

# SYSTEM OF LIMITS AND FITS

## Introduction:

- \* In nature too extremely similar things is difficult to obtain
- \* No production process is not good enough to produce all items of products exactly
- \* Production involves 3 elements, MEN, MACHINE, MATERIAL
- \* Generally component manufactured is required to match with some other mating parts.
- \* If a shaft is located in hole there is some clearance should be there.
- \* Ideally all these conditions can be obtained by specified size of hole and shaft.
- \* But unfortunately it is not possible due to inaccuracy in the manufacturing methods.

## Some main points:

- (1) It is not possible to make any part precisely to a given dimension due to variability of elements of production process
- (2) Even if part is manufactured for given dimension. But it is not possible to measure it accurately enough to prove it.
- (3) If attempts are made to achieve to ~~perfect~~ size the cost of production increases tremendously

## Limits:-

"In manufacturing some permissible variation in dimension has to be allowed." This variation has its limits. They are two. i.e. upper limit, lower limit.

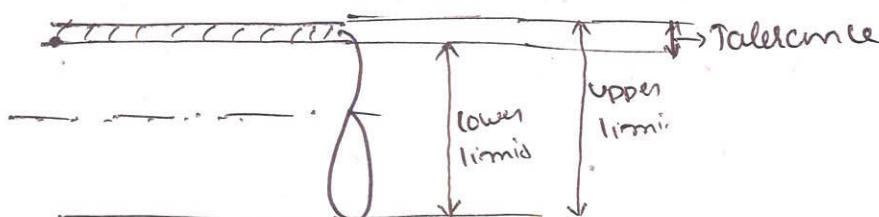
- \* The Range of permissible difference in dimension has been standardised.
- \* The actual size may lie in the two extreme limits, upper and lower limits.

## Tolerance:-

The permissible variation in size & dimension is called "tolerance".

The difference between upper limit and lower limit of dimension represents the "Tolerance limit" or "Tolerance zone".

"Tolerance is amount by which the job is allowed to go away from accuracy and perfectness without functional trouble".



Eg: A shaft 25mm basic size  $25 \pm 0.02$

$$\text{SOL} \quad \text{Upper limit} = 25 + 0.02 = 25.02 \text{ mm}$$

$$\text{Lower limit} = 25 - 0.02 = 24.98 \text{ mm}$$

$$\text{Tolerance, } [UL - LL] = [25.02 - 24.98] = 0.04 \text{ mm}$$

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## System of writing tolerances

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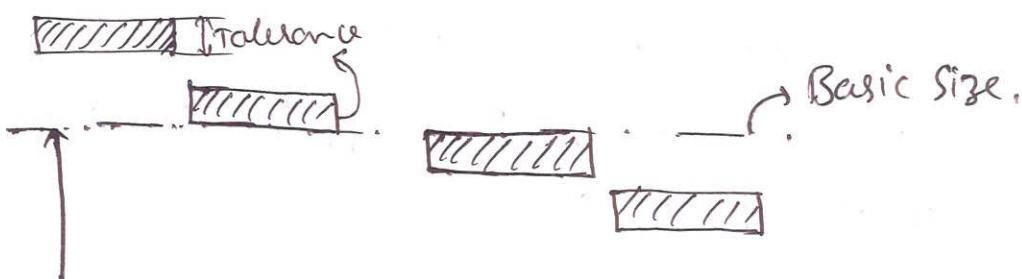
There are two types

- (i) UNILATERAL Tolerance
- (ii) BI LATERAL Tolerance

### Unilateral Tolerance:

In this type The dimension of a part is allowed to vary one side of the basic size either above or below it.

Eg



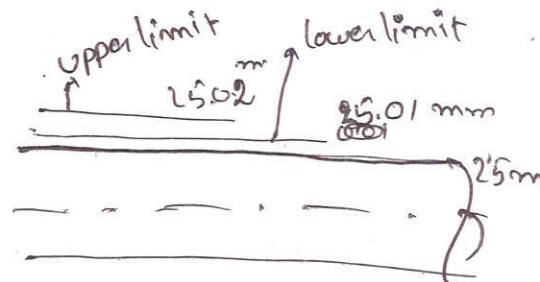
### Unilateral Tolerance System

Eg

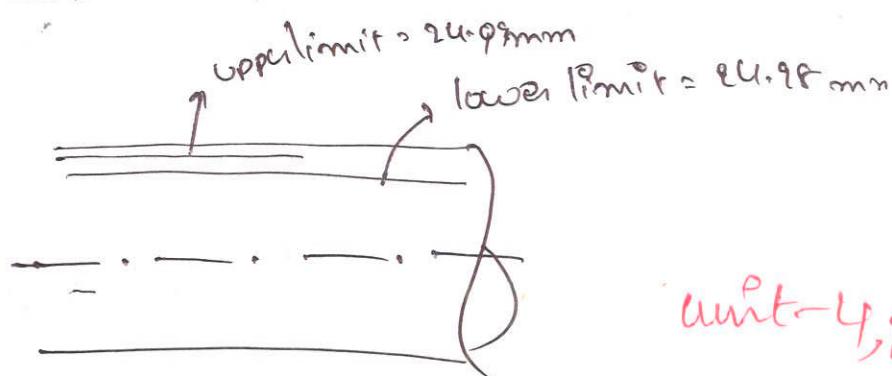
+0.02	+0.02	-0.01	+0.00
25 +0.01	25 0.00	25 -0.02	25 -0.02

- \* unilateral system is preferred for Interchangeable manufacture, precision fits are required.
- \* simpler to determine deviation
- \* different tolerance grades have same lower limit and all the shafts have upper limit

