



INTERNSHIP REPORT

Cummins India Limited, Kothrud.

Duration: 3 June – 3 July 2019

Ashutosh Kulkarni, Aniket Potdar and Dhanwanti Parate.
[B.E. Mechanical]

Contents

K6 BLOCK (6 CYLINDER)	5
NHNT CYLINDER BLOCK (6 CYLINDER)	5
KV CYCLINDER BLOCK	7
V28 CYLINDER BLOCK (12 CYLINDER).....	8
KVN CYLINDER HEAD.....	9
NHNT Cylinder Head	9
KV Cylinder Head.....	10
V28 Cylinder head	11
CAMSHAFT	11
GEARS.....	12
HEAT TREATMENT.....	13
CNC Lathe.....	13
GCC (GEAR CASE COVER)	14
Miscellaneous and Bar Capstan	15
MISCELLANEOUS.....	15
BARCAPSTAN.....	15
Flywheel	16
FLYWHEEL HOUSING	16
FLYWHEEL	17
Connecting Rod	17
PT System Machining	18
Fuel Pump Machining Line.....	18
Gear Pump Housing	19
Injector Barrel Line.....	20
Injector Cup Line	22
PT System Assembly.....	23
Injector Assembly.....	23
Fuel Pump assembly	24
N/V/K Assembly line	26
NHNT Assembly Line	26
STATION-1	26
STATION-2	26

STATION-3	27
STATION -4	27
STATION-5	27
STATION-6	28
STATION-7	28
STATION-8	28
STATION-9	29
STATION-10	29
STATION-11	29
STATION-12	29
K6 Assembly	30
Sub Assembly	30
Station 1: Crank Assembly	30
Station 2	30
Station 3	31
Station 4	31
Station 5	31
Station 6	31
Station 7	32
Station 8	32
N/V/K Testing and Upfit	33
Step 1: Setup	33
Setup 2: Testing	33
Parameters	33
Step 3: Leakage test	34
Upfit	34
Painting	34
KV Assembly	35
Station 1	35
Station 2L	35
Station 3L,3R	35
Station 4L,4R	35
Station 5L,5R	35

Station 6L,6R	35
Station 7L	35
Station 8L,8R	36
Station 9L,9R	36
Station 10L,10R	36
Station 10L,10R	36
Station 11L,11R	36
Station 12L,12R	37
Station 13L,13R	37
Station 14L,14R	37
Station 15L,15R	37
Station 16	37
Station 17L,17R	38
Station 18R,18L	38
Station 19L,19R	38
Station 20R,20L	38
Station 21R,21L	38
Station 22R,22L	38
Dry Testing	38
KV Testing and Upfit	39
Step 1: Setup	39
Setup 2: Testing.....	39
Parameters.....	40
Step 3: Leakage test	40
Upfit	40
Painting	40
TOOL ROOM.....	41
Strategies in Tool Room	41
TOOLCRIB	42
Quality.....	42
MQA	43
PPI	43
WAREHOUSE (KV and N/V/K)	43

Parts procurement procedure	44
KIT PARTS	44
Imported Stores, Spares	45
Spares.....	45

K6 BLOCK (6 CYLINDER)

It is 6 Cylinder Block used for K19 and QSK Engine.

- Semi-finished casting procured from supplier.
- Nicking operation is done on crank hub for locking of crank bush.
- HMT Liner boring machine in 3 Step liner bore finishing with chamfer.
- BFW twin spindle drilling for oil gallery.
- Milling machine is used for gap face of crank bearing hub of standard size.
- Angular oil gallery drill for crank bearing, camshaft, PCN form main oil gallery.
- Tapping the drill hole of oil gallery manually form radial drilling machine.
- Deburring process is done to remove the unwanted material.
- Washing to remove the oil which is used form operation.
- PTWT (Pressure Test and Water Test) - All holes of water and oil gallery are closed and by pressure and water the all galleries are checked. If there is any leakage it will be reworked or scrapped.
- Top face milling is done.
- Cap fitting on Crank hub By bolting with nut runner.
- Meg machine 4 side milling, mounting holes drill, crank and cam bore finishing of last 2.
- BY Bombe Lathe machine the middle 3 of crank and cam bore rough cycle and finish cycle is done.
- Final inspection
- Removal of sharp edges by deburring after the milling of crank and cam.
- Washing and bush press fitting.
- If block has any defect marking is done and it will be reworked or scrapped.

