

The image features a central hyperboloid of one sheet, a three-dimensional surface that resembles a cooling tower. It is rendered with a dense grid of thin, light gray lines that intersect to form a mesh. The surface is wider at the top and bottom and narrows in the middle. Scattered across the surface and in the surrounding space are numerous small, multi-colored dots in shades of red, blue, yellow, green, and purple. The overall composition is symmetrical and has a technical, mathematical feel.

几何公差



01 公差原则

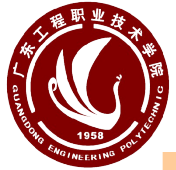
02 独立原则

03 相关要求



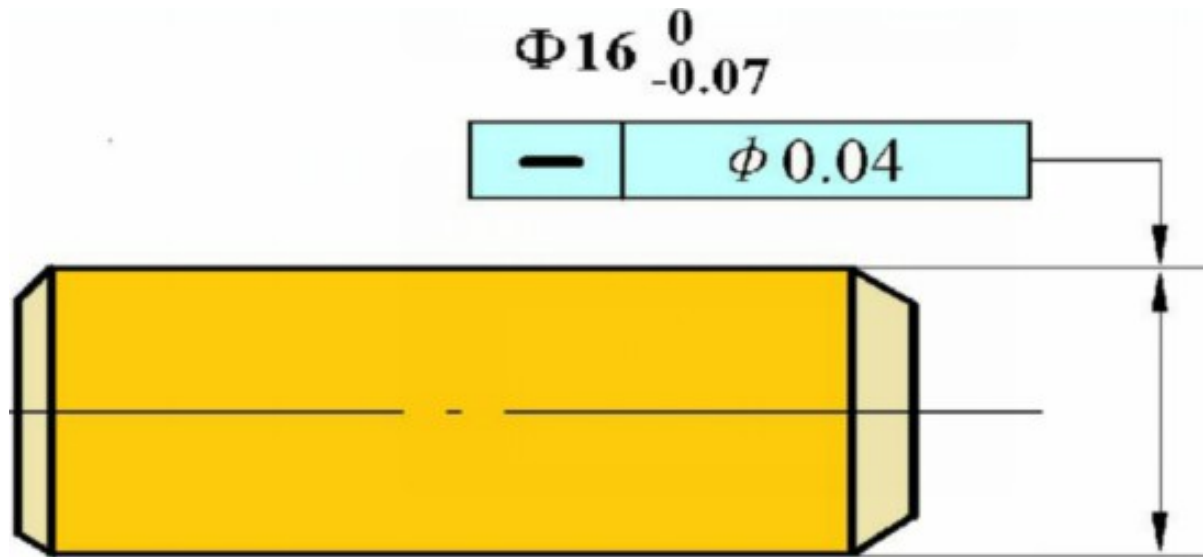


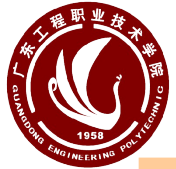
01 公差原则



公差原则

机械零件的同一被测要素既有尺寸公差要求，又有几何公差要求，处理尺寸公差 T_R 与几何公差 t 之间关系的基本原则，称为公差原则。





公差原则

$t_{\text{几何}}$ 和 $T_{\text{尺}}$
之间关系

无：独立原则

有：相关要求

包容要求

E

最大实体要求

M

最小实体要求

L

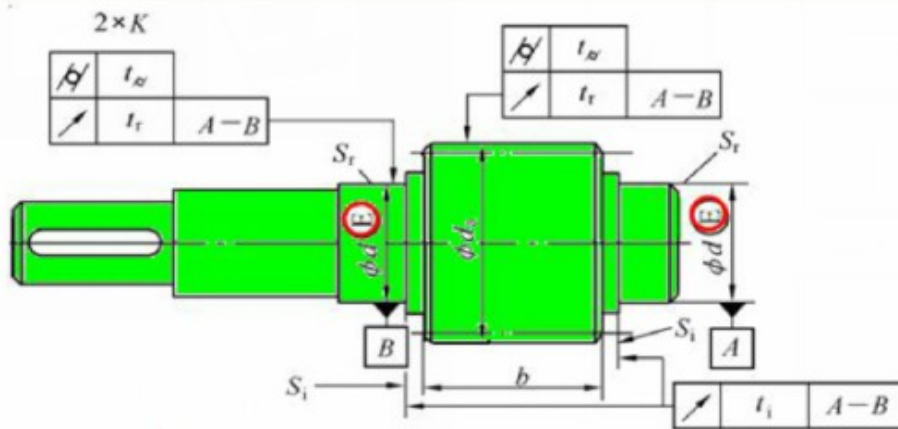
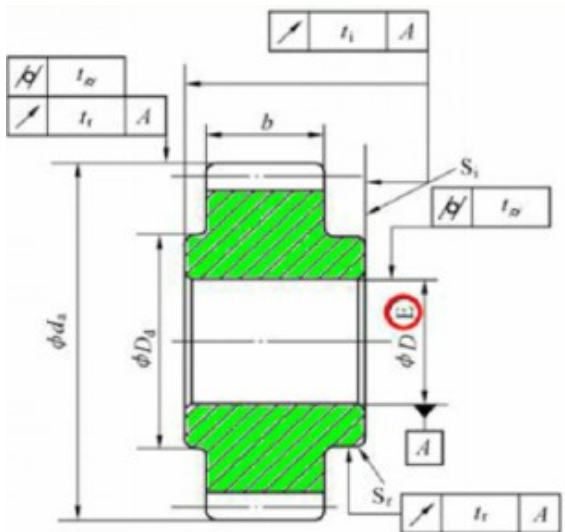
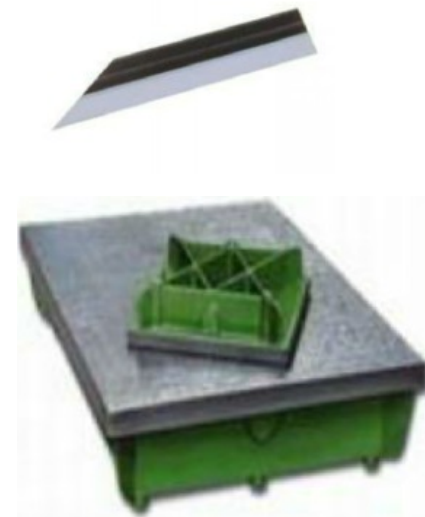
可逆要求