① 25 +0.01



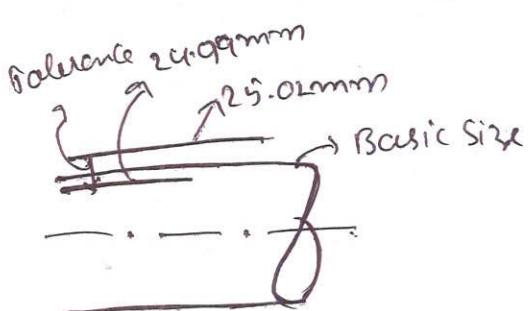
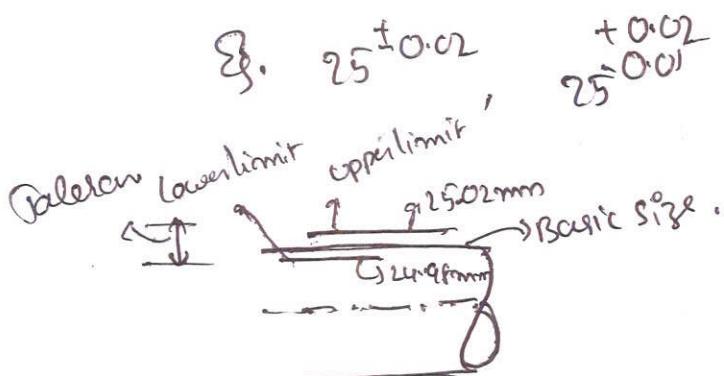
② 25 -0.01  
-0.02



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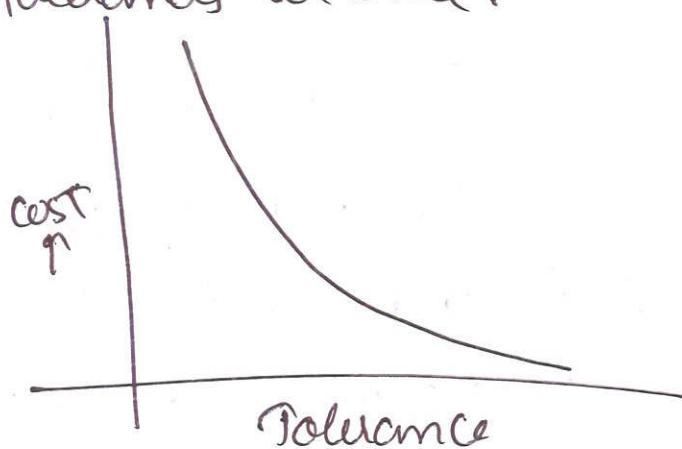
## Bilateral System :

In this System dimension of the part is allowed to vary on Both Side of the basic size. It may not be equally dispose about it.



- \* Same fit not possible.
- \* Tolerance is varied applied on the Both Sides of the Basic Size

Relation between Tolerance and cost :  
for closer tolerances we need.



- \* precision machines, tools, materials
- \* Trained and highly skilled operators.
- \* close supervision and control is essential
- \* It need more concentration of the operator, which slows down the rate of production.
- \* Trained and highly skilled operators needed

## Terminology for Limits and fits.

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- \* Shaft: It is a external dimension of component, dia of the circular shaft
- \* Hole: It is a dia of circular hole, internal, dimension of component
- \* Basic (O) Nominal Size:  
It is a standard size of the part with reference to the limits and variations of size determined.
- \* Actual Size:  
It is dimension as measured on manufactured part
- \* Zero line: "Datum line"  
It is a straight line horizontal to the basic size. In Graphical representation of limits and fits all deviations are shown w.r.t Zero line "Datum line"

### Deviation:

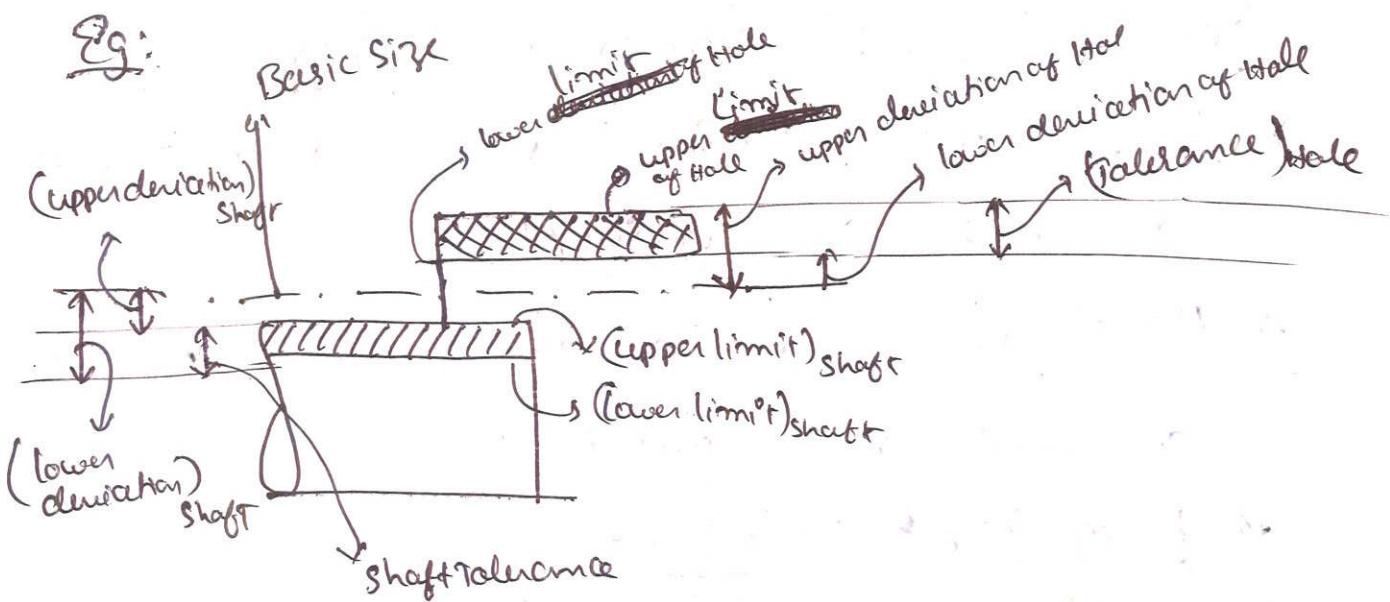
It is a algebraic difference between the size and corresponding basic size.

