TO *ELIMINATE REWORK AT CYLINDER HEAD TAPPET SETTING (SHIM DESIGN)*

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To eliminate rework at cylinder head tappet

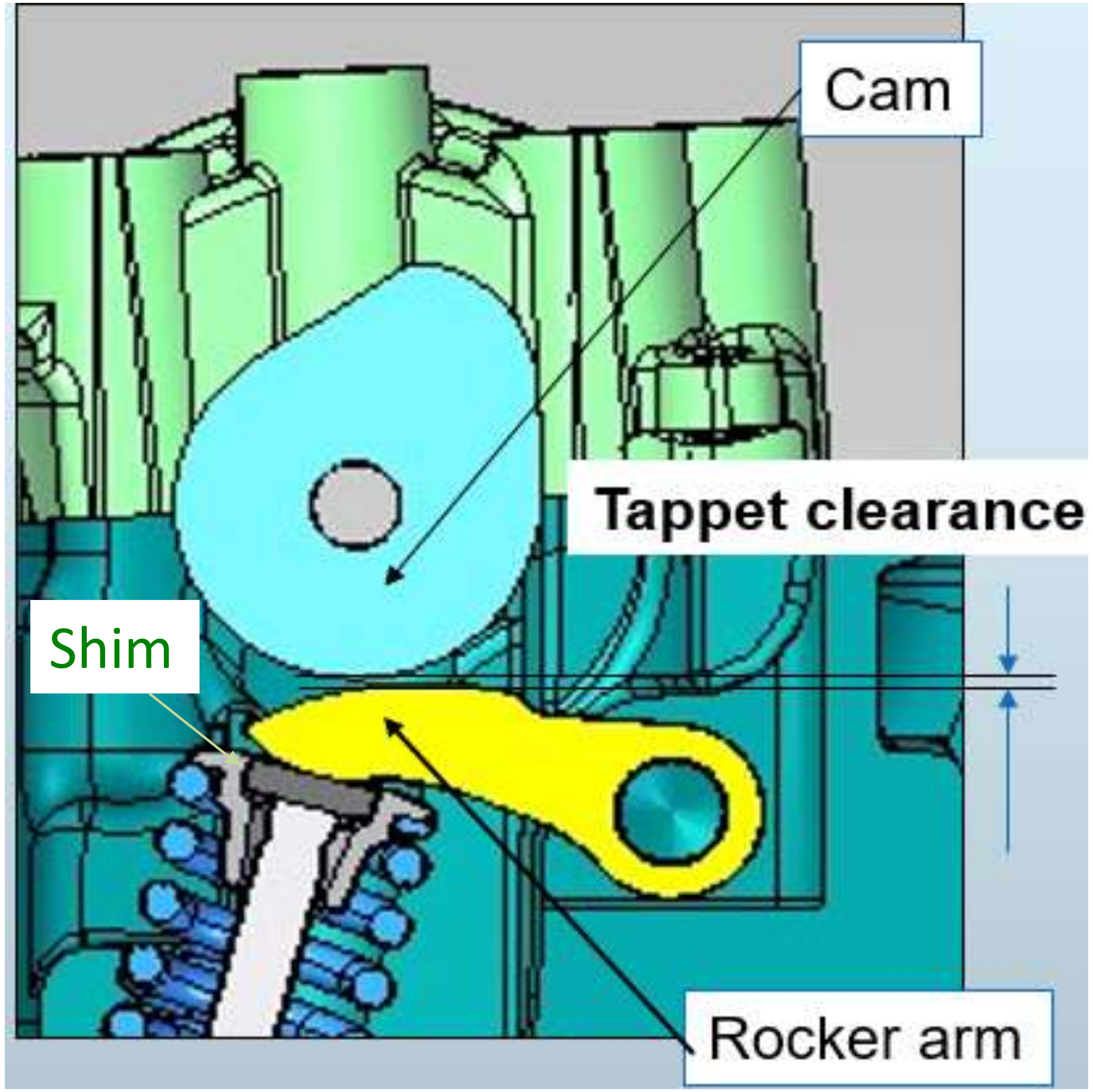
BASIC CONCEPT

Tappet clearance : The gap to be maintained between cam & rocker arm when engine is in cold condition when piston at TDC.

