Unit-3

Screw Thread And Gear Measurement

12

ACCEPTANCE TESTS FOR MACHINE TOOLS

Introduction

The quality and accuracy of the finished work depends on the accuracy of the machine tools used in their production. The machine tools must be able to produce workpieces of given accuracy within prescribed limits consistently.

It is for this reason the machine tools are tested at various stages, during assembly, after assembly, erection, repairs or overhauls as per accuracy test chart in order to determine whether it meets the requirement of specification or not.

The acceptance test of machine tool includes :

1. Alignment test or Geometrical test.
2. Performance test or practical test.

The alignment test is carried out to check the grade of manufacturing accuracy of the machine tool. It consists of checking the relationship between various machine elements (such as bed, table, spindle etc.) when the machine tool is idle and unloaded.

Performance test consists of checking the accuracy of the finished components and is known as practical test. The performance test, therefore, consists of preparing the actual test jobs on the machine and checking the accuracy of the jobs produced. Performance test is carried out to know whether the machine tool is capable of producing the parts within the specified limits or not.

In addition to the manufacturing accuracy the working accuracy of the machine is influenced by the following factors.

1. Geometry of the cutting tool (rake angle, clearance angle, etc).
2. Material of the cutting tool, shape and rigidity;
3. Material of the workpiece, its size, shape and rigidity,
4. Cutting speed, feed and depth of cut,
5. Work holding and clamping equipment,
6. Skill of the operator.
7. Working conditions etc.

Alignment or Geometrical Tests

Before conducting Geometrical tests it is essential that the machine is set up and principal horizontal and practical planes and axes are checked with spirit level etc.

The various geometrical/alignment checks generally carried out on machine tools are :

1. Straightness of guide ways and slide ways of machine tool.
2. Flatness of machine tables and slide ways.
3. Parallelism, equidistance and alignment of the slide ways and axes of various moving parts with reference to some standard planes.
4. True running and alignment of shafts and spindle relative to other areas and surfaces.
5. The error of pitch or lead of lead screw.
6. Pitch errors of gears.
7. Dividing errors of dividing heads/indexing devices.
8. Eccentricity, out of roundness, periodical axial slip, camming etc.

Main spindle is the fundamental element of the machine and is tested for eccentricity, axial slip, accuracy of axis and position, relative to other axes and surfaces.

Equipment required for geometrical tests

The measuring equipments used for alignment tests are :

1. Dial gauges
2. Test mandrels
3. Straight edges and squares
4. Spirit level
5. Auto collimator
6. Waviness metre etc.

Dial gauges. Dial gauges are widely used in alignment tests. The dial gauges selected should have measuring accuracy of 0.01 mm. The dial gauge must be mounted on robust and stiff base in order to avoid displacement due to shocks and vibrations. The initial plunger pressure should vary between 40 and 100 gm; for very fine measurement, a lower pressure as small as 20 gm is desirable.

Test Mandrels. These are used for checking the true running of the spindle. Two types of test mandrels used are :

(*a*) Mandrels with a cylindrical measuring surface and taper shank which can be inserted into the taper bore of the main spindle.

(*b*) Cylindrical mandrel which can be held between centres. Test mandrels are hardened, ground and made to length which varies from 100 to 300 mm.

Straight edges and squares. Straight edge of cast iron or steel should be heavy, well ribbed and seasoned. A square must have a wider bearing surface. Steel square is a precision tool used for laying out lines or for testing of squareness of two surfaces with each other.

The error at the top of standard square should be less than ± 0.01 mm, of a precision less than ± 0.005 mm.

Straight edge is placed on machined surfaces to check them for flatness or straightness.

Spirit level. Spirit levels are used for high grade precision work. Spirit levels used are in the shape of a bubble tube which is mounted on a cast iron base. Spirit levels should have a sensitivity of about 0.04 to 0.06 mm per metre for each deflected division. Two main types of spirit levels used for acceptance test are :

(*a*) Horizontal spirit level (*b*) Frame spirit level.

Auto Collimator. Auto collimater is very sensitive instrument. It can be used for checking deflections of long beds in horizontal, vertical or inclined planes.

Waviness Metre. Waviness metre with 50 : 1 magnification is useful in recording and examining the surface waviness.

Alignment Telescope. Optical alignment telescope can be used to indicate errors of alignment in both the vertical and horizontal planes of the optical axis.