NHNT CYLINDER BLOCK (6 CYLINDER)

- Semi finish casting form supplier.

- Cam bore and gear center rough operation.
- Cam bore SPM rough machine for push rod oil gallery, FFC hole.
- IZARTECH (high noise level machine) machine semi finish of cam bore and crank bore.
- LOH (Long Oil Hole) by Bombay lathe machine two holes form gear end to flywheel end.
- R-hole machine is used for inclined hole form cam bore to main oil gallery.
- V 921 SPM machine for Cam face milling.
- Gear back side milling on Sun KAP machine
- 3 step bore finishing of cylinder liner bore by INDAGE boring machine.
- Two machines DEAWOO and TASADA 800 machine for four side drilling and milling of flywheel and gear end.
- Gear end and flywheel end drilling and tapping by BFW single spindle CNC machine.
- KIRA 1 machine is used for face drilling and reaming of PCN (piston cooling nozzle) and mounting holes.
- Drilling, tapping of head face and pan face.
- KIRA 2 for cam face drill and tapping.
- Angular drilling hole is done by TAL angular drilling machine.
- Deburring and washing is done clean by brush and air gun.
- Crank hub and cap are tight with bolt on DC nut runner by its number.
- Final finishing of cam bore, crank bore and gear center on HMT line boring. Milling of flywheel side is done by using ITF (Internal Thrust Face). Using gauge cam bore and crank bore are check.
- BFW finish boring machine is used for finishing liner bore, depth correction and finished head milling.
- Inspection is done by GO-NOGO gauge, torch and remark are made.
- PTWT (Pressure Test and Water Test) all hole and gallery are closed and check the leakage by passing water and air.
- Final cleaning.
- Final inspection and bush fitting on cam bore and cam fitting on crank bore.

KV CYCLINDER BLOCK

1) Homma Area

LOH- Long Oil Hole is done by SPM machine

- i) MVR25 Homma1&Homma2-bottom up drilling boring of pc pad
- ii) DMG- rear end gear end lube oil cooler holes
- iii) MHI-side bolt
- iv) Manually mounting of caps
- v) Oil galleries by BFW machine
- vi) Semi finish of cam bore
- vii) Cam bore &crank bore finish
- viii) Rear end &gear end finish by Mazak force-1 machine
- ix) Camboxes finishing by Mazak force-2 machine

2) Pegard Region

- i) Pegard-oil gallery counter& vent hole
- ii) KTM-Liner finish & liner finish and face finish
- iii) Ingersoll- Head finish milling, 1,2,3 liner finish, undercut of cylindrical DC &crevice finish
- iv) KTM- Kearney &Trecker Marcoin Ltd. Makes mounting holes drilling and tapping
- v) Homma 4&5- VMC-Vertical Machining Center, dowel holes, four plug finishing, mounting heads

3) Final Area

- i) Butler SHW machine- Cam bore oil gallery, mounting holes
- ii) Washing & deburring to remove sharp edges
- iii) Pressure test water test by coolant
- iv) Inspection time starts
- v) Remark correction
- vi) Bush press fitting in cam bore.

vii) Remark is corrected by rework and checked

V28 CYLINDER BLOCK (12 CYLINDER)

It is 12-cylinder 28-liter engine produce 500-800hp.

- Casting procured from supplier.
- Fitching-1 is used to rough milling operation of Pan Face, Cap seat, Side bolt pad, Water head face. Fitching-2 is used for finishing operation of Fitching-1.
- Dowell hole for locater is used for fixing in fixture is drill and water head face drill by radial drilling machine.
- Rough milling of Gear end and Flywheel end.
- By multi-spindle drilling hand hole pad drilling on LBRB (Left Bank and Right Bank).
- LOH (Long oil hole) drill Throughout form gear end to flywheel end.
- US Drill head machine is used to for rough and semi-finish crank bore and cam oil gallery drill.
- Milling operation of Cap Gap of crank, it maintains the width between two crank bores. Nicking operation is done.
- NATCO machine is used for tapping of water head face and hand hole pad.
- By multi spindle drilling oil gallery for crank form main oil gallery is done.
- NATCO multi spindle main bearing bolt hole reaming and pan face hole drilling.
- By radial machine tapping of pan face hole.
- Main bearing bolt hole tapping and oil pan hole tapping by radial machine.
- Rough wash and deburring.
- Cap fitting by its number on cap.
- Cam bore of middle 3 cam roughing, semi finishing, Finish.
- 3 step rough liner finish of all Cylinder.
- NATCO head face drilling machine drills water grommet holes.
- Michigan boring machine is used for crank bore finish operation.
- Le Marie machine is used for liner bore finish.
- MAKINO CNC machine is also used for oil pan drilling, tapping. Oil gallery spot facing, LBRB boss hole-drilling and tapping, PCN drilling, tapping, reaming.