Purpose of tappet clearance

1. To accommodate valse expansion in Hot condition
2. Tappet noise.

INTAKE SIDE	EXHAUST SIDE
GO gauge (90 micron)	GO gauge(140 micron)
NO GO gauge (130 micron)	NO GO gauge (180 micron)



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Modelwise details

Conveyor A (manual)	Conveyor B (robotic)
KT26,JY,KT10,TRIUMPH	JU,JG,KT23,KT25,KT26

MODEL	NO. OF CAMSHAFT USED
JU/JG/JY/KT10/KT26	DOUBLE(DOHC,4LOBES)
KT23/KT25	SINGLE(SOHC,2 LOBES)
Triumph	DOUBLE(DOHC,4LOBES)

Tappet Clearance is common across all models.

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PROCESS AT MACHINE

Operator assembles the respective Master Shim on the cylinder head

Operators load and locate the Cylinder head and Camshaft with Cam Cover Manually on the Fixture

The Operator Authorizes Cycle Start.

The Swing Clamp (Pneumatic) clamps the Part; The Top Clamp (Hydraulic) Slide Clamps the Cam cover with Camshaft

The Bottom Probe take reading1.

The Top Clamp (Hydraulic) Slide descends and Clamps the Cam cover with the Camshafts.

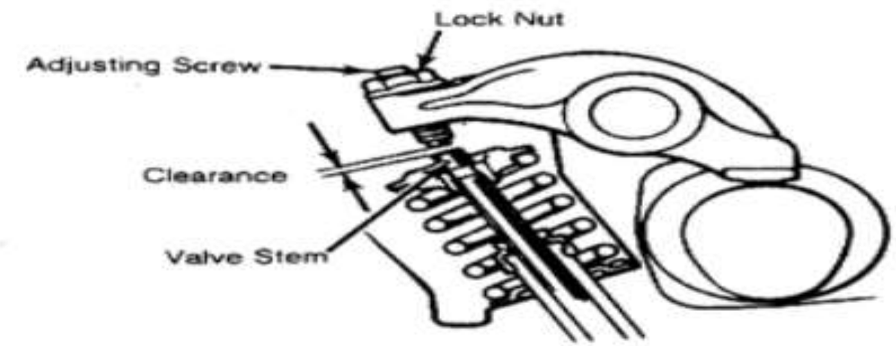
The Bottom Probe takes Reading 2.

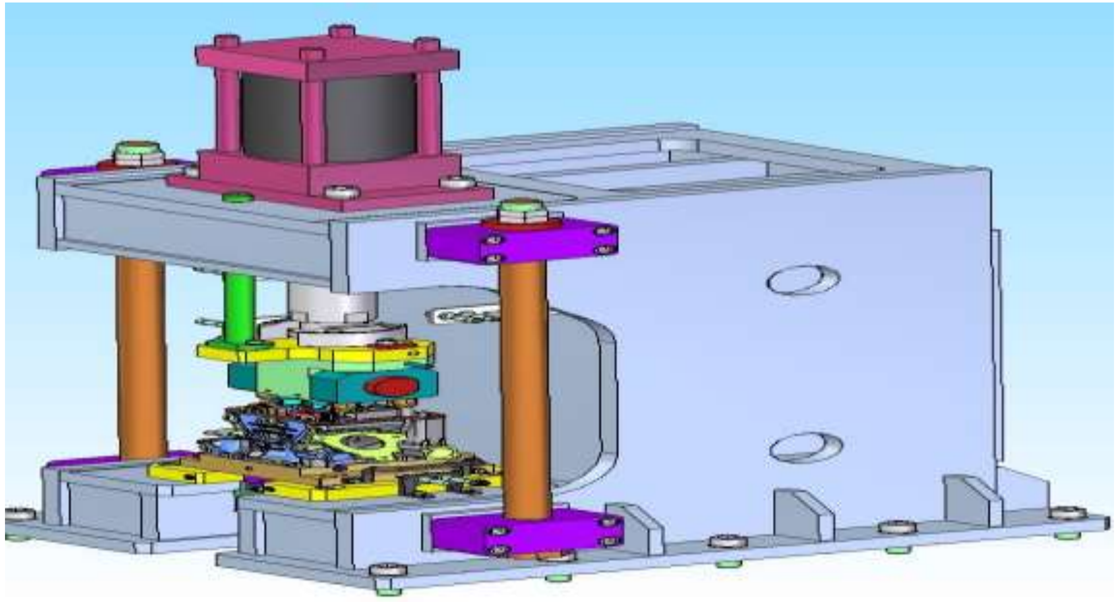
Top Clamp Slide Retracts. (Hydraulic)

The Head Clamp Slide Retracts. (Pneumatic)

The System Calculates the Shim Size and Displays on the HMI

Operator Manually unloads the Part and assembles displayed Shim.