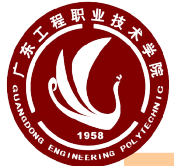
R



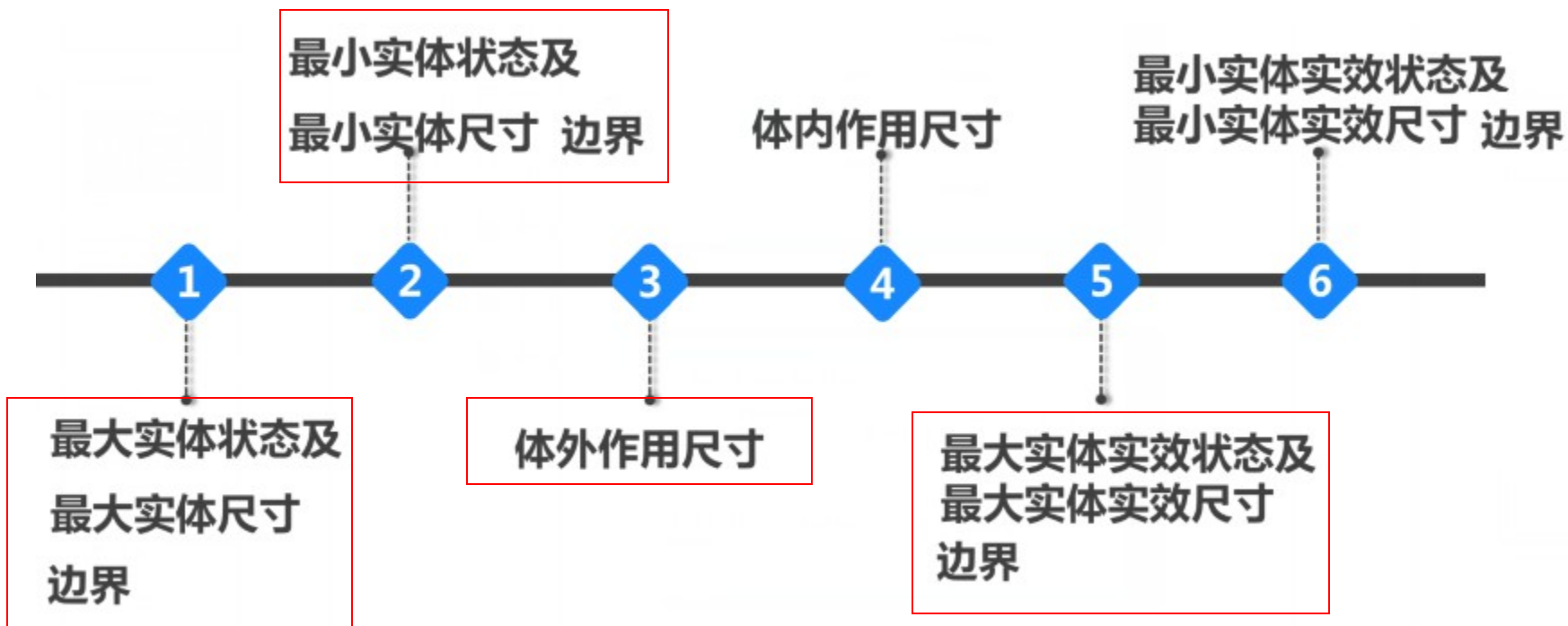
公差原则——

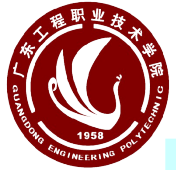
1. 一般采用**独立原则**（刀口直尺，测量平板）
2. 有配合性质要求的要素，一般采用**包容要求**（齿轮内孔与轴）
3. 对于保证可装配性、无配合性质要求的中心要素，采用**最大实体要求**（法兰、轴承盖通孔）





有关术语及定义





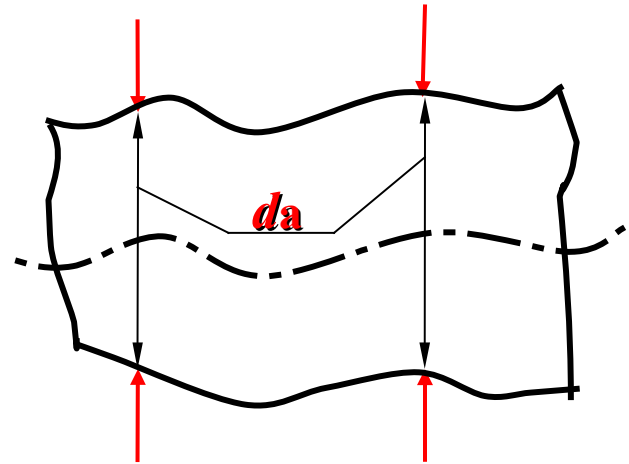
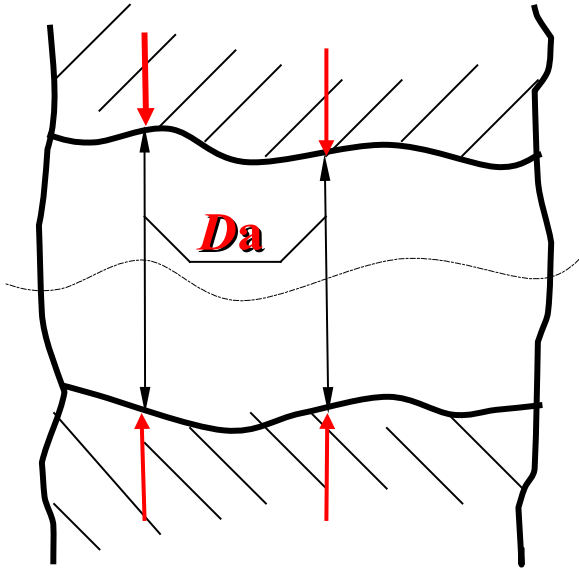
公差原则