- Drilling and reaming for lubrication pump, thrust cap dovel holes.
- Miscellaneous hole drilling.
- Final washing
- Inspection of liner size, porosity, blow hole, cracks. If there it can rework or scrap.

KVN CYLINDER HEAD

- 1) NHNT Cylinder Head
- 2) V28 Cylinder Head
- 3) KV Cylinder Head

NHNT Cylinder Head

- Casting form Suppler
- There are 2 Cylinder Head inline. 2 intake and 2 Exhaust valve per Cylinder.
- Milling operation is done on Combustion side, Top side and side of head by DAEWOO machine. Injector bore roughing, grooving, finishing, Valve seat and Valve guide roughing, finishing.
- Size are check by air plug gauge.
- Deburring Process is done it remove small unwanted material at the edge of job. Washing is done to remove the oil.
- Injector Sleeve is inserted in injector bore made of copper to resist the heat. Rolling operation is done to remove some material for proper fitting of fuel injector.
- Final washing for remove the burr using water.
- Core Plug assembly by SPM machine for close water passage.
- All the water passage, oil gallery, fuel line is test by Air Pressure test machine to check the leakage of line.
- Copper valve seat per valves by hydraulic press machine and insert valve guide.

- Assemble the inlet and exhaust valve form combustion side. On top side washer above is Valve spring is held and spring is hold by the half pellets.
- Vision Inspection System- It is used to check all parts are properly fit.
- Vacuum Pressure Test is done it is test of valve to be properly seal at the combustion stroke. Vacuum is created on valve on combustion side check whether there is more leakage between valve seat and valve. If more leakage the job is rejected, and it send to rework area.
- Send to assembly line.

KV Cylinder Head

- Semi-finished casting from supplier
- There is 1 Cylinder Head.2 Intake and 2 Exhaust Valve per Cylinder.
- Loading and Unloading of Cylinder head form machine operation is done by Automatic Overhead Conveyor System by PLC program.
- There are 2 Stage operation
- 1 Stage-Finish Milling on top side and Combustion side and 4 side of Cyl. head, Drilling, Boring-injector, valves. It takes 12 min for all process.
- 2 Stage- In 2 Stage 4 Process are done Rough washing, Finish washing, Air blower, Final finish. At a time 4 Cyl. head can be done.
- Plug are inserted to close water passage.
- Pressure Test it check leakage all water and oil passages and fuel line by passing Air.
- 4 valve guide inserted and 4 valve seat are press by hydraulic press machine.
- Valves are inserted for combustion side. To check the valve are properly insert are not Poka-yoke System is there because inlet valve has bigger diameter as compere to exhaust valve.
- Retainer Spring for 4 valves and collet to hold the spring.
- Vacuum test is done to check minimum leakage between valve and valve seat.
- Vision inspection system to check the valve are properly fitted.
- Send to assembly line as required.

V28 Cylinder head

- Semi finish casting form supplier.
- There are 3 Cylinder head inline. 2 inlet and 2 exhaust per Cyl.
- Milling operation on Combustion and Rocker side.
- Boring operation on valve seat and valve guide by Daewoo-V-400 Machine. It is 17 min operation.
- In V28 Cyl head exhaust manifold is in cross. Milling operation for exhaust in cross by HC-620 Machine.
- Copper Sleeve is inserted and Rolling operation is done for proper fitting of injector.
- Final washing
- Core plug is inserted for all water passage by hydraulic press machine.
- Pressure test for all galleries to check the leakage.
- Visual inspection
- 4 valve seats per Cylinder and valve is insert. Spring retainer and collect
- Vision inspection system to check the valve are properly fitted.
- Vacuum test of valves
- Send to assembly line as required.