Machine Tool Tests. The tests applied for machine tools irrespective of type, fall into well defined group which may be summarised as follows :

1. The level of installation of the machine in the horizontal and vertical planes.
2. Flatness of machine bed and straightness and parallelism of bed ways or bearing surfaces.
3. Test for true running of the main spindle and its axial movement.
4. Test for parallelism of spindle axis to guide ways or bearing surface.
5. Tests for the line of movement of various members e.g. saddle and table cross-slides etc, along their ways.
6. Practical test in which some test pieces are machined and their accuracy and finish checked.

Alignment Tests for Lathe

1. Test for level of installation.

(*a*) In longitudinal direction. (*b*) In transverse direction.

Measuring instruments. Spirit level, gauge block to suit the guide ways of the lathe bed.

Procedure. The gauge block with the spirit level is placed on the bed ways on the front position, back position and in the cross wise direction. The position of the bubble in the spirit level is checked and the readings are taken.

Permissible error. Front guide ways. 0.02 mm/metre convex only. Rear guide ways, 0.01 to 0.02 convexity. Bed level in cross-wise direction ± 0.02/metres. Straightness of slide ways (for machines more than 3 m turning length only, measurements taken by measuring taught wire and microscope or long straight edge). Tailstock guide ways parallel with movement of carriage 0.02 mm/m. No twist is permitted.

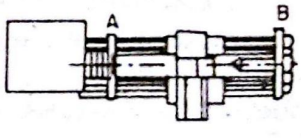

Fig. 12.1

The error in level may be corrected by setting wedges at suitable points under the support feel or pads of the machine.

2. Straightness of Saddle in horizontal plane.

Measuring instruments. Cylindrical test mandril (600 mm long), dial indicator.

Procedure. The mandrel is held between centres. The dial indicator is mounted on the saddle. The spindle of the dial indicator is allowed to touch the mandrel. The saddle is then moved longitudinally along the length of the mandrel. Readings are taken at different places. *Permissible error.* 0.02 mm over length of mandrel.

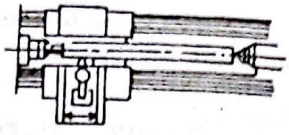

Fig. 12.2

3. Alignment of both the centres in the vertical plane

Measuring instruments. Cylindrical mandrel 600 mm long, dial gauge.

Procedure. The test mandrel is held between centres. The dial indicator is mounted on the saddle in vertical plane as shown in figure. Then the saddle along with the dial gauge is travelled longitudinally along the bed ways, over the entire length of the mandrel and the readings are taken at different places.

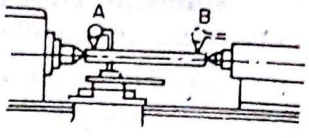

Fig. 12.3

Permissible error 0.02 mm over 600 mm length of mandrel (Tail stock centre is to lie higher only).

4. True running of taper socket in main spindle

Instruments required. Test mandrel with taper shank and 300 mm long cylindrical measuring part, dial gauge.

Procedure. The test mandrel is held with its taper shank in a head stock spindle socket. The dial gauge is mounted on the saddle. The dial gauge spindle is made to touch with the mandrel. The saddle is then travelled longitudinally along the bed ways and readings are taken at the points *A* and *B* as shown in figure.

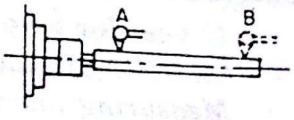

Fig. 12.4

Permissible error. Position A, 0.01 mm, position B 0.02 mm.

5. Parallelism of main spindle to saddle movement.

(*a*) In a vertical plane (*b*) In horizontal plane

Measuring instruments. Test mandrel with taper shank and 300 mm long cylindrical measuring part, dial gauge.

Procedure. The dial gauge is mounted on the saddle. The dial gauge spindle is made to touch the mandrel and the saddle is moved to and fro. It is checked in vertical as well as in horizontal plane.

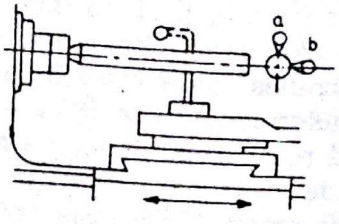

Fig. 12.5

Permissible errors. (*a*) 0.02/300 mm mandrel rising towards free end only. (*b*) 0.02/300 mm mandrel inclined at free end towards tool pressure only.

6. Movement of upper slide parallel with main spindle in vertical plane

Measuring instruments. Test mandrel with taper shank and 300 mm long cylindrical measuring part, dial gauge.