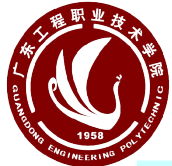
局部实际尺寸（实际尺寸）（ D_a 、 d_a ）

实际尺寸是通过测量得到的尺寸

$$\phi 25_0^{+0.021}$$

$$\phi 25.02$$





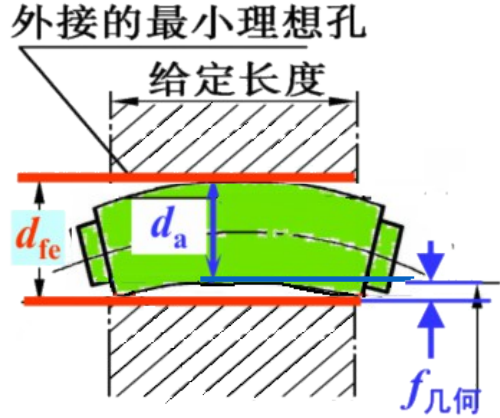
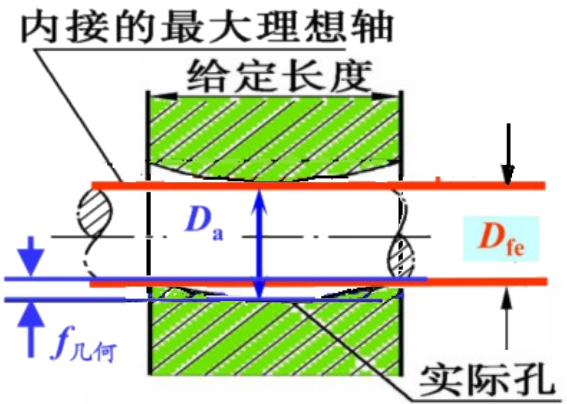
公差原则

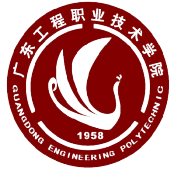
体外作用尺寸 (D_{fe} 、 d_{fe})