CAMSHAFT

- Camshaft are made for following engine they are-
N14, BIGCAM, K6, V28, KV12, KV16, QSK50, QSK60
- Raw material in the form of bar.
- Keyway slot milling is done for Gear mounting.
- Cam profile is made by kataota milling machine using keyway like inlet, injector, exhaust profile for QSK engine no injector profile is made.
- Deburring machine is used to remove the small material at the edge of profile.
- EMA-1, EMA-2, EMA-3 three induction machines are used to hardening the camshaft. First is heated at 800⁰-900⁰ C and then immediately Quenched by water. Which change the structure austenite to martensite.
- Normalizing process is done to increase the hardness of camshaft.

- Grinding machine is used to machining the journal and cam profiles and maintains the diameter of profiles. Diameter is check by air gauge machine or GO-NOGO gauge.
 - Bend removing machine or axis correction machine is used to remove the bend of camshaft. This can also be done by manually.
 - Burn test by electrolytic etch process in which solution is used NaOH (low concentration), HCL, NaOH (high concentration). This solution is applied on shaft and the crack is seen it should be minimum.
 - Megnaplus machine is used to check the crack in camshaft. Shaft is mounted on two support electric current is pass at high ampere shaft become magnetic and solution is applied (magnaglow) the solution is glow on crack by elimination of UV rays.
 - Super finishing process is done it remove material in mirco on profile.
-
- CMM machine is used to check the angle of profile which shaft is placed vertically on machine and by the probe is check.
 - Inspection is done by dial gauge, GO-NOGO gauge and visual inspection.
 - Rumbling Machine is used finishing. Shaft is placed in tub it contain of ceramic stone by vibration shaft is finished. By this process shaft can hold oil properly.

GEARS

- 1) Hobbing- for making keyway
- 2) Washing
- 3) Heat treatment: Carbon is added to make teeth soft
- 4) CNC machine: Face width
- 5) Inner Diameter grinding
- 6) Teeth grinding- Teeth engagement & grinding
- 7) MAR Gear GMX-400 C machine for checking gear.

HEAT TREATMENT

- 1) Induction hardening: Specific area hard up to 2mm deep, to increase hardness at bearing surface.
 RF- Radio frequency is used
 Polymer (10-15%) in water
 Temp- 850-900
 Quenching time- 10 sec used to attach fuel pump & engine
- 2) Softening machining
 Placed in between copper coil then heated and made to cool at atmospheric temperature and so it becomes soft
 Temp-240
- 3) Kept in a stand and it is kept in the furnace at 950 temp.
 Methanol acetone to increase the carbon content carburizing, copper coils
- 4) Tempering: The products from furnace from carburizing is placed in a furnace at a particular temp and blower to release the stresses and make hardness uniform.
- 5) Sealed quench furnace: components are cooled by dipping it into oil.
- 6) Washing
- 7) Gear –Brinell machine
- 8) Small job hardness by hardness tester by diamond point tool.

Phosphating- acid + water+ ferrous dip the job

Blackodizing- ferrous blackening + water + specific temperature for 20-30 mins so that component(liner) gets a coating which stops it from rusting.

Shot peening: ceramic stone of 1mm 2mm dia. after heat treatment

CNC Lathe

1. This department deals with the programming of CNC machines.
2. The CNC machine programs have two important aspects.

3. G codes: These are preparatory codes used for initialization of the machine tool.
4. M codes: These are auxiliary codes used for other support functions.
5. Programming can be done by incremental method or absolute method.
6. Incremental method; In this method the tool is indexed based on previous point of machining. This method has a disadvantage- If there is an error in any one of the points, the error is carried forward to all other locations.
7. Absolute method: In this method, the tool is indexed with respect to a absolute point set by the programmer. Here the error is not carried forward.

GCC (GEAR CASE COVER)

It is Gear Case cover which mount timing gears on it. It is different for different model like K6, KV, NHNT engines.

- Casting procured from supplier.
- Dowell hole are drill by radial machine for fixture.
- Milling operation (VMC) on inner side (gear mounting side), outer side, boring of mounting gears.
- Oil gallery drilling for gears by Radial machine.
- Radial machine is also used for drilling and tapping for GCC mounting on block.
- HMC is used for both side face milling.
- Deburring for remove unwanted material.
- Washing for remove oil which used for operations.
- PT (Pressure Test) for oil gallery; if leakage is found it is scrapped not reworked.
- Final inspection.