Procedure. The test mandrel is fitted into the spindle and a dial gauge clamped to the upper slide. The slide is traversed along with the dial gauge plunger on the top of the stationary mandrel. Permissible error – 0.02 mm over the total movement of the slide.

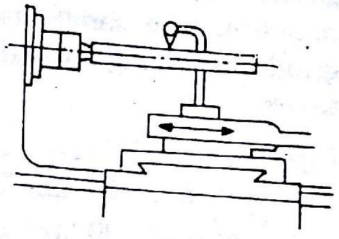

Fig. 12.6

7. True running of locating cylinder of main spindle

Measuring instrument. Dial gauge.

Procedure. The dial gauge is mounted on the bed, touching at a point on main spindle.

The main spindle is rotated by hand and readings of dial gauge are taken.

Permissible error – 0.01 mm.

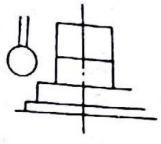

Fig. 12.7

8. True running of head stock centre

Measuring instrument. Dial gauge.

Procedure. The live centre is held in the tail stock spindle and it is rotated. Its trueness is checked by means of a dial gauge.

Permissible error – 0.01 mm

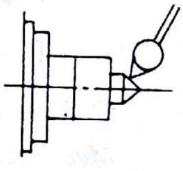

Fig. 12.8

9. Parallelism of tailstock sleeve to saddle movement

Measuring instrument. Dial indicator.

Procedure. Tailstock sleeve is fed outwards. The dial gauge is mounted on the saddle. Its spindle is touched to the sleeve at one end and then saddle is moved to and fro, it is checked in H.P. and V.P. also.

Permissible error. (*a*) 0.01/100 mm (Tailstock Sleeve inclined towards tool pressure only). (*b*) 0.01/100 mm (Tailstock Sleeve rising towards free end only).

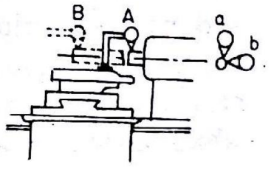

Fig. 12.9

10. Parallelism of tail stock sleeve taper socket to saddle movement (*a*) in V.P. (*b*) in H.P.

Measuring instruments. The mandrel with taper shank and a cylindrical measuring part of 300 mm length, dial gauge.

Procedure. Test mandrel is held with its taper shank in a tail-stock sleeve taper socket. The dial gauge is mounted on spindle. The dial gauge spindle is made to touch with the mandrel. The saddle is then traversed longitudinally along the bed way and readings are taken.

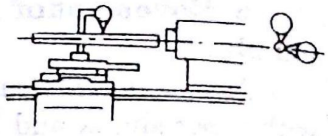

Fig. 12.10

Permissible error

(*a*) 0.03/300 mm (Mandrel rising towards free end only)

(*b*) 0.03/300 mm (mandrel inclined towards tool pressure only).

Alignment tests on milling machine knee type horizontal and vertical.

(1) **Flatness of work table**

(*a*) In longitudinal direction.

(*b*) In transverse direction

Measuring instruments. Spirit level.

Procedure. A spirit level is placed directly on the table at points about 25 to 30 cm apart, at *A, B, C* for longitudinal tests and *D, E* and *F* for the transverse test.

The readings are noted.

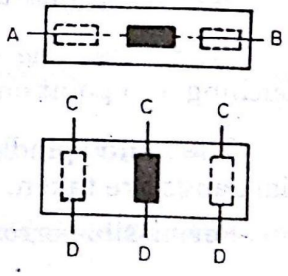

Fig. 12.11

Permissible error :

Direction *A–B–C* , ± 0.04 mm

Direction *D–E–F*, ± 0.04 mm

(2) **Parallelism of the work table surface to the main spindle**

Measuring instruments : Dial indicator, test mandrel 300 mm long, spirit level.

Procedure. The table is adjusted in the horizontal plane by a spirit level and is then set in its mean position longitudinally. The mandrel is fixed in the spindle taper. A dial gauge is set on the machine table, and the feeler adjusted to touch the lower surface of the mandrel. The dial gauge readings at (A) and (B) are observed, the stand of the dial gauge being moved while the machine table remains stationary.

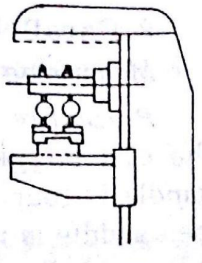

Fig. 12.11 (*a*)

Permissible error. 0.02/300 mm.