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SHIM FORMULA

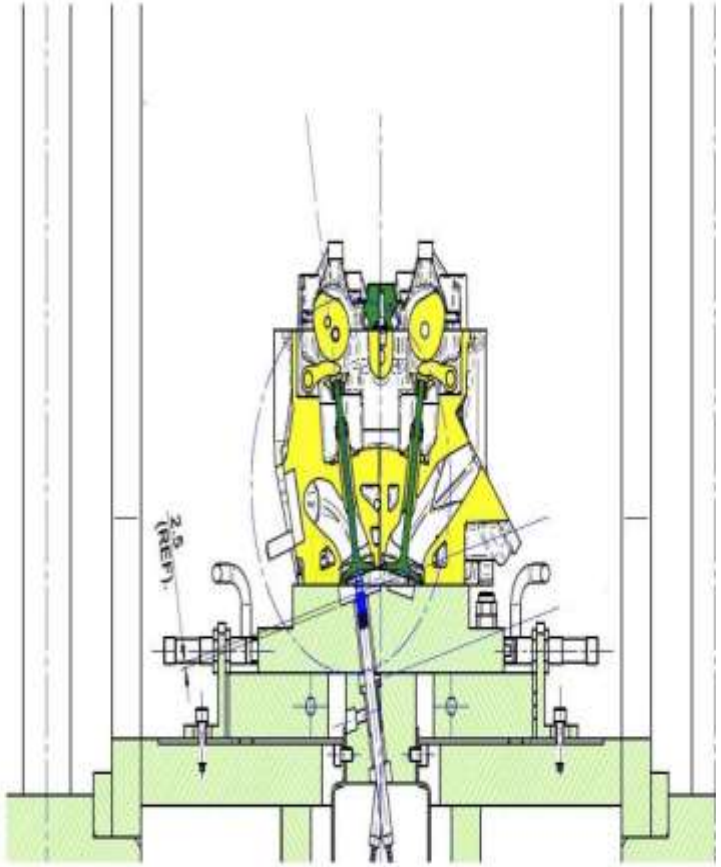
The formula for Shim Calculation:

Shim Size=Master Shim -(R2-R1) –Gap-Constant

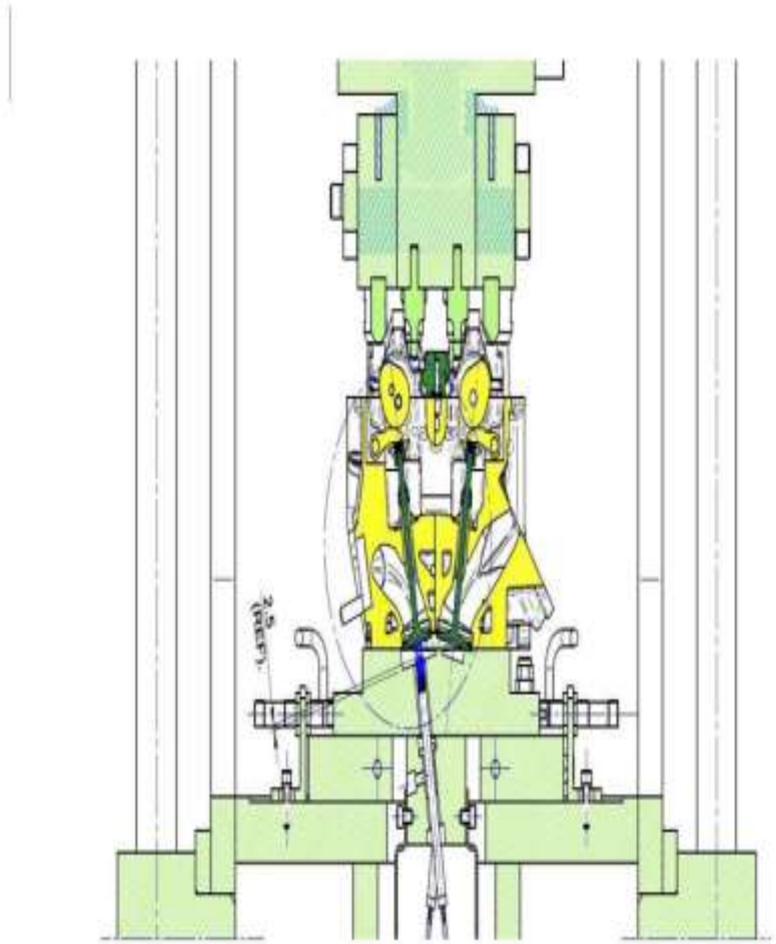
Note:

1. Master Shim is of Higher size .
2. Gap (Separate for Intake and exhaust).
3. Constant can be Positive or Negative .

Reading - 1 Position



Reading - 2 Position



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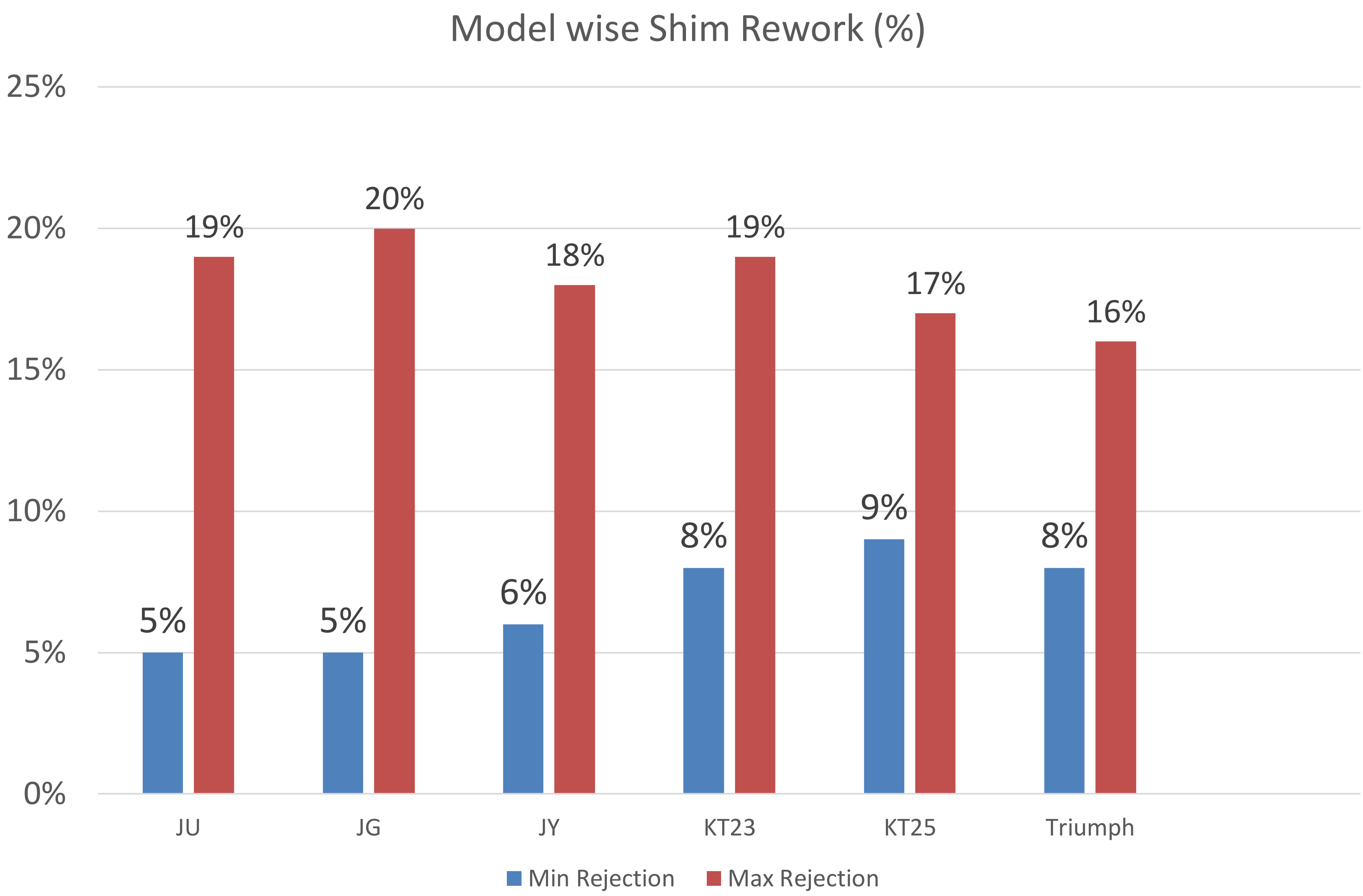