在被测要素的给定长度上，与实际外表面（轴）体外相接的最小理想面或与实际内表面（孔）体外相接的最大理想面的直径或宽度。

$$D_{fe} = D_a - f_{几何}$$

$$d_{fe} = d_a + f_{几何}$$



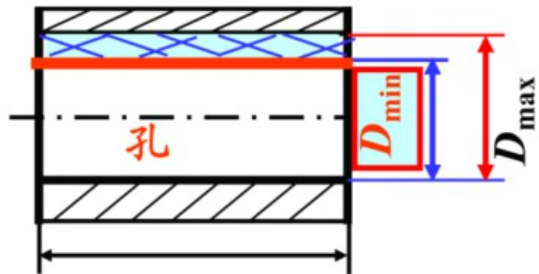


公差原则

最大实体尺寸 (MMS 孔或轴在尺寸公差范围内, 具有材料最多时的状态 (最大实体状态 MMC) 下的极限尺寸, (D_M, d_M))。

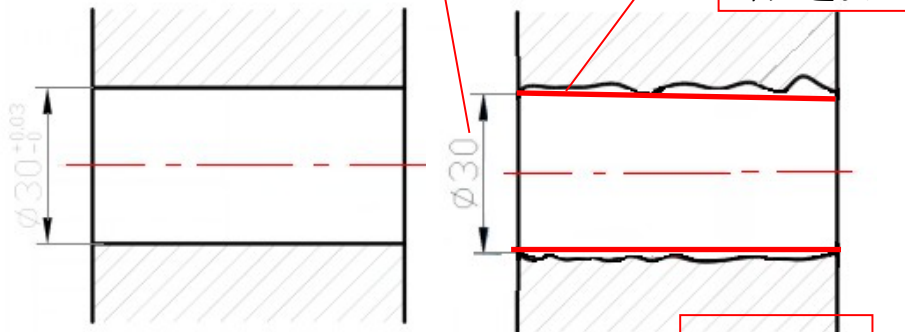
最大实体边界 (MMB 尺寸为最大实体尺寸的边界。

$$D_M = D_{\min}$$

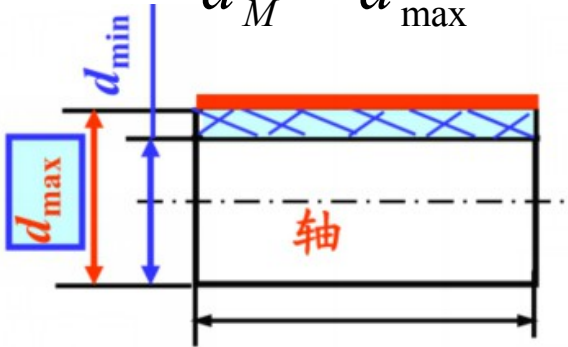


$$\phi 30^{+0.03}_0$$

$$D_m = D_{\min}$$

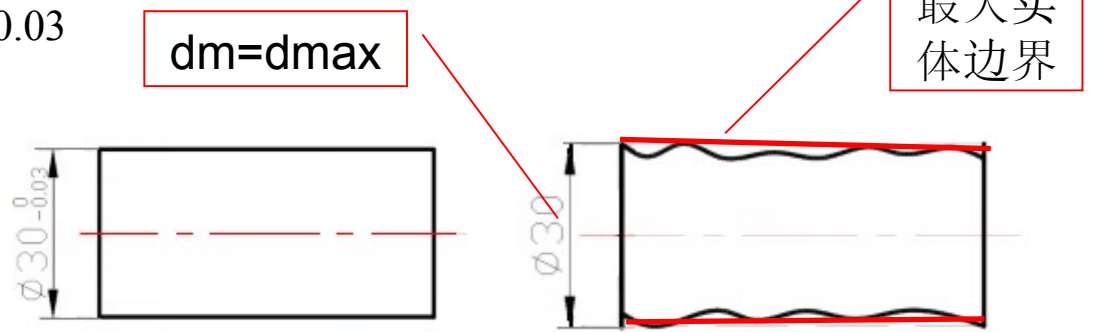


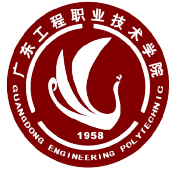
$$d_M = d_{\max}$$



$$\phi 30^0_{0.03}$$

$$d_m = d_{\max}$$





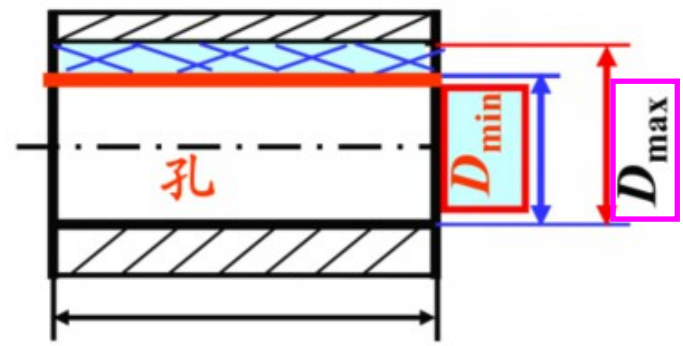
公差原则

最小实体尺寸 (LMS) 孔或轴在尺寸公差范围内，具有材料最少时的状态 (最小实体状态 MMC) 下的极限尺寸， (D_L, d_L) 。

最小实体边界 (LMB) 尺寸为最大实体尺寸的边界。

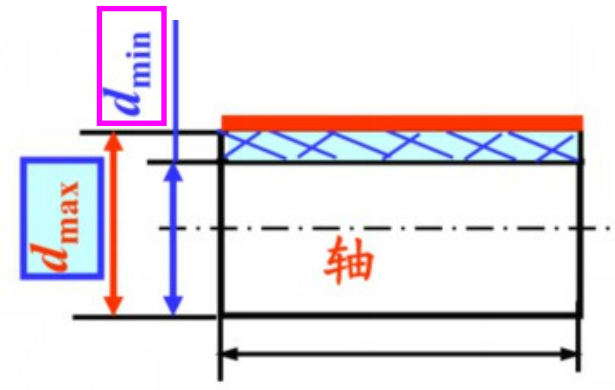
$$D_L = D_{\max}$$

$$\phi 30^{+0.03}_0$$



$$d_L = d_{\min}$$

$$\phi 30^0_{0.03}$$



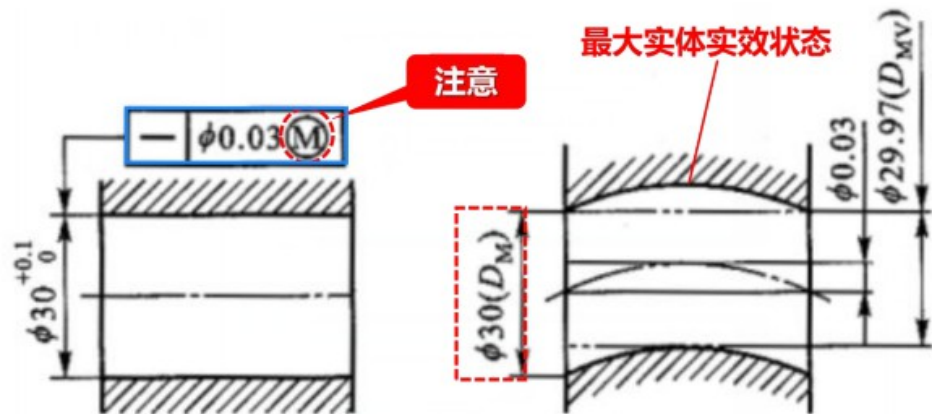


公差原则

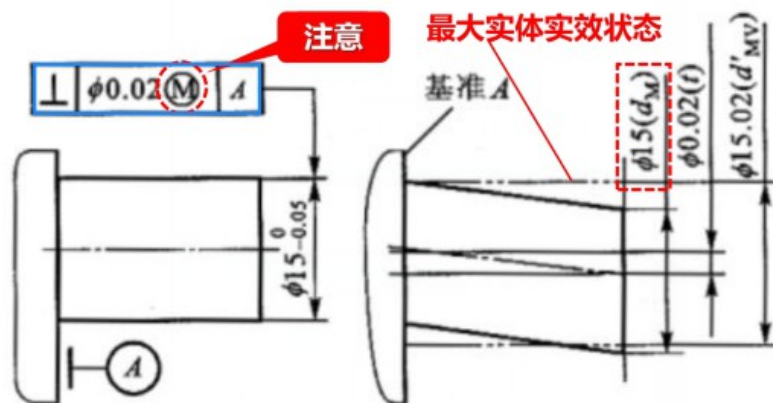
最大实体实效状态 (MMVC) 实际尺寸达到最大实体尺寸且几何误差达到给定几何公差值时的极限状态。

最大实体实效尺寸 (MMVS) 最大实体实效状态下的体外作用尺寸, (D_{MV} , d_{MV})

最大实体实效边界 (MMVB) 尺寸为最大实体实效尺寸的边界。



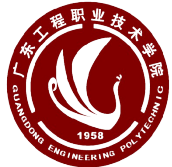
$$\begin{aligned} \text{孔: } D_{MV} &= D_M - t = D_{\min} - t \\ &= 30 - 0.03 = 29.97 \end{aligned}$$



$$\begin{aligned} \text{轴: } d_{MV} &= d_M + t = d_{\max} + t \\ &= 15 + 0.02 = 15.02 \end{aligned}$$