(3) **Parallelism of the clamping surface of the work table in its longitudinal motion**

Instruments. Dial gauge, straight edge.

Procedure. A dial gauge is fixed to the spindle. The dial gauge spindle is adjusted to touch the table surface. The table is then moved in longitudinal direction and readings are noted. If the table surface is uneven it is necessary to place a straight edge on its surface and the dial gauge feeler is made to rest on the top surface of the straight edge.

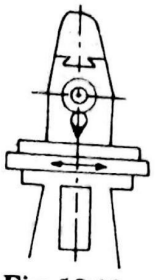

Fig. 12.12

Permissible error. 0.02 up to 500 mm length of traverse, 0.03 up to 1000 mm and 0.04 above 1000 mm length of traverse.

(4) **Parallelism of the cross (transverse) movement of the worktable to the main spindle**

(*a*) In a vertical plane

(*b*) In horizontal plane

Instruments. Dial gauge, test mandrel with taper shank.

Procedure. The work table is set in its mean position. The mandrel is held in the spindle. A dial gauge fixed to the table is adjusted so that its spindle touches the surface of the mandrel. The table is moved cross-wise and the error is measured in the vertical plane and also in the horizontal plane.

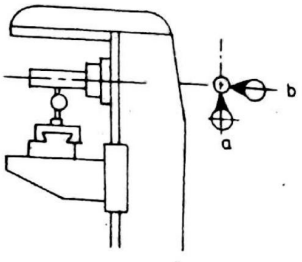

Fig. 12.13

Permissible error. 0.02 for the overall traverse movement of the worktable.

(5) **True running of internal taper of the main spindle.**

Instrument 300 mm long test mandrel, dial gauge.

Procedure. The test mandrel with its taper shank is held in the main spindle. Dial gauge is kept scanning the periphery of the mandrel. Spindle is rotated and dial gauge readings are noted at different points say *A* and *B* as shown.

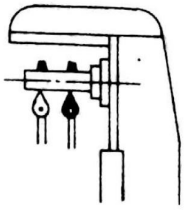

Fig. 12.14

Permissible error. Position A : 0.01 mm, Position B : 0.02 mm.

(6) **Squareness of the centre T-slot of worktable with main spindle**

Instruments. Dial gauge, special bracket.

Procedure. To check the perpendicularity of the locating slot and the axis of the main spindle. The table should be arranged in the middle position of its longitudinal movement, and a bracket with a tenon at least 150 mm long inserted in the locating slot, as shown in figure.

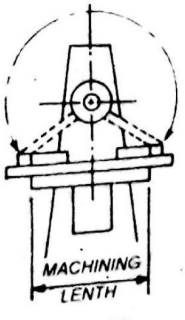

Fig. 12.15

A dial gauge should be fixed in the spindle taper, the feeler being adjusted to touch the vertical face of the bracket. Observe the reading on the dial gauge when the bracket is near one end of the table, the swing over the dial gauge and move the bracket so that the corresponding readings can be taken near the other end of the table.

Permissible error. 0.025 mm in 300 mm.

(7) Parallelism of the T-slot with the longitudinal movement of the table

Instruments. Dial gauge, special bracket.

Procedure. The general parallelism of the T-slot with the longitudinal movement of the table is checked by using 150 mm long braked having a tenon which enters the slot. The dial gauge is fixed to the spindle taper and adjusted so that its feeder touches the upper surface of the bracket. The table is then moved longitudinally while the bracket is held stationary by the hand of the operator and dial gauge deviations from parallelism are noted down.

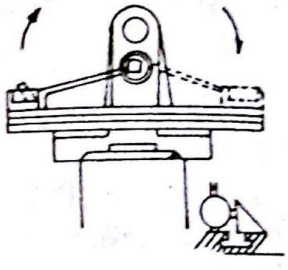

Fig. 12.16

Permissible error. 0.0125 mm in 300 mm.

(8) Parallelism between the main spindle and guiding surface of the overhanging arm

Instruments. Dial gauge, mandrel.

Procedure. The overhanging arm is clamped in its extreme extended position. The dial gauge is fixed to the arbor support.

The fecler of the dial gauge is adjusted to touch the top or ride of the test mandrel. The arbor support can then be moved along the overhanging arm and the deviations from paralielism observed on the dial gauge.