Contributing Factors for Shim Rework

1) Master Shim Size Variation

2) Engine Shim Size Variation

3) Wrong Shim assembly

4) Master Shim LVDT Repeatability

5) Master Shim LVDT Linearity

6) Inherent errors in the inspection system.

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1) Master Shim Size Variation

MODEL	Machine No	Master Shim Variation (Target < 2um)
JU/JG/JY/KT10/KT26	1	14 um
KT23/KT25	2	13 um
Triumph	3	9 um

Sr. No	Spec (mm)	Measured (mm)	Deviation (um)	Remark
1	3.54 +/- 0.002	3.542	2	ok
2		3.541	1	ok
3		3.549	9	Not ok
4		3.544	4	Not ok
5		3.541	1	ok
6		3.541	1	ok
7		3.547	7	Not ok
8		3.543	3	Not ok
9		3.540	0	ok
10		3.547	7	Not ok
11		3.554	14	Not ok
12		3.548	8	Not ok

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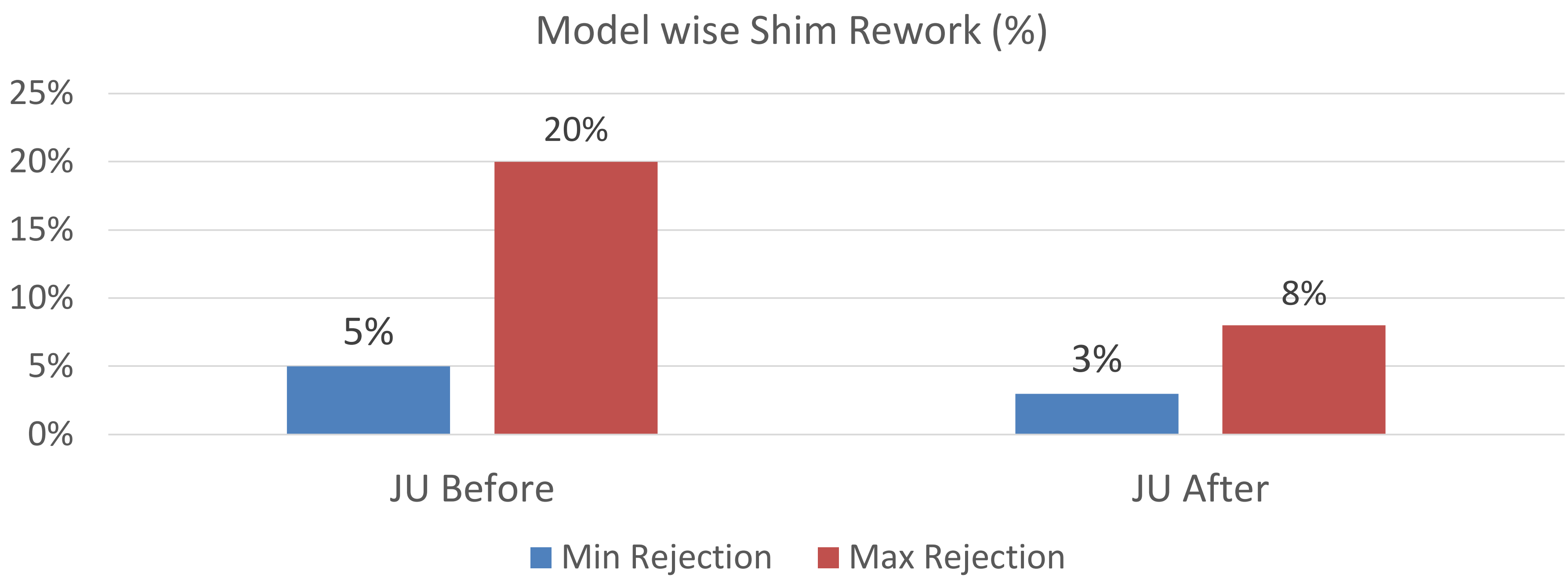
Master Shim for JU model corrected & rework monitored.



