equal to pitch of the thread. Depth of cut is normally adjusted equal to the full depth of threads.

1.10 INDEXING
Indexing is the operation of dividing the periphery of a workpiece into any number of equal parts. For example if we want to make a hexagonal bolt. Head of the bolt is given hexagonal shape. We do indexing to divide circular workpiece into six equal parts and then all the six parts are milled to an identical flat surface. If we want to cut ‘n’ number of teeth in a gear blank. The circumference of gear blank is divided into ‘n’ number of equal parts and teeth are made by milling operation one by one. The main component used in indexing operation is universal dividing head.

Universal Dividing Head
It is most popular and common type of indexing arrangement. As indicated by its name “universal”, it can be used to do all types of indexing on a milling machine. Universal dividing head can set the workpiece in vertical, horizontal, or in inclined position relative to the worktable in addition to working principle is explained below with the help of illustration in Figure 1.15. The worm gear has 40 teeth and the worm has simple thread. Crank is directly attached with the worm. If we revolve crank by 40 revolutions the spindle attached with worm gear will revolve by only one revolution and one complete turn of the crank will revolve the spindle only by 1/40th revolution (turn). In order to turn the crank precisely a fraction of a revolution, an indexing plate is used. An indexing plate is like a circular disc having concentric rings of different number of equally spaced holes. Normally indexing plate is kept stationary by a lock pin. A spring loaded pin is fixed to the
crank which can be fixed into any hole of indexing plate. The turning movement of the workpiece is stably controlled by the movement of crank as explained below.

If the pin is moved by one hole on the indexing plate in the circle of 20 holes, the spindle will revolve by \( \frac{1}{40} \times \frac{1}{20} = \frac{1}{600} \) th turn of one revolution.

### 1.11 INDEXING METHOD

There are different indexing methods in popularity. These are:

(a) Direct indexing

(b) Simple indexing

(c) Compound indexing

(d) Differential indexing

**Direct Indexing**

It is also named as rapid indexing. For this direct indexing plate is used which has 24 equally spaced holes in a circle. It is possible to divide the surface of workpiece into any number of equal divisions out of 2, 3, 4, 56, 8, 12, 24 parts. These all numbers are the factors of 24.

In this case fist of all worm and worm wheel is disengaged. We find number of holes by which spring loaded pin is to be moved. If we want to divide the surface into 6 parts than number of holes by which pin is to be moved \( = \frac{24}{N} \) for 6 parts 

\[ N = 6. \]

So number of holes \( = \frac{26}{6} = 4 \) holes that is after completing one pair of milling whole surface of workpiece we have to move the pin by 4 holes before next milling operation, that is to be done for 5 number of times for making hexagonal bolt.

**Simple Indexing**

It is also named as plain indexing. It over comes the major limitation of direct indexing that is possibility of dividing circumference of workpiece into some fixed
number of divisions. In this case worm and worm gear is first engaged. So one
complete turn of indexing crank revolves the workpiece by \( \frac{1}{40} \) th revolution.

Three indexing plates are used. These plates have concentric circles of holes with
their different numbers as described below:

<table>
<thead>
<tr>
<th>Plate No. 1</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate No. 2</td>
<td>21</td>
<td>23</td>
<td>27</td>
<td>29</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>Plate No. 3</td>
<td>37</td>
<td>39</td>
<td>41</td>
<td>43</td>
<td>47</td>
<td>49</td>
</tr>
</tbody>
</table>

These are the standard indexing plates followed by all machine tool
manufacturers.

**Indexing Procedure**

(a) Divide 40 by the number of divisions to be done on the circumference
of workpiece. This gives movement of indexing crank.

\[
\text{Indexing crank movement} = \frac{40}{N}
\]

\( N \) is the number of divisions to be made on the circumference of
workpiece.

(b) If the above number is a whole number, then crank is rotated by that
much number of revolutions after each milling operations, till the
completion of the work.

For example, if we want to divide the circumference into 10 number
of parts.

\[
\text{Indexing crank movement} = \frac{40}{10} = 4 \text{ revolutions.}
\]

That is the indexing crank is given 4 revolutions after each of milling
operation for 9 more milling operations.

(c) If indexing crank movement calculated by \( \frac{40}{N} \) is not whole number,
it is simplified and then expressed as a whole number and a fraction.

(d) The fractional part of the above number is further processed by
multiplying its denominator and numerator by a suitable common
number so that the denominator will turn to a number equal to any
number of holes available on the any of indexing plates.

(e) That particular holes circle is selected for the movement of crank pin.

(f) The numerator of the process fraction stands for the number of holes
to be moved by the indexing crank in the selected hole circle in
addition to complete turns of indexing crank equal to whole number
part of \( \frac{40}{N} \).

Let us do the indexing to cut 30 teeth on a spur gear blank that means
we need to divide the circumference of gear blank into 30 identical,
parts. Crank movement is calculated s given below.

\[
\text{Crank movement} = \frac{40}{N} = \frac{40}{30}
\]

Here, \( N = 30 \).

\[
= \frac{40}{30} = \frac{10}{3} = \frac{1}{3}
\]
Let us multiply both numerator and denominator by 5.

\[
\frac{5}{15}
\]

Denominator becomes ‘15’ so we will select 15 hole circle of plate 1.

**Action 1**

After each milling operation we will rotate indexing crank by one complete turn and 5 holes in 15 holes circle. This way we do milling total 30 times.

In this case we can multiply numerator and denominator by ‘7’ a the place of ‘5’ as described below.

Indexing crank movement = \( \frac{40}{N} \) (\( N = 30 \) teeth)

\[
= \frac{40}{30} = \frac{10}{3} = 1 \times \frac{7}{3} = \frac{7}{21}
\]

**Action 2**

We will select the hole circle of 21 holes. After each milling operation indexing crank will be rotated by 1 complete circle and 7 holes in 21 holes circle. This way milling operation will be done by total 30 times.

Both the answers determined in the above problem are correct and substitute of each other.

**Limitations**

This method can used for indexing upto 50 for any number of divisions after 50 this method is not capable for some numbers like 96, etc.

Compound indexing overcomes the limitations.

**Compound Indexing**

The word compound indexing is an indicative of compound movements of indexing crank and then plate along with crank. In this case indexing plate is normally held stationary by a lock pin, first we rotate the indexing crank through a required number of holes in a selected hole circle, then crank is fixed through pin.

It is followed by another movement by disengaging the rear lock pin, the indexing plate along with indexing crank is rotated in forward or backward direction through predetermined holes in a selected hole circle, then lock pin is reengaged.

Following steps are to be followed for compound indexing operation. The procedure is explained with the help of numerical example.

**Example 1.1**

Let us make 69 divisions of workpiece circumference by indexing method.

(Using compound indexing)

**Solution**

Follow the steps given below :

(a) Factor the divisions to be make (69 = 3 × 23) \( N = 69 \).

(b) Select two hole circles at random (These are 27 and 33 in this case, both of the hole circles should be from same plate).

(c) Subtract smaller number of holes from larger number and factor it as \( (33 – 27 = 6 = 2 \times 3) \).