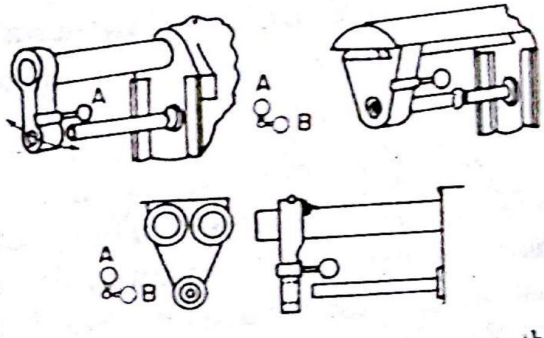

Fig. 12.17. Checking the overarm to the cutter spindle

Alignment tests on pillar type drilling machine

Before carrying out the alignment tests, the machine is properly levelled in accordance with the manufacturers instructions.

The various tests performed on pillar drilling machine are :

Instruments. Straight edge, two gauge blocks; feeler gauges.

1. **Flatness of clamping surface of base.** The test is performed by placing a straight edge on two gauge blocks on the base plate in various positions and the error is noted down by inserting feeler gauges.

Permissible error. The error should not exceed 0.1/1000 mm clamping surface and the surface should be concave only.

2. **Flatness of clamping surface of table**

The test is performed in the same manner as test (1), but not on the label. The permissible error is also same.

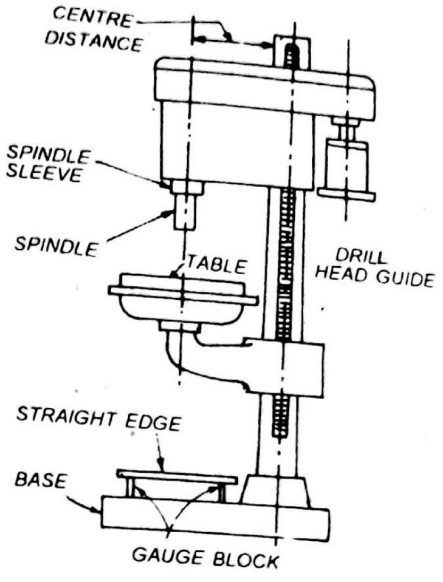

Fig. 12.23. Checking flatness of clamping surface of base

3. Perpendicularity of drill guide to the table base plate

Instruments. Frame level.

The squareness (perpendicularity) of drill head guide to the table is tested.

(*a*) In a vertical plane passing through the axes of both spindle and column, and

(*b*) In plane at 90° to the plane at (*a*).

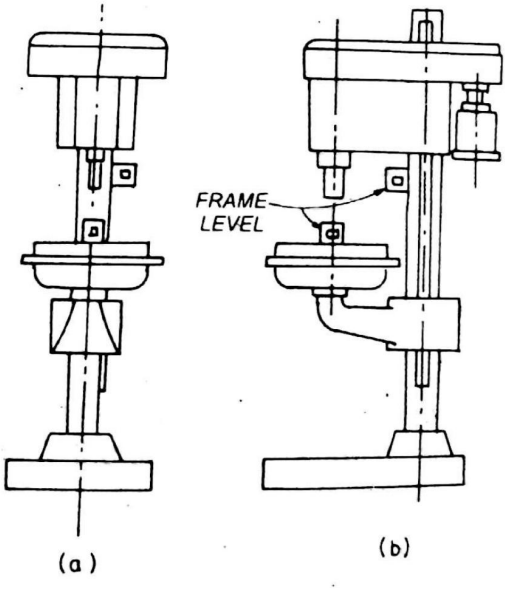

Fig. 12.24. Test for perpendicularity of drill head guide with table

The test is performed by placing the frame level (with graduations from 0.03 to 0.05 mm) on guide column and table and the error is noted by noting the difference between the readings of the two levels.

Permissible error. The error should not exceed 0.25/1000 mm guide column for (*a*) and the guide column should be inclined at the upper end towards the front only, and 0.15/1000 mm for (*b*).

For testing the perpendicularity of drill guide to the base plate the test is similar as above, the only difference being that the frame level is to be placed on the base instead of a table.

4. Perpendicularity of spindle sleeve with base plate

This test is performed in both the planes as specified in test (3) and in the similar manner. The only difference is that the frame levels are to be placed on spindle sleeve and base plate.

Permissible error. The error (*i.e.*, the difference between the readings of the two levels) should not exceed 0.25/1000 mm for plane (*a*) and the sleeve should be inclined towards column only, and 0.15/100 mm for plane (*b*).