### Upper deviation:

It is algebraic difference between upper deviation and basic size

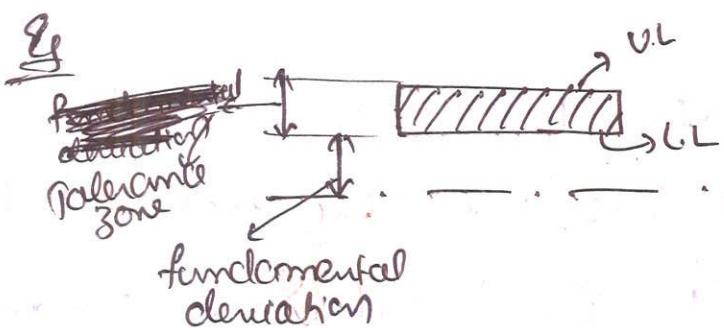
### Lower deviation:

It is algebraic difference between lower deviation and basic size.



### \* Fundamental deviations

- In two deviations, one of the nearer deviation is called "Fundamental deviation."



All Capital letters are indicate for "HOLE"

All Small letters are Indicate for "SHAFT"

### \* Basic Shaft:-

Basic Shaft is the whose upper deviation is zero

\* Basic Hole whose lower deviation is zero (L.I.)

### \* Tolerance zone:

It is the zone bounded by two limits.

of Size.

### \* Tolerance Zone

## Tolerance Grade :-

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It indicates the degree of accuracy of manufacture. It is indicated by the letter "IT". IT stands for "International Tolerance Grade". There are IT01, IT00, IT1, ..., IT16. It is a function of Basic Size.

## FIT :-

FIT is defined as degree of tightness or looseness between two mating parts to perform definite function.

According to the fit may result either in a movable joint & fixed joint.

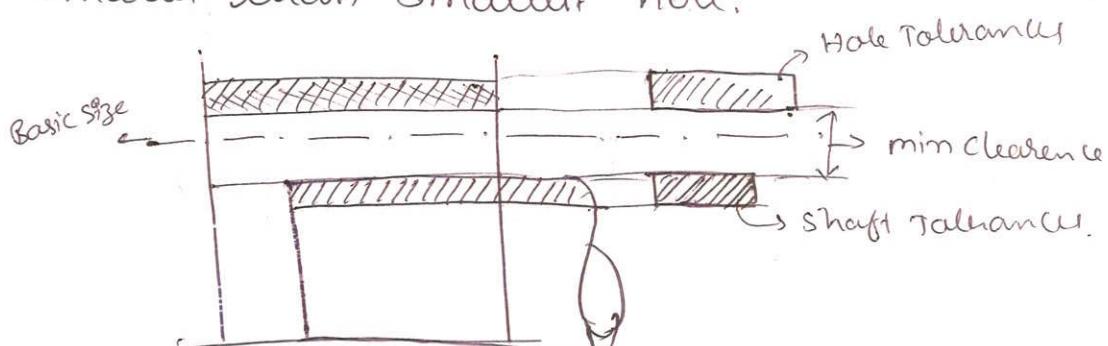
### Type of FITS :-

On the basis of the positive, zero, negative value of clearance. There are 3 types.

1. Clearance fit
2. Transition fit
3. Interference fit.

#### (1) Clearance fits :-

In this type of fit shaft always smaller than the hole. i.e. the largest permissible shaft diameter is smaller than smallest hole.



max clearance :- It is difference b/w min size of shaft and max hole

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min clearance :- It is difference b/w max size of shaft and min hole.

### \* Slide fit:

This type of fit has very small clearance. The min. clearance being zero.

### \* Easy slide fit:

This type of fit provides for a small guaranteed fit, Eg. slow and non regular motion.

### \* Running fit:

There is an appreciable clearance between mating parts. This clearance is for lubrication.

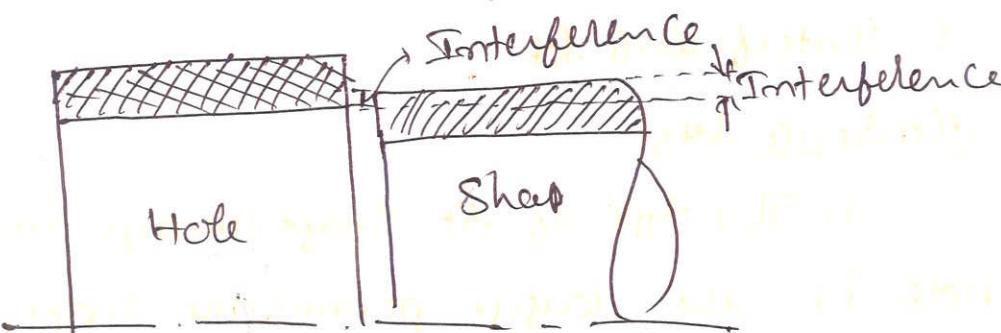
### \* Strengthening fit:

Eg: Arm shaft in IC Engines, Shaft of Centrifugal pump

### \* Loose Running fit: very high Speed, Idle pulley

## (2) Interference fit:

In this type of fit, the min permissible dia of the shaft is larger than the maximum allowable diameter of the hole.



\* Shaft and Hole are attached permanently.

\* No relative motion b/w them.

Eg: Steel tyres on railway car wheel, bearing in the gear of the lathe.

(3) Free fit: In this the mating parts cannot be disassembled during their total service.

Eg: Forging machine, Gears on the shaft.

### \* Tight fit:

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It provides less interference than loose fit.

In tight fits may be replaced when overhauling of the machine.

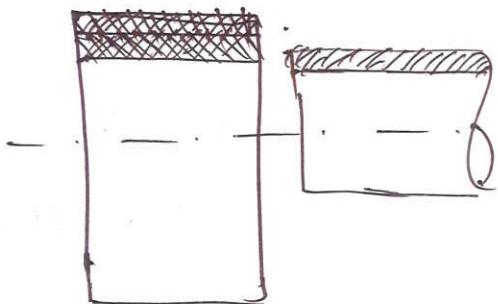
Eg: Stepped pulleys on drive shaft, Grinding machine

### \* Heavy force and "Shrink fit":-

It refers to the maximum negative allowance. force is needed to assembly.

