IE-352

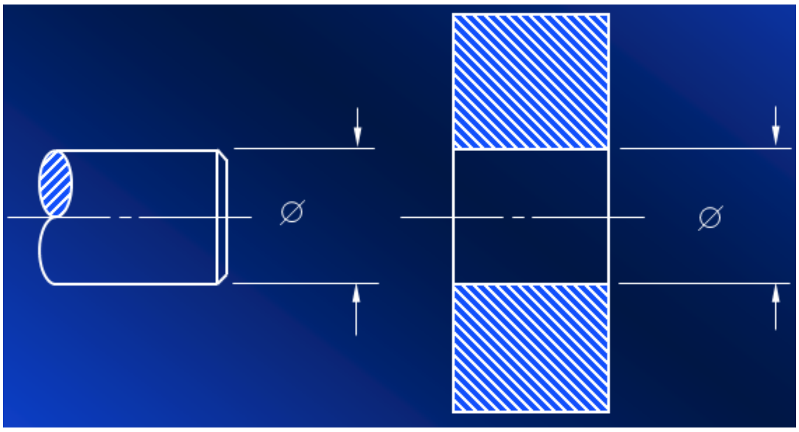
Summer Semester 1433-34 H

MANUFACTURING PROCESSES - 2

Homework 2 ANSWERS

Answer the following questions.

1. Look at the hole-shaft system below and answer the following questions



Basic Shaft System

Nominal Size = 15.5 mm

Hole Tolerance = .041

Shaft Tolerance = .027

Allowance = .013

Determine,

a) Hole size using stacked limits form and referenced to basic size

b) Shaft size using stacked limits form and referenced to basic size

Given:

- Basic shaft system
- $Basic\ size\ =\ 15.500\ mm$
- $Allowance\ =\ 0.013$
- $Tol_{sh} = 0.027$
- $Tol_{hole} = 0.041$

Shaft	Hole
$BS = 15.500$ $MMC = BS = 15.500$ $LMC = MMC - Tol_{sh}$ $= 15.500 - 0.027$ $= 15.473$ Shaft size: • **Stacked limits form:** $\phi^{15.500}_{15.473}$ • **Referenced to BS:** $\phi\, 15.500\, ^{0}_{-0.027}$	$BS = 15.500$ $MMC = BS + Allowance$ $= 15.500 + 0.013$ $= 15.513$ $LMC = MMC + Tol_{hole}$ $= 15.513 + 0.041$ $= 15.554$ Hole size: • **Stacked limits form:** $\phi^{15.554}_{15.513}$ • **Referenced to BS:** $\phi\, 15.500\, ^{+0.054}_{+0.013}$

2. Using the standard fit tables, you are required to determine the limits for a nominal $1\frac{2}{16}$" diameter RC 5 fit between a shaft and a hole.

Determine,

a) Hole size using stacked limits form and referenced to basic size

b) Shaft size using stacked limits form and referenced to basic size

Given:

- Hole-shaft system
- $Basic\ size\ = 1\frac{2}{16}\ in = 1 + 0.125 = 1.1250$ in.
- RC 5 fit, i.e. Running/Sliding Fit of classification (type) 5
- Assume: basic hole system (to access ANSI table for RC fits)

Required:

- Shaft size (stacked limits form and referenced to BS)
- Hole size (stacked limits form and referenced to BS)

Solution:

- Using BS (1.125 in) and RC table (attached) ⇒

Nominal Size Range, (in.) Over To	Limits of clearance (in./1000)	Hole limits (in./1000)	Shaft limits (in./1000)
0.71 < **BS (1.125)** < 1.19	+1.6	+1.2	-1.6
	+ 3.6	-0.0	-2.4

<u>Shaft</u>

$BS = 1.1250$

$MMC = BS - \left(\frac{1.6}{1000}\right)$

$= 1.1250 - 0.0016$

$= 1.1234$

$LMC = BS + \left(\frac{-2.4}{1000}\right) = 1.1250 - 0.0024$

$= 1.1226$

Shaft size:

- **Stacked limits form:** $\phi^{1.1234}_{1.1226}$
- **Referenced to BS:** $\phi\,1.1250\,^{-0.0016}_{-0.0024}$

<u>Hole</u>

$BS = 1.1250$

$MMC = BS + 0 = 1.1250$

$LMC = BS + \left(\frac{1.2}{1000}\right)$

$= 1.1250 + 0.0012$

$= 1.1262$

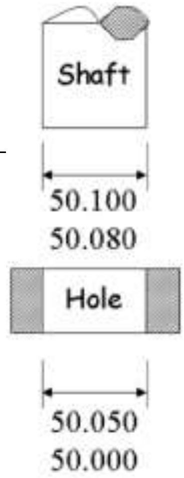
Hole size:

MMC (clearance)

LMC (clearance)

- **Stacked limits form:** $\phi^{1.1262}_{1.1250}$
- **Referenced to BS:** $\phi\,1.1250\,^{+0.0012}_{0}$

3. Examine the figure below showing a series of shaft-hole systems all having the same basic size of $50.000\ in$.



Case 1:

Shaft	Hole
$BS = 50.000$	$BS = 50.000$
$MMC = 50.100$	$MMC = 50.000 = BS$
$LMC = 50.080$	(i.e. Basic Hole system)
	$LMC = 50.050$
Shaft size:	Hole size:
a) **Stacked limits form:** $\boldsymbol{\phi^{50.100}_{50.080}}$	a) **Stacked limits form:** $\boldsymbol{\phi^{50.050}_{50.000}}$
b) **Referenced to BS:**	b) **Referenced to BS:**
$\phi\,50.000\,^{50.100-50.000}_{50.080-50.000} =$	$\phi\,50.000\,^{50.050-50.000}_{50.000-50.000} =$
$\boldsymbol{\phi\,50.000\,^{+0.100}_{+0.080}}$	$\boldsymbol{\phi\,50.000\,^{+0.050}_{0}}$

c) First note from signs in b) that there is no clearance, i.e. only interference. Also note that -as opposed to clearance- max. interference occurs at the MMC and min. interference occurs at LMC as seen from the figure on the right: $\boldsymbol{\phi^{50.100}_{50.080}}$ MMC LMC $\boldsymbol{\phi^{50.050}_{50.000}}$
Thus,

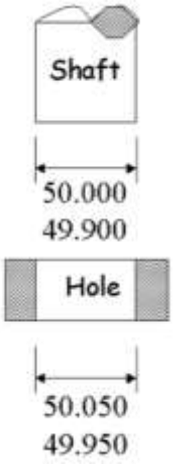
$$\boldsymbol{intereference_{Max}} = MMC_{shaft} - MMC_{hole} = 50.100 - 50.000 = \mathbf{0.100}$$

$$\boldsymbol{intereference_{min}} = LMC_{shaft} - LMC_{hole} = 50.080 - 50.050 = \mathbf{0.030}$$

d) As shown above, this is a **Basic Hole system**

e) This is a **force fit** (most likely since values form relatively large interferences) or **location intereference fit**

Case 2:



Shaft	Hole
$BS = 50.000$ $MMC = 50.000 = BS$ (i.e. Basic Shaft system) $LMC = 49.900$ Shaft size: a) **Stacked limits form:** $\phi^{50.000}_{49.900}$ b) **Referenced to BS:** $\phi\, 50.000\ ^{50.000-50.000}_{49.900-50.000} =$ $\boldsymbol{\phi\, 50.000\ ^{0}_{-0.100}}$	$BS = 50.000$ $MMC = 49.950$ $LMC = 50.050$ Hole size: a) **Stacked limits form:** $\phi^{50.05}_{49.950}$ b) **Referenced to BS:** $\phi\, 50.000\ ^{50.050-50.000}_{49.950-50.000} =$ $\boldsymbol{\phi\, 50.000\ ^{+0.050}_{-0.050}}$

c) It is obvious here from signs in b) that there is both clearance and interference; thus, $\phi^{50.000}_{49.900}$ (MMC ↔ 49.950; LMC ↔ 50.050) $\phi^{50.050}_{49.950}$

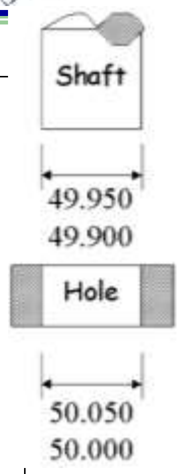
$$\boldsymbol{interefer ence_{Max}} = MMC_{shaft} - MMC_{hole} = 50.000 - 49.950 = \mathbf{0.050}$$

$$\boldsymbol{clearance_{Max}} = LMC_{hole} - LMC_{shaft} = 50.050 - 49.900 = \mathbf{0.150}$$

d) As shown above, this is a **Basic Shaft system**

e) The transition shown from interference (@MMC) to clearance (@LMC) shows this to be a **location transition fit**

Case 3:



<u>Shaft</u>

$BS = 50.000$
$MMC = 49.950$
$LMC = 49.900$

Shaft size:

a) **Stacked limits form:** $\phi^{49.950}_{49.900}$

b) **Referenced to BS:**

$\phi\, 50.000\, ^{49.950-50.000}_{49.900-50.000} =$

$\boldsymbol{\phi\, 50.000\, ^{-0.050}_{-0.100}}$

<u>Hole</u>

$BS = 50.000$
$MMC = 50.000 = BS$
(i.e. Basic Hole system)
$LMC = 50.050$

Hole size:

a) **Stacked limits form:** $\phi^{50.050}_{50.000}$

b) **Referenced to BS:**

$\phi\, 50.000\, ^{50.050-50.000}_{50.000-50.000} =$

$\boldsymbol{\phi\, 50.000\, ^{+0.050}_{0}}$

c) First note from signs in b) that there is only clearance.