5. True running of spindle taper

Instruments. Test mandrel, dial gauge.

Procedure. The test mandrel is placed in the tapered hole of spindle and a dial indicator is fixed on the table and its feeler made to scan the mandrel. The spindle is rotated slowly and readings of indicator noted down.

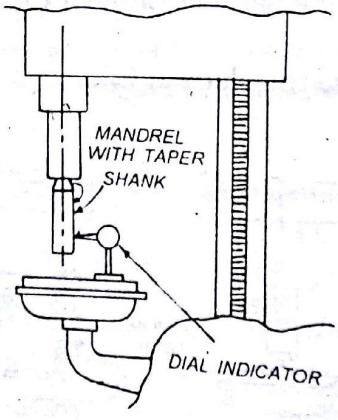

Fig. 12.25

Permissible error. The error should not exceed 0.03/100 mm for machines with taper up to Morse No. 2 and 0.04/300 mm for machines with taper larger than Morse No. 2.

6. Parallelism of the spindle axis with its vertical movements.

Instruments. Test mandrel, dial gauge.

Procedure. This test is performed into two planes (A) and (B) at right angles to each other. The test mandrel is fitted into the taper hole of the spindle and the dial gauge is fixed on the table with its feeler touching the

mandrel. The spindle is adjusted in the middle position of its travel. The spindle is moved in upper and lower directions of the middle position with slow vertical feed mechanism and the readings of the dial gauge are noted down.

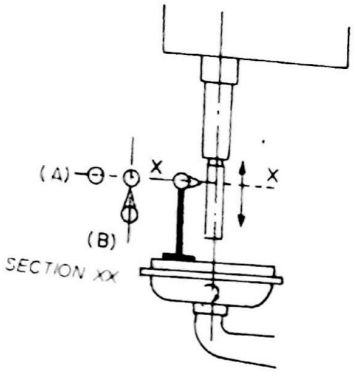

Fig. 12.26. For machines with tapper upto Morse No. 2. For machines with taper larger than Morse No. 2

Possible error. For plane (A) and (B) both 0.03/100 mm, 0.05/300 mm.

7. **Squareness of clamping surface of table to its axis.**

Instruments. Dial gauge.

Procedure. The dial indicator is mounted in the tapered hole of the spindle and its feeler is made to touches the surface of table. The table is then moved slowly and the readings of dial gauge noted down.

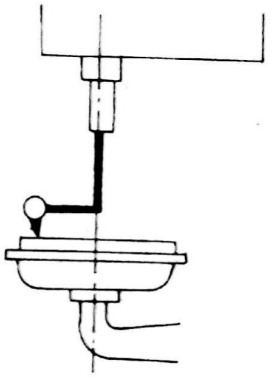

Fig. 12.27

Permissible error. The permissible error should not exceed 0.05/300 am diameter.

8. **Squareness of the spindle axis with table**

Instruments. Straight edge, dial gauge.

Procedure. This test is performed by placing the straight edge in positions *AA'* and *BB'*. The work table is arranged in the middle of its vertical travel. The dlal gauge is mounted in the tapered hole of the spindle and its feeler is made to touch the straight edge first at A and readings are taken. Then the spindle is rotated by 180° so that the feeler touches at point

A' and again the reading is taken. The difference of these two readings is the error in squareness of spindle axis with table. Similar readings are taken by placing the straight edge in position BB'.

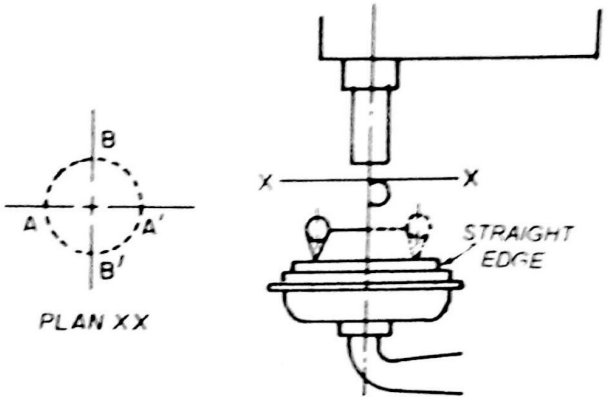

Fig. 12.28

Permissible error. The permissible errors are 0.08/300 mm with lower end of spindle inclined towards column only for set up AA' and 0.05/300 mm for set up BB'.