- For other models , Data monitoring in progress.
- Master shim calibration updated in JH check sheet on weekly basis.

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2) Engine Shim Size Variation

- Total 40 varieties if shim are used from 2.12mm to 2.9mm with 20um difference.

- Most used shims check for size variations.

Shim Size	Master Shim Variation (Spec : 14um)
2.3	5 um
2.36	7 um
2.4	4 um

3) Wrong Shim assembly

- Shims removed from rework engines checked & found as per size , no mix up.

4) Master Shim LVDT Repeatability

- Same job checked on the machine 5 times , repeatability observed 3 um max.

REPEATABILITY						
JU						
			EXHAUST		INTAKE	
			ACTUAL	APPROX	ACTUAL	APPROX
RH			2.455	2.46	2.34	2.34
LH			2.417	2.42	2.273	2.28
RH			2.457	2.46	2.34	2.34
LH			2.415	2.42	2.272	2.28
RH			2.457	2.46	2.34	2.34
LH			2.415	2.42	2.273	2.28
RH			2.458	2.46	2.341	2.34
LH			2.414	2.42	2.273	2.28
RH			2.457	2.46	2.341	2.34
LH			2.415	2.42	2.274	2.28
MAX DEVIATION(MICRON)						
RH			3		1	
LH			3		2	

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5) Master Shim LVDT Linearity

- Shims from rework engine analyzed and sizes found from 2.26mm to 2.50 mm.
- Same shim sizes are used & found ok in engines where rework is not required, hence LVDT linearity issues not observed.

Batch 1 : JU, 3/48 Reworked.								
03-07-2024	ILH		IRH		ELH		ERH	
Eng no	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
15	36		42		26	30	20	
24	26	28	44	46	30		22	
37	56		28	30	30		38	

Batch 2 : JU, 2/48 Reworked.								
03-07-2024	ILH		IRH		ELH		ERH	
Eng no	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
34	44	42	40		20		50	
42	52		48	46	20		16	

Batch 3 : JU, 4/48 Reworked.								
04-07-2024	ILH		IRH		ELH		ERH	
Eng no	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
6	32	34	32	34	34		30	
17	50	48	40		22		30	
27	24		30	34	40		34	
45	40		38		34	32	30	28

6) Inherent errors in the inspection system.

a) Machine round off error : 10 um

b) Shim Tolerance : 7 um

c) Master Shim tolerance : 2 um

d) LVDT Repeatability : 3 um

e) Base circle touch point is different in master shim & actual: ~ 5 um.

f) Cam shaft Base circle runout : ~5 um.

g) Manual Inspection error in feeler gauge : 5 um.

h) Part deflection variation from batch to batch : 20 um.

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a) Machine round off error : 10 um

- Exact shim is not available so the lower or higher available shim is selected by the operator.

- 5 heads that were rejected on line were reinspected on master shim machine with same parts.
- Difference observed in shim upto 20 um due to the round off error.

S.NO.	HEAD NO.	ILH	IRH	ELH	ERH
1	496	42	44	34	36
2	409	40	42	12	34/32
3	399	36	42	36	34
4	356	46	36	34	30
5	516	20/40	56	38	36

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e) Base circle touch point is different in master shim & actual: 5 um.