Thus, $\phi^{49.950}_{49.900}$ MMC LMC $\phi^{50.050}_{50.000}$

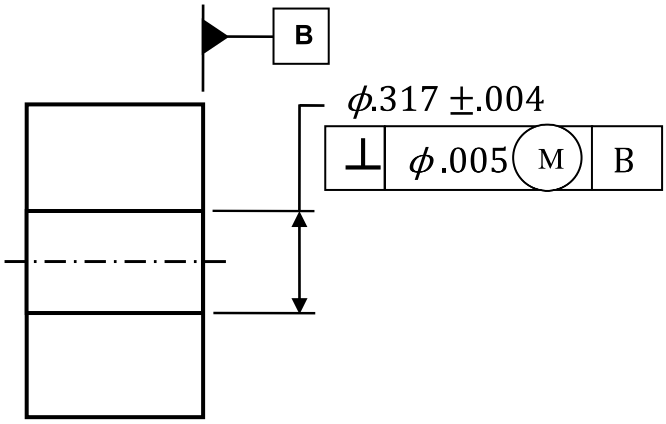
$$\boldsymbol{clearance_{Max}} = LMC_{hole} - LMC_{shaft} = 50.050 - 49.900 = \mathbf{0.150}$$

$$\boldsymbol{clearance_{min}} = MMC_{hole} - MMC_{shaft} = 50.000 - 49.950 = \mathbf{0.050}$$

d) As shown above, this is a **Basic Hole system**

e) This is a **running/sliding fit** (most likely since values form relatively large clearances) or **location clearance fit.**

4. Examine the hole system below (dimensions in *mm*) and answer the following questions.



Calculate the geometric tolerance for cross sections in the system having the following sizes:

a) 0.322

b) 0.319

c) Basic size

d) 0.311

Finally, you are required to repeat each of questions a) through d) above giving that the geometric tolerance is specified RFS.

Given:

- $BS = 0.317\ mm$
  - $Size\ Tol. = \pm 0.004$
  - $\Rightarrow MMC = BS - 0.004 = 0.317 - 0.004 = 0.313$
  - $\Rightarrow LMC = BS + 0.004 = 0.317 + 0.004 = 0.321$
  - $\Rightarrow \mathbf{0.313 \le \boldsymbol{size} \le 0.321}$
- Feature control frame: | ⊥ | $\phi .005$ Ⓜ | B |
  - Perpendicularity geometric tolerance (hole)
  - $GT = 0.005\ @\ MMC$ (i.e. allowable GT at MMC is 0.005 mm)
  - $\Rightarrow$ Virtual Condition: $V_c = MMC - 0.005 = 0.313 - 0.005 = 0.308$
  - $\Rightarrow$ @ LMC: $GT_{LMC} = LMC - V_c = 0.321 - 0.308 = 0.013$

- $\Rightarrow \mathbf{0.005}_{@MMC} \le \boldsymbol{GT} \le \mathbf{0.013}_{@LMC}$

Required:

a) $GT_{0.322} = ?$

b) $GT_{0.319} = ?$

c) $GT_{BS} = GT_{0.317} = ?$

d) $GT_{0.311} = ?$

Solution:

a) $size = 0.322$

Check if within size limits: $0.322 > 0.321 \Rightarrow$ **part is rejected** (note, remachining is not possible here)

b) $size = 0.319$

- Check size: $0.313 < 0.319 < 0.321 \Rightarrow$ part is acceptable
- $GT_{0.319} = size - V_c = 0.319 - 0.308 = 0.011$
- Check if within GT limits: $0.005 < 0.011 < 0.013$ ($\Rightarrow$ ok)

$$\boldsymbol{GT_{0.319} = 0.011}$$

c) $size = 0.317$

- Check size: $0.313 \le 0.317 \le 0.321$ ($\Rightarrow$ ok)
- $GT_{0.371} = size - V_c = 0.317 - 0.308 = 0.009$
- Check GT: $0.005 < 0.009 < 0.013$ ($\Rightarrow$ ok)

$$\boldsymbol{GT_{0.317} = 0.009}$$

d) $size = 0.311$

- Check size: $0.311 < 0.313 \Rightarrow$ **part is rejected** (note, remachining may be possible in this case)

Finally, you are required to repeat each of questions a) through d) above giving that the geometric tolerance is specified RFS.