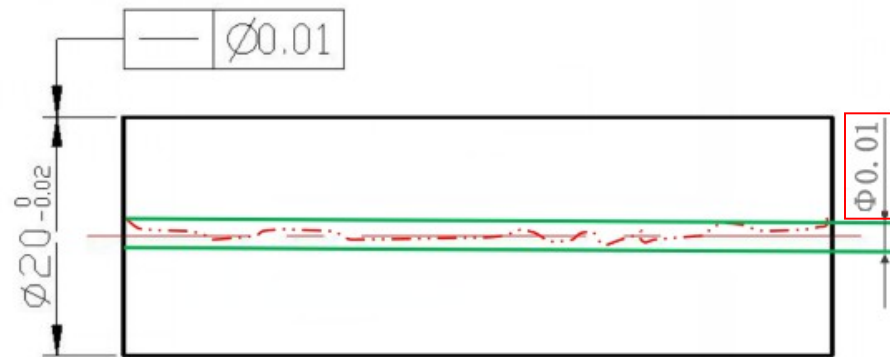
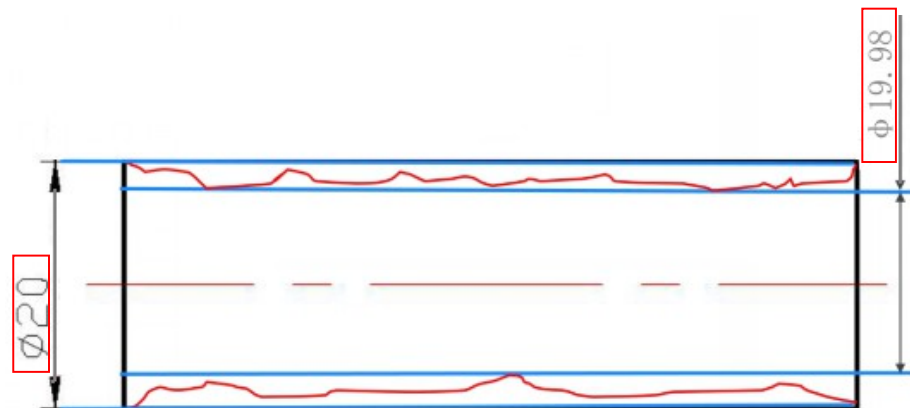
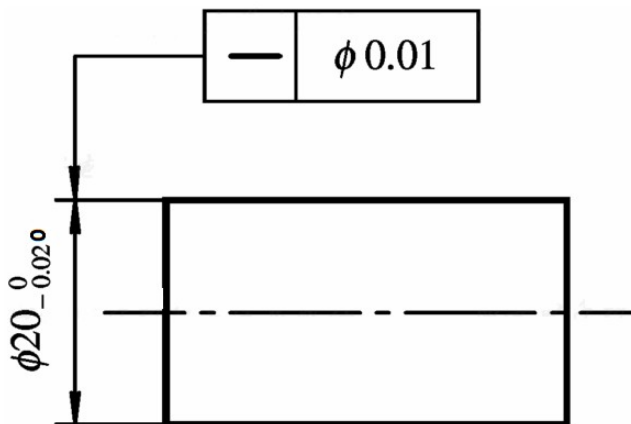
02 独立原则



独立原则

独立原则

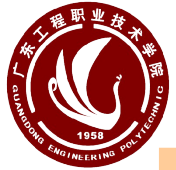
尺寸公差与几何公差相互无关，分别给定，分别测量，分别满足要求的一种原则。



直线度允许误差	实际尺寸
$\phi 0.01$	$\phi 20$
$\phi 0.01$	$\phi 19.99$
$\phi 0.01$	$\phi 19.98$



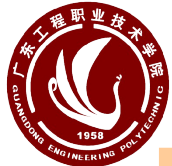
03 相关要求



相关要求

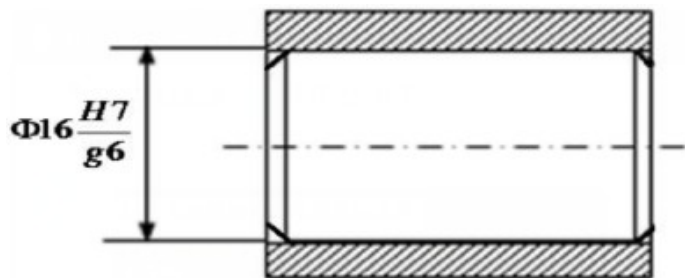
图样上给定的几何公差与尺寸公差相互有关的公差要求。

- ◆ 包容要求 (E)
- ◆ 最大实体要求 (M)
- ◆ 最小实体要求 (L)
- ◆ 可逆要求 (R)



包容要求 —— 适用于单一尺寸要素 E

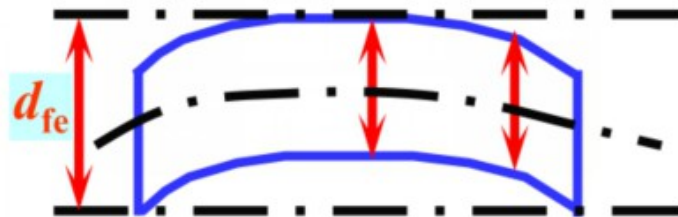
包容要求用最大实体边界控制单一要素的实际尺寸和形状误差的综合结果，即被测实际要素应不得超越其最大实体边界，其局部实际尺寸不得超出最小实体尺寸的一种公差要求。



$$d_{fe} = d_a + f_{\text{几何}} \quad \text{?} \quad d_M$$

$$d_a \quad \text{?} \quad d_L \quad d_{\min}$$

允许的形状误差：0 ~ $\frac{T}{\dots}$





图样标注

在被测要素的尺寸极限偏差或公差带代号后加注“ \textcircled{E} ”符号。



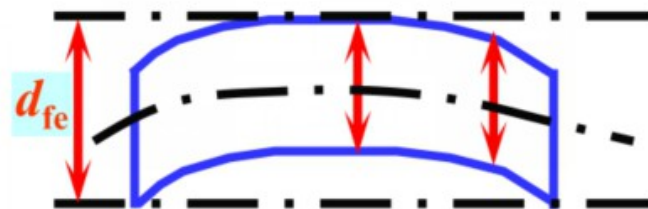
”