### (3) Transition fit:

Transition fit lies mid way between clearance and interference fit. In this type the size limits of mating parts.



Transition fit

There are two types :-

#### (i) wringing fit :-

It provides either zero interference or a clearance.

Eg: parts replaced while minor repairs

#### (2) push fit:

This fit provides small clearance. It is employed for parts that must be disassembled during the operation of machine

Eg: Change gears, slip bushings.

## allowance

allowance is a difference between the dimension of ~~any~~ <sup>two</sup> mating parts for any type of fit.

" It is algebraic difference between the lower limit of "Hole" and upper limit of "Shaft"

## Difference between Tolerance and allowance

Tolerance	Allowance
* permissible variation in the part (Hole/Shaft)	* prescribed difference between two mating parts
* difference b/w higher and lower limit of part	* It is diff b/w lower limit of Hole, and upper limit of Shaft.
* It has absolute value without sign	* Allowance may be positive or negative.

## System of obtaining different types of fit:

There are two types of fits

(1) Hole basis System

(2) Shaft basis System.

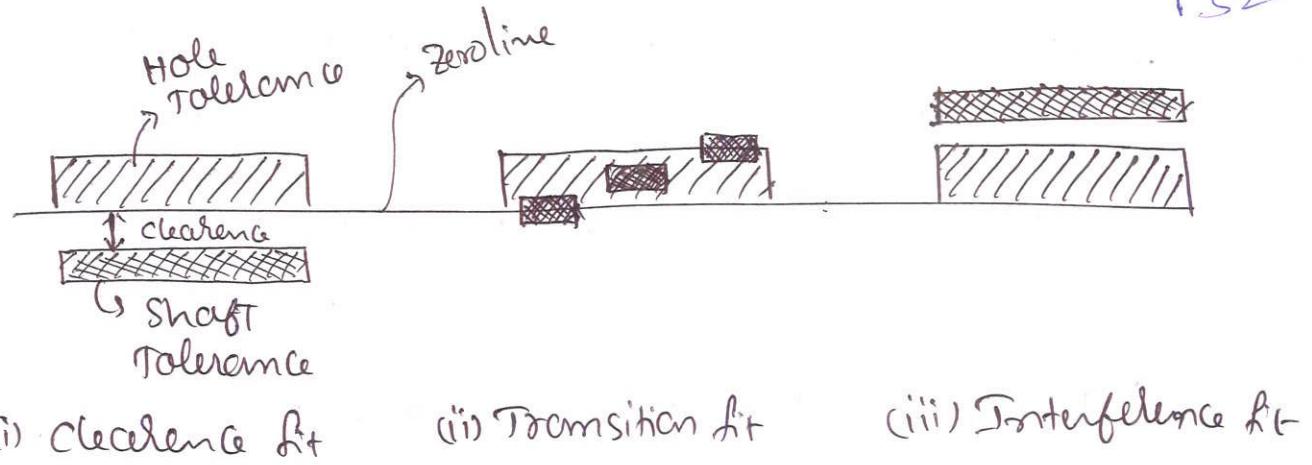
### (1) Hole basis System :-

In this system the hole is kept constant and shaft sizes are varied to the given various types of fits.

\* lower deviation of hole is zero.

\* Low limit of Hole is same as its

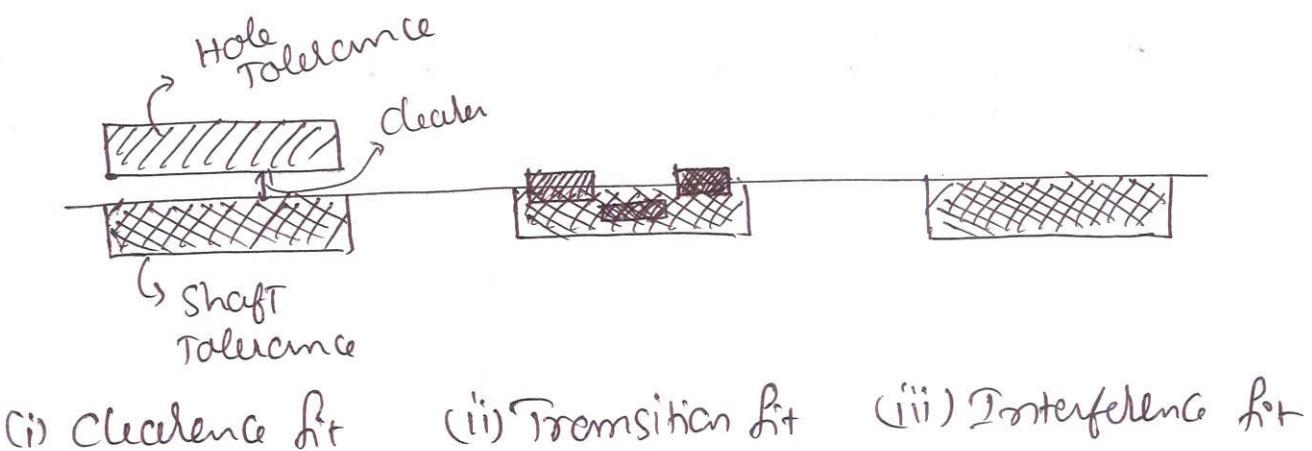
Basic Size



## (2) Shaft basis System :-

In the Shaft basis System the Shaft is kept constant and Size of the hole is varied to the given various parts.

- \* Upper deviation of the Shaft is zero.
- \* High limit of Shaft is the same as Basic Size



### NOTE

- \* Hole basis System is Generally used. Because.
- \* more convenient to make correct holes.
- \* Size of the hole and shaft produced by the turning, grinding etc. can be very easily varied.