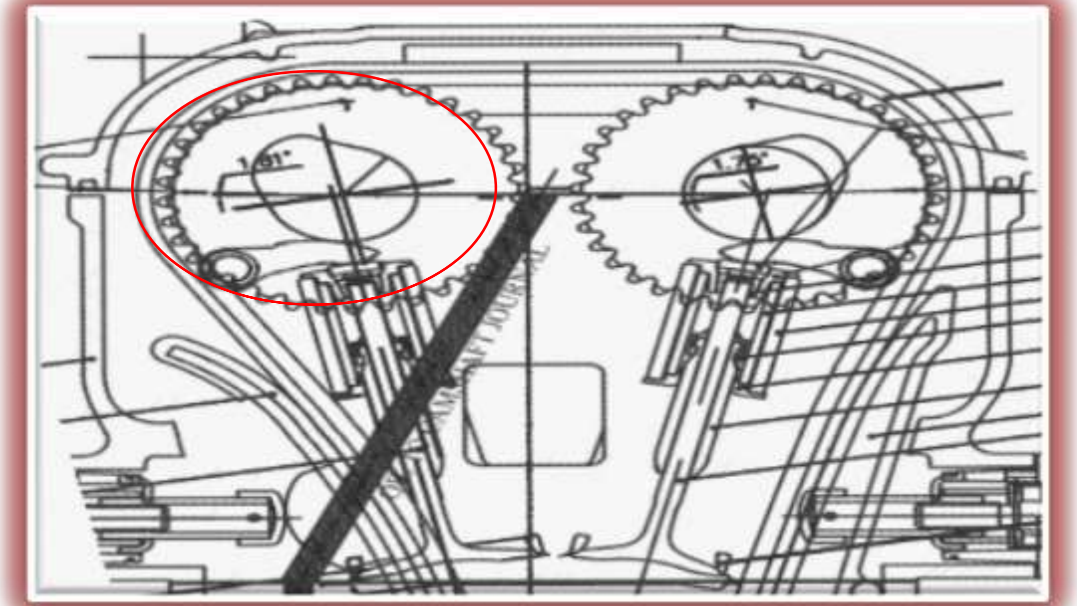
Master Shim

Actual Engine condition

Master shim Thickness – 3.54mm

Engine shim Thickness – 2.16 to 2.6 mm

Master SHIM thickness was more due to which rocker arm line contact with master shim & Engine shim is different.



h) Part Deflection after Bolt tightening

- On JU Cylinder heads , after master shim selection process , cam holders were tightened manually.
- 3 Cylinder heads were rejected in feeler gauge checking indicating the clearance is reduced to part deflection after bolt clamping

S.NO.	HEAD NO.	ILH	IRH	ELH	ERH
1	617	30/28	32	36/34	36
2	747	54	42	30	28
3	737	34	26	24	36
4	741	38	26	50	22
5	592	42	40	38	18
6	735	28	34	40	34
7	753	30/32	40/42	34	26
8	734	56	48	32	30
9	605	42	26	44	42
10	714	24	42	30/28	24/22

- Same phenomenon is observed in KT25 cylinder heads where design in tower type.

Thank you for your attention.

ご清聴ありがとうございました

Force calculations

- Cam Holder Clamping Force = Final clamping force in Engine Assembly
- Tightening torque for 8 holding bolts= 0.9 kgm
- We know that, T=C*D*F

Where,T=tightening torque

C=nut factor (0.2)

F=axial clamping force ,

F=T/(C*D)