表示的含义

\textcircled{E}
 $\Phi 16_{-0.006}^{-0.017}$



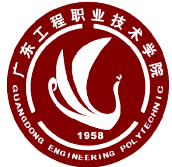
允许形状误差	实际尺寸
$\Phi 0$	$\Phi 15.994$
$\Phi 0.004$	$\Phi 15.99$
$\Phi 0.011$	$\Phi 15.983$



形状
误差

← 补偿给

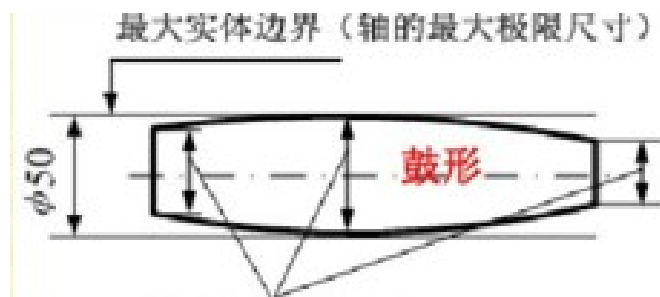
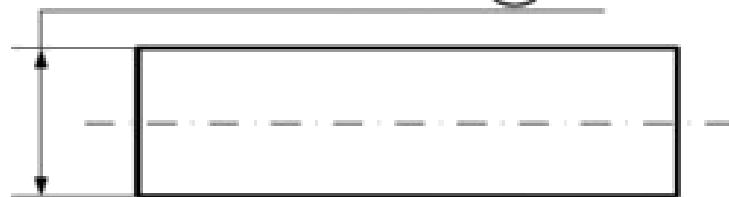
尺寸



包容要求

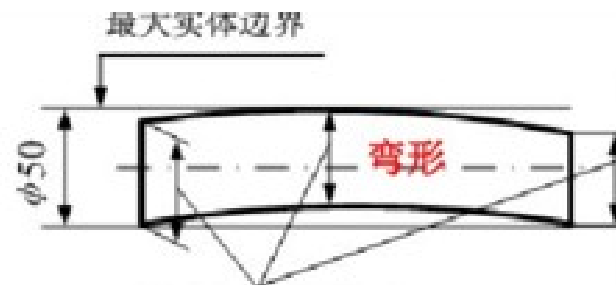
单一轴遵守包容要求

$\phi 50h7 (-0.025) \text{ (E)}$



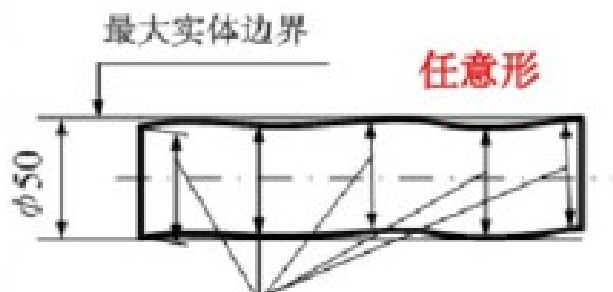
$$d_{fe} = d_a + f \quad \phi 50$$

$$\phi 49.975 \# d_a \quad \phi 50$$



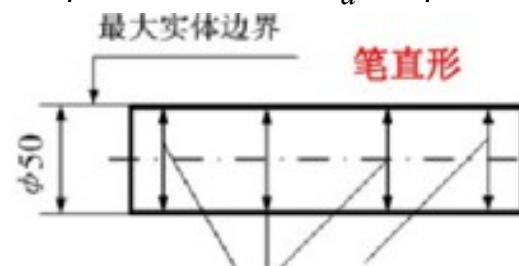
$$d_{fe} = d_a + f \quad \phi 50$$

$$\phi 49.975 \# d_a \quad \phi 50$$

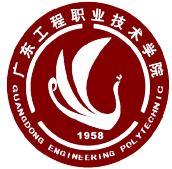


$$d_{fe} = d_a + f \quad \phi 50$$

$$\phi 49.975 \# d_a \quad \phi 50$$

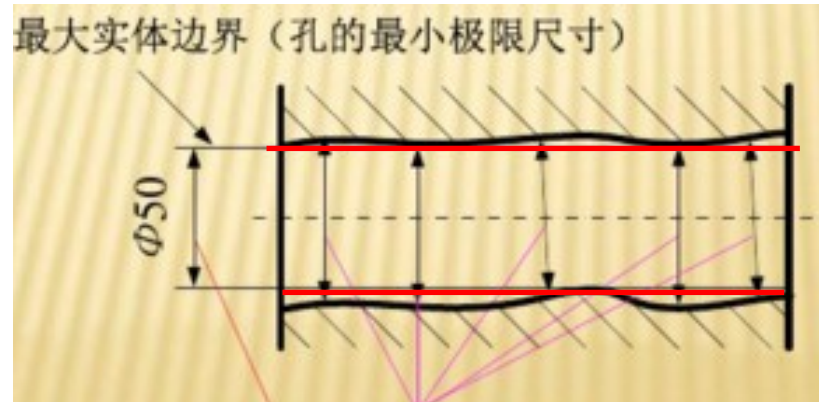
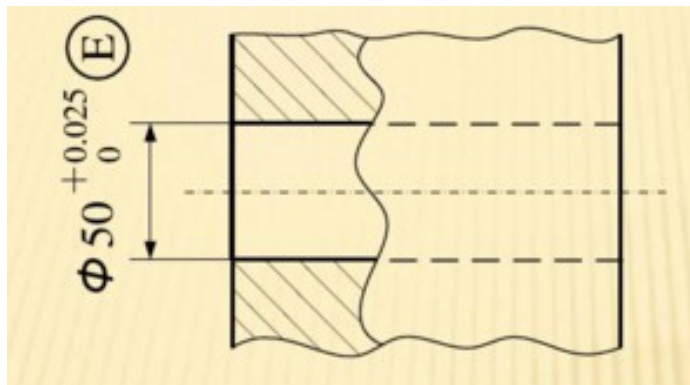