### Hole Basis System

- \* Hole lower deviation is zero [H-hole]
- \* Limits on hole kept constant. Shaft size varies.
- \* Preferred for small production.
- \* Very much easy to vary shaft size according to fit.
- \* Less amount of capital and storage space for tools.
- \* Gauging of shaft can be easily done.

### Shaft Basis System

- \* Shaft upper deviation is zero (h-shaft).
- \* Limits of shaft kept constant hole size may varies.
- \* Not suitable for mass production.
- \* Rather difficult to vary the hole size.
- \* Large amount of capital and storage space for large no. of tools to produce hole of different size.
- \* Being internal measurement gauging of holes cannot be easily and conveniently done.

## Types of Assemblies

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Q There are 3 ways by which the mating parts can be made to fit together in the desired manner

(i) Trial and error

(ii) Interchangeable assembly

(iii) Selective assembly

(i) Trial and error :-

In this assembly one part is to be made to its nominal size and other part is then machined with a small amount at a time. by trial and error until they fit into required manner.

(ii) Interchangeable Assembly :-

In this system any one component is selected at random will assembled with the another mating part that too selected at random. This is called "Interchangeable Assembly"

- \* In mass production using this type. why because one part is produced at different work stations
- \* part should be manufactured with specified "tolerance limit"
- \* It requires precise machines.
- \* In this reduction in manufacturing cost.

Advantages of Interchangeability:

\* Assembly time is reduced.

\* Increased output with reduced production

\* A operator has to perform same operation again and again. he may specialist in that

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- \* which helps to Imcheck the Quality.
- \* The replacement of worn-out ( $\delta$ ) defective parts and repairs become very costly
- \* The cost maintenance and shut down period is also reduced to minimum.

### (3) Selective Assembly:

In Selective Assembly the components produced are classified into groups according to their sizes by automatic grading. This is done for both mating parts, holes and shafts and only matched groups of mating parts are assembled. It results in complete protection against defective assemblies and reduces matching cost, parts may produce with wider tolerances.

Eg: pistons with cylinder Bore.

Bore Size 50mm and clearance required for assembly is 0.12mm on the diameter. If the tolerance of "Bore" and "Cylinder" is 0.04mm.

Sol:

$$\text{dimension of Bore dia} = 50 \pm 0.02 \text{ mm}$$

$$\text{dimension of piston shaft} = 49.88 \pm 0.02$$

By Grading the parts as the clearance is 0.12mm

Cylinder Bore	$49.98 \}$	$50.00 \}$	$50.02 \}$
piston	$49.86 \}$	$49.88 \}$	$49.90 \}$

## Standard limit Systems :-

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Every country has its own Standard for Engineering limits and fits. But in order to have universal interchangeability it is essential to follow a uniform Standard throughout the world.

(i) British Standard BS-4500-1969

(ii) The International Standard ISO: 286-1988

(iii) Indian Standard IS-919.

All these Standards basically make use of the following:

(i) Standard tolerance

(ii) Fundamental deviation.

## Indian Standard System of limits and fits :-

\* It contains 18 Grades of fundamental tolerance.

\* Grades of accuracy for manufacturer and 25 types of fundamental deviation.

\* 18 Grades of Tolerances are, IT01, IT0, IT1... IT16.

\* The fundamental deviations are indicated by the letters for Hole, "A to Z<sub>e</sub>"

A B C D E F G H J<sub>s</sub>, J, m N, P R, S T, U, V, X, Y, +

+<sub>a</sub> +<sub>b</sub> +<sub>c</sub>

\* for Shaft

a, b, c, d, e, f, g, h, i, j, m, n, p, r, s, t, u, v, -Z, Y, -

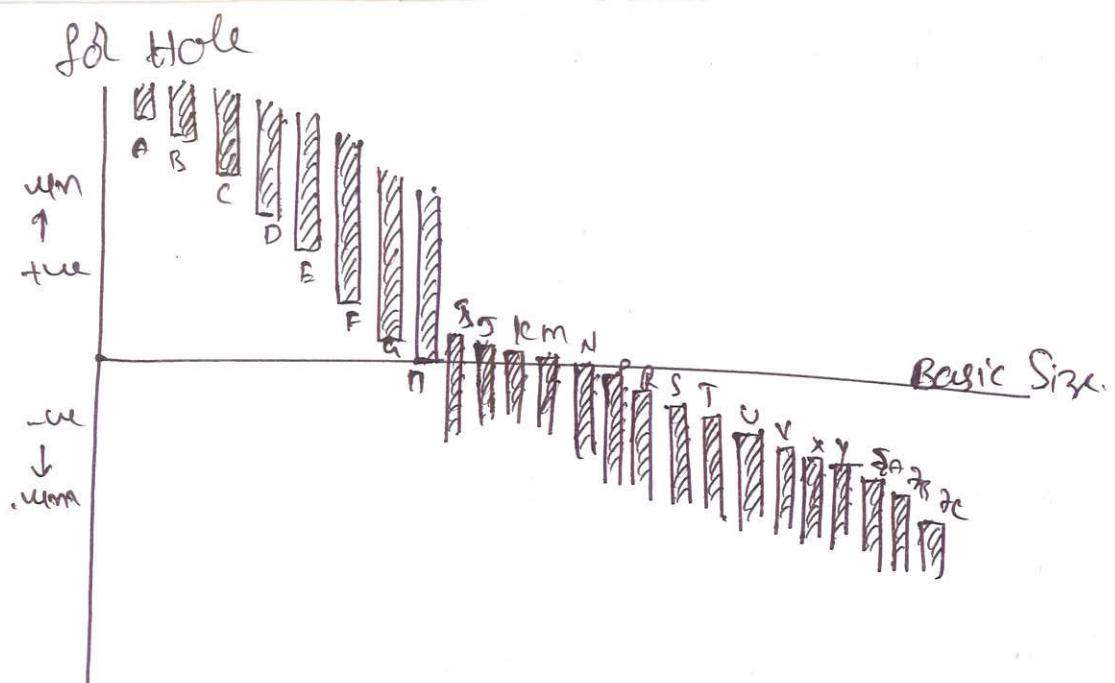
-<sub>a</sub> -<sub>b</sub>, -<sub>c</sub>

\* Each 95 Holes has the 18 tolerance grades.