Dia =6mm,CD=0.0012m,F=(0.9)/(0.2*0.006)kg

F=7389.521N=753.26kg

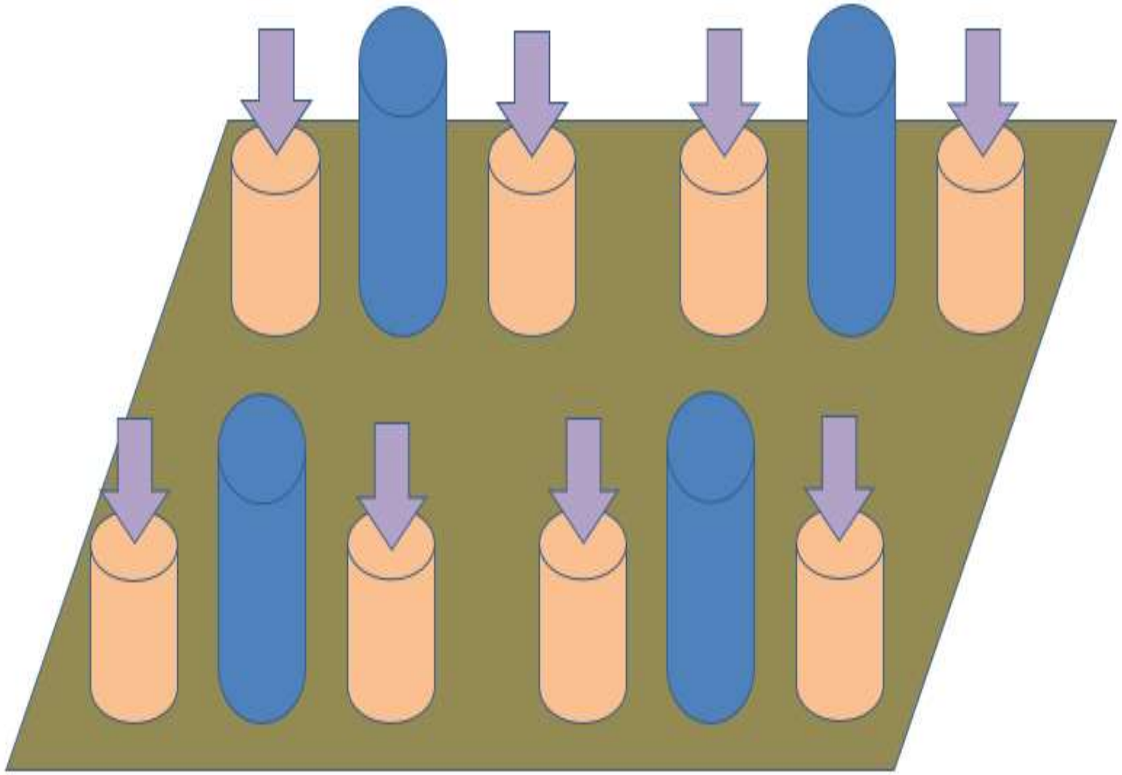
Dia. Of cylinder =30mm

Area=3.14*(0.03^2)/4=7.0685cm^2

Pressure required in 30mm cylinder =753.26/7.0685=106.57kg/cm^2

Part clamping force=753.26*8=6026.08kg=6.02 ton

Pressure required in 125mm cylinder =49.12 kg/cm^2



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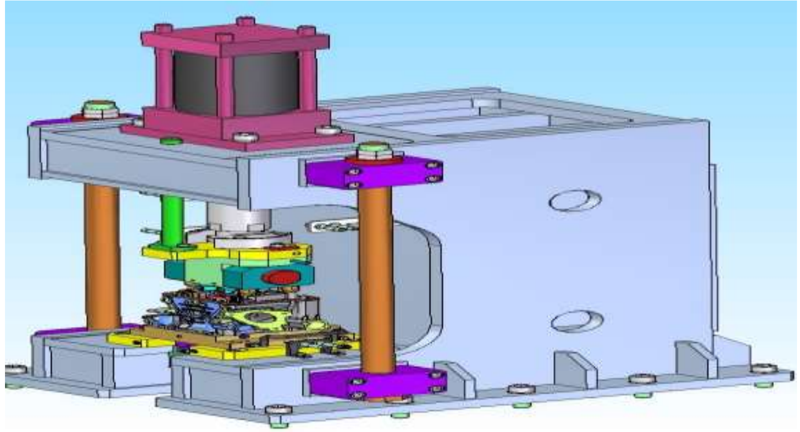
Force calculations

- We can also calculate it by MOTOSH equation,
- T=F*[(p/2*3.14)+{u(t)*r(t)/cos(b)+u(n)*r(n)}]
- Bolt –M6*1
- Where,p=pitch of thread=1mm
- U(t)=coeff of friction in threads=0.15
- U(n)=coeff of friction under head(b/w head and mating parts)=0.15
- R(t)=effective radius of thread contact(half of thread pitch diameter)=0.5*{d(majaor)-0.6495*p}=0.5*(5.974-0.6495)=2.662mm
- R(n)=(y+1)*d/4
- D=nominal dia of bolt
- Y=ratio of outside to inside radii of contact area=11/6.8=1.618
- R(n)=3.926mm
- B=half angle of thread form=30 degree;
- F=744.27kg
- P(30mm) cylinder =105.3kg/cm^2
- Part clamping force=5954.15 kg ; P(in 125mm) cylinder =48.48kg/cm^2



Machine fixture

JY/KT10

JU/JG