当所有局部尺寸都等于 $\phi 50$ 时，就一点形状误差都不能有，否则就会超出最大实体边界。



包容要求

单一孔遵守包容要求



$$D_{fe} = D_a - f \quad \phi 50$$

$$\phi 50 \# D_a \quad \phi 50.025$$

合格条件

孔: $D_{fe} \begin{cases} \geq D_M \\ \leq D_{\min} \end{cases}$

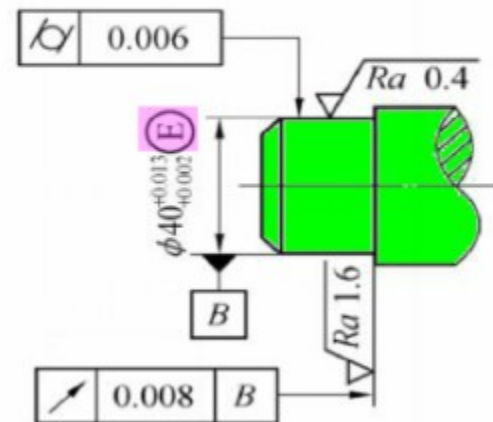
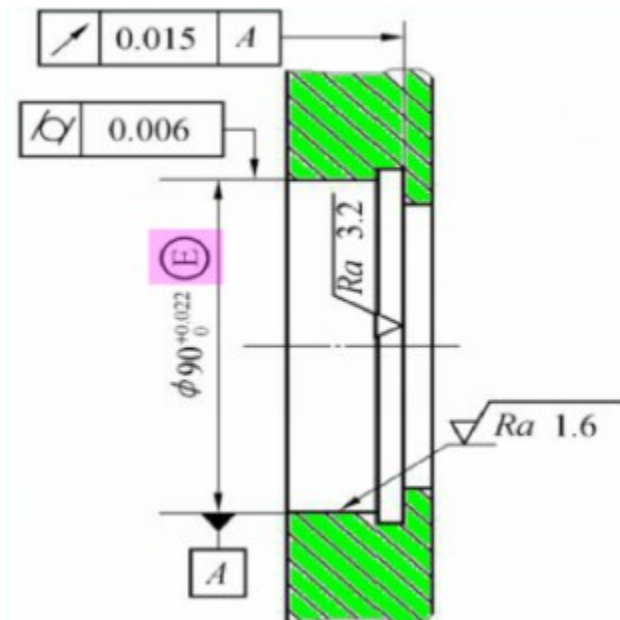
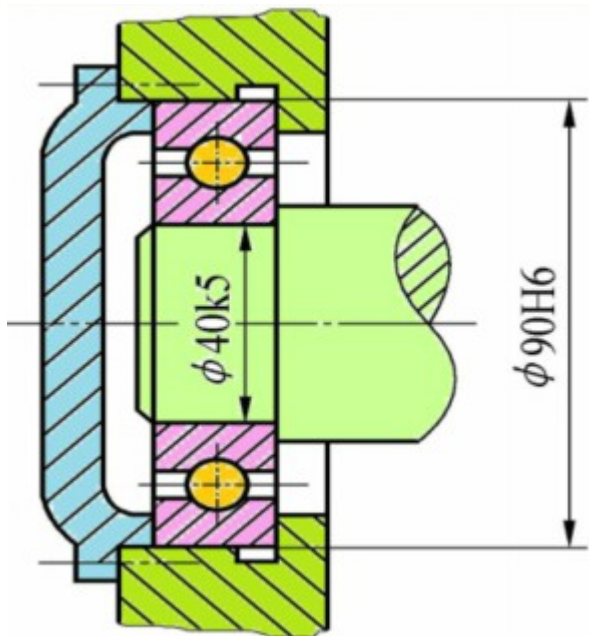
$D_a \quad D_L \quad D_{\max}$

轴: $d_{fe} \begin{cases} \leq d_M \\ \geq d_{\max} \end{cases}$

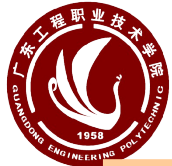
$d_a \quad d_L \quad d_{\min}$



包容要求

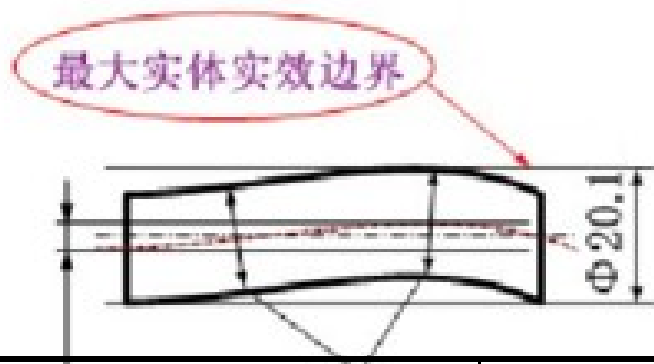
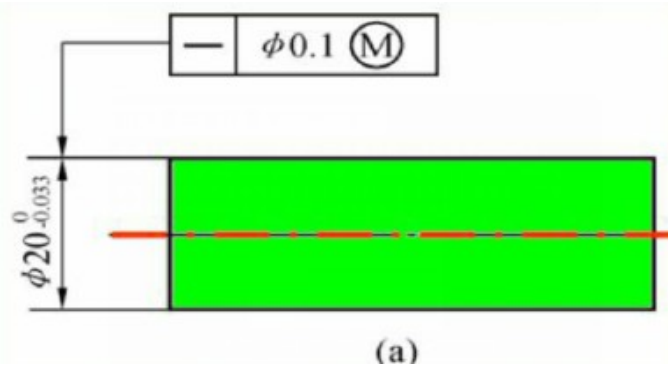