\* for Shaft "a to h" upper deviation is below the zero line, "j<sup>o</sup> to Z<sub>e</sub>" it is above the zero line.

\* Similarly for Holes "A to H" upper deviation is below zero line, "J<sup>o</sup> to Z<sub>e</sub>" is above zero line.

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for Shaft Similar with Small Steps.

The numerical values of Standard Tolerances are determined in terms of Standard formula. Standard Tolerance unit is " $i^\circ$ ". where in  $i^\circ$  in microns. Expressed by the formula.

$$i^\circ = 0.45 \sqrt{D} + 0.001D$$

"D" = Geometric mean of diametral steps.

The various diametral steps are. 15-919 are

1-3, 3-6, 6-10, 10-14, 14-18, 18-24, 24-30, 30-40, 40-50, 50-65, 65-80, 80-100, 100 to 120, 120-140, 140-160, 160-180, 180-200mm.

$$1 \text{ micron} = 10^{-3} \text{ mm}$$

The values of Tolerance for Tolerance Grade for IT<sub>5</sub> to IT<sub>16</sub>

Grade	IT <sub>5</sub>	IT <sub>6</sub>	IT <sub>7</sub>	IT <sub>8</sub>	IT <sub>9</sub>	IT <sub>10</sub>	IT <sub>11</sub>	IT <sub>12</sub>	IT <sub>13</sub>	IT <sub>14</sub>	IT <sub>15</sub>	IT <sub>16</sub>
Value	71°	101°	161°	251°	401°	641°	1001°	1601°	2501°	4001°	6401°	10001°

for tolerances for IT<sub>11</sub> to IT<sub>5</sub> are calculated in "micron".

$$IT_{11} \rightarrow 0.3 + 0.08D \text{ micron}$$

$$IT_{10} \rightarrow 0.5 + 0.12D \text{ micron}$$

$$IT_9 \rightarrow 0.8 + 0.02D \text{ micron}$$

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Q. ① 50H7 Ø)

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where 50 - Basic Size

H → Hole Basis System

7 → IT7 → Tolerance Grade.

② 50f8

where 50 - Basic Size

f → Shaft basis System

8 - IT8 → Tolerance Grade.

Small letters indicate the Shaft basis System

Capital letters indicate the Hole basis System

problems:

i) find the values of allowance, Tolerance for hole and shaft

Hole:  $25^{+0.05}_{-0.00}$

Shaft:  $25^{-0.02}_{-0.05}$

Sol:

i) Hole: [Tolerance = upper limit - lower limit]  
 $= 25.05 - 25.00$   
 $\therefore 0.05\text{mm}$

ii) Shaft: [Tolerance = upper limit - lower limit]  
 $= 24.98 - 24.95$   
 $\therefore 0.03\text{mm}$

iii) (Allowance = low limit of Hole - High limit of shaft)

Allowance  
 $= 25.00 - 24.98$   
 $\therefore 0.02\text{mm}$

Pr.① for each of the following hole and shaft assembly find the shaft tolerance, hole tolerance, state whether type of fit

$$\text{Hole: } 50_{-0.00}^{+0.25}, \quad \text{Shaft: } 50_{+0.005}^{+0.005} \text{ mm.}$$

Solution

$$\text{Hole: Tolerance} = \text{upper limit} - \text{lower limit}$$

$$= 50.25 - 50.00$$

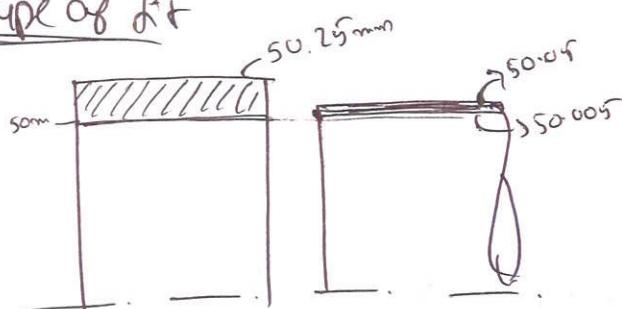
$$(\text{Tolerance})_H = 0.25 \text{ mm}$$

$$\text{Shaft: Tolerance: upper limit - lower limit}$$

$$= 50.05 - 50.005$$

$$(\text{Tolerance})_S = 0.045 \text{ mm.}$$

Type of fit



To know about fit we have to know the Allowance

$$\text{allowance} = (\text{lower limit})_H - (\text{upper limit})_S$$

$$= 50.00 - 50.05 = \frac{0.045 \text{ mm}}{-0.05 \text{ mm}}$$

-ve indicates the Interference fit.

③ A hole and shaft are ~~to~~ to have a nominal assembly size of 60mm. The assembly have the maximum clearance 0.15mm. and a min clearance of 0.05mm. The hole Tolerance is 1.5 times the shaft Tolerances. determine the hole and shaft. By using

(i) Hole basis System

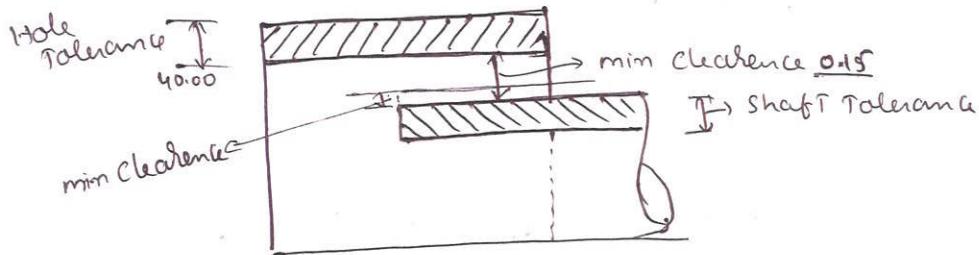
(ii) Shaft basis system

## Solution

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### (1) Hole basis System:

It means its lower deviation is zero means Basic Size.



$$(\text{Tolerance})_H > 1.5 (\text{Tolerance})_S$$

$$\text{max clearance} = (\text{Tolerance})_H + \text{min clearance} + (\text{Tolerance})_S$$

$$0.15 = 1.5 (\text{Tolerance})_S + 0.05 + (\text{Tolerance})_S$$

$$0.15 = 2.5 (\text{Tolerance})_S + 0.05$$

$$0.10 = 2.5 (\text{Tolerance})_S$$

$$(\text{Tolerance})_S = 0.04 \text{ mm}$$

$$(\text{Tolerance})_H > 1.5 (0.04) = 0.06 \text{ mm.}$$

for Hole Basic Size: 40mm

$$\begin{aligned} \text{Hole basis System} &\Rightarrow U.L = 40 \text{ mm} \\ U.L &= U.O + \text{Tolerance} \\ &= 40 + 0.06 \end{aligned}$$

$$U.L = 40.06 \text{ mm}$$

$$\text{fd Hole, } 40^{+0.06}_{-0.00}$$

for Shaft:

$$\begin{aligned} \text{min clearance} &= (\text{low limit})_H - (\text{high limit})_S \\ 0.05 &= 40.00 - (\text{high limit})_S \end{aligned}$$

$$(\text{high limit})_S = 39.95 \text{ mm}$$

$$(\text{low limit})_S = 39.91 \text{ mm}$$

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## for Shaft basis System:

In This System min deviation is zero means upper limit of shaft is Basic size.

$$\begin{aligned}\text{low limit of shaft} &= \text{B.L.} - \text{Tolerance} \\ &= 40 - 0.04 \\ &= 39.96 \text{ mm}\end{aligned}$$

$$\text{max Clearance} = (\text{High limit})_H - (\text{low limit})_S$$

$$0.15 = (\text{High limit})_H - 39.96$$

$$(\text{High limit})_H = 40.11 \text{ mm}$$

$$\text{Low limit of Hole} = 40.11 - 0.06 = 40.05 \text{ mm}.$$

## Plain Guages:

plain Guages are used for checking plain.

### (i) acc to their type:

- (i) Standard guages
- (ii) Limit Guages.

(i) Standard guage: If a guage is made as an exact copy of the mating part of the Component to be checked. it is called as Standard Guage.

### (ii) Limit Guages:

\* Limit Guages are used very widely used in Industries. As there are two permissible limits of the dimension of a part high and low two Guages are needed to check each dimension of the part, one corresponding the low limit of size and other to the high limit of size of that dimension. They are known as Go, No-Go Guage.

\* The difference between These two Guages is Equal to the Tolerance on the work piece.

## Go-Gauge :

It works on the maximum material condition.

for Hole MMC is  $\rightarrow$  Lower limit

for Shaft MMC is High limit

## No-Go Gauge :

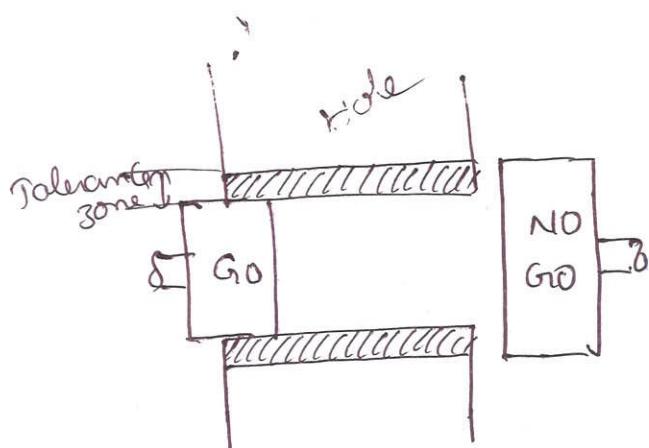
It works on the "Low material condition".

for Hole LMC is Upper limit

for Shaft = LMC is Lower limit

## Taylor's principle of Gauge design

It States that, Go Gauge should be designed to check the maximum material limit. while the No-Go Gauge Should be designed to check the minimum material limit.



now plug gauges are used to check the hole  
therefore size of the Go plug gauge should be low limit of hole. while no-plug gauge corresponds to the high limit of hole

Go Gauge should check all the related dimensions like Grandney, Size location, Similarly No Go Gauge Should check only one element of the dimension at a time.

Ex: problem:

Design the General type Go and no-go Gauge for components. having.  $\text{H}20\text{H}7\text{f}8$  fit.

(i)  $C^0 \text{ micron} = 0.45(D)^{1/3} + 0.001D$

(ii) upper deviation of shaft =  $-5.5 D^{0.41}$

(iii) 20 mm falls in the diameter Step of 18mm to 30mm

(iv)  $\text{IT}7 = 6^{\circ}$

(v)  $\text{IT}8 = 25^{\circ}$

(vi) wear allowance. 10% of Gauge tolerance.

Solution:

The dia meter value 20mm in the diametral steps of 18 to 30mm.

$$D, \sqrt{18 \times 30} = 23.2329.$$

$$C^0 = 0.45D^{1/3} + 0.001D$$

$$C^0 = 0.45(23.23)^{1/3} + 0.001(23.23)$$

$$C^0 = 1.3024 \text{ micron} = 0.021 \text{ mm}$$

now upper deviation of its shaft

$$= -5.5 D^{0.41}$$

$$= -5.5(23.23)^{0.41}$$

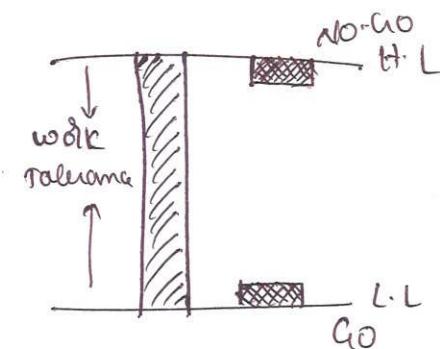
$$= 20 \text{ micron} > 0.02 \text{ mm}$$

$$\text{ITA} = 16^{\circ}, 16 \times (0.02) = 21 \text{ micron} > 0.02 \text{ mm}$$

$$\text{IT8} = 25^{\circ}, 25 \times (0.02) = 33 \text{ micron} > 0.02 \text{ mm}$$

## (ii) plug gauge

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plug gauge.