Given:

- $BS = 0.317\ mm$
    - $Size\ Tol. = \pm 0.004$
    - $\Rightarrow$ again $MMC = 0.313$
    - $\Rightarrow$ again $LMC = 0.321$
    - $\Rightarrow \mathbf{0.313 \le size \le 0.321}$
- Feature control frame:

⊥	$\phi .005$	B

    - Perpendicularity geometric tolerance (hole)
    - $GT = 0.005\ (RFS)$ (i.e. allowable GT at any cross section is 0.005 mm)

Required:

a) $GT_{0.322} = ?$

b) $GT_{0.319} = ?$

c) $GT_{BS} = GT_{0.317} = ?$

d) $GT_{0.311} = ?$

Solution:

a) $size = 0.322$

Check if within size limits: $0.322 > 0.321 \Rightarrow$ **part is rejected** (note, remachining is not possible here)

b) $size = 0.319$

- Check size: $0.313 < 0.319 < 0.321 \Rightarrow$ part is acceptable
- $GT_{0.319} = 0.005$

$$\boldsymbol{GT_{0.319} = 0.005}$$

c) $size = 0.317$

- Check size: $0.313 \le 0.317 \le 0.321$ ($\Rightarrow$ ok)

- $GT_{0.317} = 0.005$

$$\boldsymbol{GT_{0.317} = 0.005}$$

d) $size = 0.311$

- Check size: $0.311 < 0.313 \Rightarrow$ **part is rejected** (note, remachining may be possible in this case)

Nominal Size Range in Inches	Class RC 1			Class RC 2			Class RC 3			Class RC 4			Class RC 5			Class RC 6		
	Limits of Clearance	Standard Limits Hole H5	Standard Limits Shaft g4	Limits of Clearance	Standard Limits Hole H6	Standard Limits Shaft g5	Limits of Clearance	Standard Limits Hole H7	Standard Limits Shaft f6	Limits of Clearance	Standard Limits Hole H8	Standard Limits Shaft f7	Limits of Clearance	Standard Limits Hole H8	Standard Limits Shaft e7	Limits of Clearance	Standard Limits Hole H9	Standard Limits Shaft e8
0 - 0.12	0.1 0.45	+ 0.2 - 0	- 0.1 - 0.25	0.1 0.55	+ 0.25 - 0	- 0.1 - 0.3	0.3 0.95	+ 0.4 - 0	- 0.3 - 0.55	0.3 1.3	+ 0.6 - 0	- 0.3 - 0.7	0.6 1.6	+ 0.6 - 0	- 0.6 - 1.0	0.6 2.2	+ 1.0 - 0	- 0.6 - 1.2
0.12 - 0.24	0.15 0.5	+ 0.2 - 0	- 0.15 - 0.3	0.15 0.65	+ 0.3 - 0	- 0.15 - 0.35	0.4 1.12	+ 0.5 - 0	- 0.4 - 0.7	0.4 1.6	+ 0.7 - 0	- 0.4 - 0.9	0.8 2.0	+ 0.7 - 0	- 0.8 - 1.3	0.8 2.7	+ 1.2 - 0	- 0.8 - 1.5
0.24 - 0.40	0.2 0.6	+ 0.25 - 0	- 0.2 - 0.35	0.2 0.85	+ 0.4 - 0	- 0.2 - 0.45	0.5 1.5	+ 0.6 - 0	- 0.5 - 0.9	0.5 2.0	+ 0.9 - 0	- 0.5 - 1.1	1.0 2.5	+ 0.9 - 0	- 1.0 - 1.6	1.0 3.3	+ 1.4 - 0	- 1.0 - 1.9
0.40 - 0.71	0.25 0.75	+ 0.3 - 0	- 0.25 - 0.45	0.25 0.95	+ 0.4 - 0	- 0.25 - 0.55	0.6 1.7	+ 0.7 - 0	- 0.6 - 1.0	0.6 2.3	+ 1.0 - 0	- 0.6 - 1.3	1.2 2.9	+ 1.0 - 0	- 1.2 - 1.9	1.2 3.8	+ 1.6 - 0	- 1.2 - 2.2
0.71 - 1.19	0.3 0.95	+ 0.4 - 0	- 0.3 - 0.55	0.3 1.2	+ 0.5 - 0	- 0.3 - 0.7	0.8 2.1	+ 0.8 - 0	- 0.8 - 1.3	0.8 2.8	+ 1.2 - 0	- 0.8 - 1.6	1.6 3.6	+ 1.2 - 0	- 1.6 - 2.4	1.6 4.8	+ 2.0 - 0	- 1.6 - 2.8
1.19 - 1.97																		
1.97 - 3.15																		