应用：包容要求应用于有严格要求保证配合性质要求的孔轴，不会因为孔轴形状误差影响配合性质，如轴承和齿轮。



最大实体要求 — 适用于中心要素有几何公差要求的情况 (M)

最大实体要求是用最大实体实效边界控制被测尺寸要素的实际尺寸及其导出要素几何误差的综合结果，即被测实际要素的实际轮廓不得超越最大实体实效边界，并要求实际尺寸不得超出极限尺寸。



$$d_{fe} = d_a + f_{几何}$$

$$d_{MV} = d_M + t = 20 + 0.1 = 20.1$$

允许的几何误差: $t \sim (T+t)$

直线度允许误差	实际尺寸
$\Phi 0.1$	$\Phi 20$
$\Phi 0.12$	$\Phi 19.98$
$\Phi 0.133$	$\Phi 19.967$

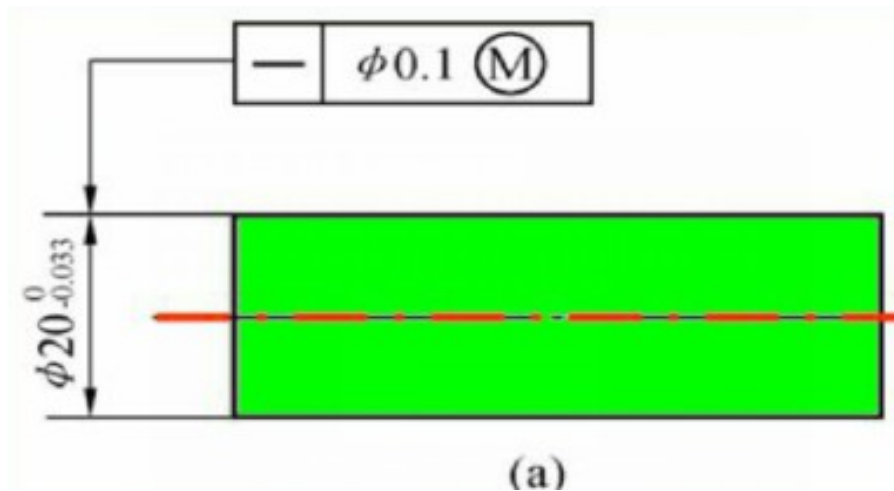
几何误差 补偿给 尺寸



标注方法

应用于被测要素时，在公差框格的第二格公差值后加注符号 \textcircled{M}

应用于基准要素时，在基准字母代号后加注符号 \textcircled{M}



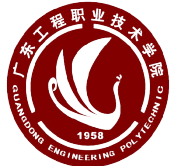
合格条件

$$\text{孔: } D_{fe} \text{ 且 } D_{MV} - D_{\min} \leq t$$

$$D_{\min} \quad D_a \quad D_{\max}$$

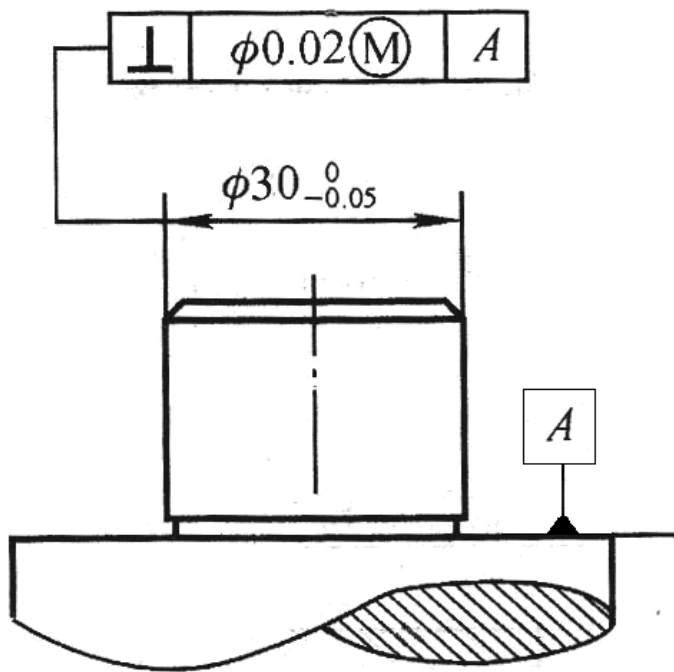
$$\text{轴: } d_{fe} \text{ 且 } d_{MV} + d_{\max} \leq t$$

$$d_{\max} \quad d_a \quad d_{\min}$$



最大实体要求

【案例】 } 如图所示，若实测零件的圆柱直径为 $\phi 29.98\text{mm}$ ，其轴线对基准平面A的垂直度误差为 $\phi 0.03\text{mm}$ ，试判断其垂直度是否合格？为什么？



垂直度允许误差	实际尺寸
$\phi 0.02$	$\phi 30$
$\phi 0.04$	$\phi 29.98$
$\phi 0.07$	$\phi 29.95$

$$d_{MV} = d_M + t = d_{\max} + t = 30 + 0.02 = 30.02$$

$$d_{fe} = d_a + f = 29.98 + 0.03 = 30.01 \leq d_{MV}$$

$$d_{\min} \leq d_a \leq d_{\max}$$

轴: $d_{fe} \begin{cases} \diamond \\ \square \end{cases} d_{MV} + d_{\max} \begin{cases} \square \\ \diamond \end{cases} \quad d_{\max} \quad d_a \quad d_{\min}$

The background features a complex geometric structure, a hyperboloid of one sheet, rendered with a dense network of thin, light gray lines. The structure is centered and extends towards the corners of the frame. Scattered throughout the scene are numerous small, multi-colored dots in shades of red, blue, yellow, green, and purple. The text '下次课再见' is centered horizontally and vertically over the structure.

下次课再见