\* unilateral system providing tolerance is preferred.

In this System Gauge tolerance zone lies entirely within the work tolerance zone.

for Eg: If the size of the hole to be checked be  $50 \pm 0.02 \text{ mm}$  Then

$$U.L \text{ of Hole} = 50.02 \text{ mm}$$

$$L.L \text{ of hole} = 49.98 \text{ mm}$$

The Gauge tolerance  $\approx 0.1 \cdot \text{work tolerance}$

$$\text{Gauge tolerance} \approx \frac{10}{100} \times (0.04) = 0.004 \text{ mm}$$

Then dimensions of  $GO$  plug gauge is:  $49.98 - 0.004 \text{ mm}$

Dimension of NO-GO plug Gauge:  $50.02 + 0.004 \text{ mm}$

$GO$  - Gauge for shaft - low material condition

$NO-GO$  Gauge for shaft - max material condition

$GO$  - Gauge for hole  $\rightarrow$  low material condition

$NO-GO$  Gauge for hole  $\rightarrow$  max material condition

$GO$  - Gauge  $\rightarrow$  low material condition

$NO-GO$  Gauge  $\rightarrow$  max material condition

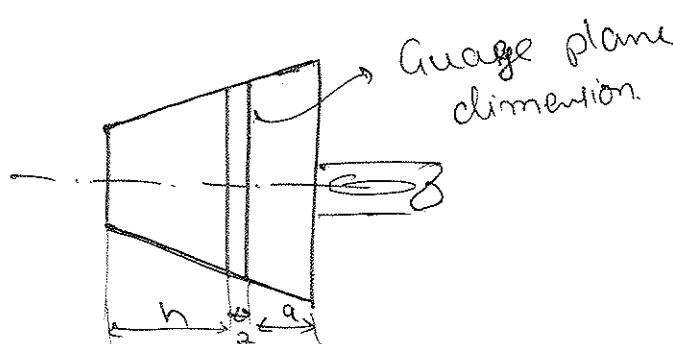
## Wear allowance

- \* wear is caused due to two mating parts in the rotation.
- \* In Go-Gauge lab continuously against the surface of the work piece during the checking.
- \* This result Go-Gauge losing its initial size.
- \* Thus Go-plug gauge is reduced its value.
- \* While Snap & Ring Gauges are increased.
- \* For No-Go Gauge wear allowance is not provided means it not much effect by the wear.

wear allowance  $> 50\%$  (work tolerance)

## Taper Gauges :-

- \* A taper plug Gauge is used for checking taper hole and taper ring gauge for checking the shaft.
- \* Taper limit Gauges do not check the angle of taper of the work.
- \* They are used to check the diameter at bigger end and change the diameter per unit length.



The plane Gauge is located at a distance 'a' from the free end and it is vary from ~~free end~~ 2mm to 10mm. Consider a taper plug gauge.

If the diameter is 'd' The diameter Diametral Deviation -  $\frac{d}{2} \pm \frac{D}{2}$

## Method of measurements:

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1. Direct method
2. Indirect method
3. Absolute & fundamental method
4. Comparative method
5. Transposition method.
6. Coincidence method
7. Deflection method
8. Complementary method
9. Contact, method
10. Contact less method

### (i) Direct method

Eg: without calculation. Scale, vernier calliper, micrometer, protractor

### (ii) Indirect method: Calculation needed.

we can measure object by calculating the other physical properties

Eg: Sine bar, Screw pitch dia,

### (iii) Absolute & fundamental method:

measurement linked with the definitions of quantities to be measured.

### (iv) Comparative method:

value of quantity to be measured. <sup>is</sup> with the compared with the known value of same Qty.

Eg: dial indicator,

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### (5) Transposition method:

It is direct comparison.

The value of Qty measured is first balanced by initial known value 'A' of the same Qty.

Eg:- Simple balance weighing is best example

### (6) Coincidence method:

- \* Differential method of measurement
- \* Small diff value of Qty to be measured and Reference is to be determined by observation

Eg:- Vernier Calliper.

### (7) Deflection method:

Quantity to be measured is directly indicated by a deflection of pointer on Calibrated Scale.

### (8) Complimentary method:

The value of Qty to be measured is combined with a known value of same Qty.

Eg: determination of volume of solid by liquid displacement in water.

### (9) Contact method:

Sensor (or) measuring tip of instrument actually touches the Qty.

Eg: Vernier Calliper. dial indicator.

### (10) Contactless method:

There is no direct contact with the surface to be measured.

Eg: Tool maker microscope, projection unit - SF, Compacted etc Pg: 27/29

Errors in the measurement caused due to

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- \* Accuracy and design of measuring instruments
- \* The skill of operator
- \* method adopted for measurement
- \* Temperature variations
- \* Elastic deformation of the part.

Precision :-

- \* This is performance parameter.

Precision is nothing but the repeatability of the measuring process. It refers to the group of measurements for the same characteristic taken under identical conditions.

Accuracy :-

Accuracy is the degree to which the measured value of the quality characteristics agrees with the true value.

Error: "The difference between the true value and measured value"

Sensitivity: The rate of displacement of the indicating device of an instrument with respect to the measured quantity.

Readability:-

Ease with which the reading of a measuring instrument can be read.

Fine and widely spaced graduation lines improves the readability.

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Calibration :- Generally used for checking of measuring instruments.

Magnification:

Magnification means increase the magnitude of output signal of measuring instrument.

Repeatability:

The ability of measuring instrument to repeat the same result for the same Qty for different times.

Reproducibility:

Consistency of pattern of variation in measurement.