Miscellaneous and Bar Capstan

MISCELLANEOUS

- In this department various part are done which required for engine like intake manifold, exhaust manifold, filter head, pulley, lub. pump body.
- On radial machine exhaust and intake manifold mounting holes drilling, tapping with proper fixture.
- Milling operation on filter head drilling, tapping for mounting oil filter, reaming.
- ID grinding of filter and it diameter is check by gauge.
- Deburring is done. Washing and final inspection.
- For pulley it is in form of blank disc.
- On CNC lathe pulley grooves is done. Milling of both side of pulley. ID grinding.
- Balancing of pulley of Pulley is check if pulley is unbalance then material is removed by drilling hole. More than 4 is not accept.
- Keyway slot is done.
- Deburring and washing is done then final inspection.
- So, more than 300 part include small and big part are prepare as required with proper fixture.

BARCAPSTAN

- In the department the part in form of bar is prepare like valve guide, gear fuel pump drive etc.
- Bar is raw material is taken and in CNC lath OD, ID, Grooving, turning as requirement of part is made.
- By radial machine throughout drill is done on bars.
- Hobbing of gear pump of fuel is done. Deburring, washing is done then sent to heat treatment.
- External threading machine is used for making the bolt as required and some part need internal threading is also done.
- Threading is done by rolling the job between roller and press.

Flywheel

FLYWHEEL HOUSING

Station1

Machine: W&W; to maintain the width flywheel casting grinded on both sides.

Station2

Machine: HMT Radial drill; drill the mounting holes on flywheel

Station3

Machine: FB 500 HMC; Cam clearance is done; Starter bore to attach starter motor& oil pan relief.

Station 4

Machine: YASDA (HMC); Peripheri, milling, drilling, tapping

Station 5

Machine: V Turning Centre; Clutch boring and main boring(crank shaft)

Station 6

Machine: HMT Radial machine; Clutch side mounting holes

- Station 7

Deburring

Station 8

Washing

Station 9

Final inspection

Station 10

Assembly/ store

FLYWHEEL

- 1) 4GF casting machine: Turning, facing, boring, 2setup on both sides
- 2) VTC (Vertical Turning Center): Flywheel mounting holes drilling operation
- 3) Tapping operation & chamfer
- 4) Ring gear: furnace-350- increasing internal diameter it is attached to flywheel on, and then cooled and then attached to starter motor.
- 5) Flywheel balancing; Flywheel is rotated on the test machine and excess material weight and location is noted. This excess material is removed by drilling at specific location. Multiple drills may be required. Size of drill and depth may vary.

Connecting Rod

- 1) Laser marking on Conrod.
- 2) Torqueing of cap bolts about 200-275 ft pound
- 3) BFW machine boring of 2 holes (crank end and small end) facing and chamfer. Con rod is flipped for machining of opposite face.
- 4) Inspection (Baker Gauge- checks center distance), crank smallbore dia., thickness, CD-bend, twist, taper, squareness, perpendicularity.
- 5) WIDMA- Balancing Machine- To remove excess material both sides milling at ends of conrod, crank bore, smallbore
(KV- only one side chamfering
K6- both side chamfering).
- 6) Deburring, oil hole chamfer manually
- 7) Honing operation- finish make hatch pattern ..
- 8) Venus Bush Press machine- for bush press (tin-brass)
- 9) WIDMA machine- boring operation..
- 10) Centre distance, diameter of boring is checked.
- 11) Venus Dismantling- bolt remove station.

- 12) AMS nicking- nicking cutter is used bearing locking slot.
- 13) Single Wash.

Inspection- Nicking serial no., see bend mark.

PT System Machining

Fuel Pump Machining Line

1. DAEWOO HMC

- Face milling of flange side and gear pump side.
- Chamfering at drill location.
- Drilling.
- Tapping/Boring/Reaming/Counter-tapping of drilled holes.

2. Karey Drilling Machine

- Oil gallery drilling from both sides.
- Here a special fixture is used for the job.

3. Radial drilling Machine

- The operations which are not performed on the HMC are done here.
- Operations include drilling and tapping.

4. Long Oil boring Machine

- Boring of Barrel bore and Bush bore is done here.
- The bush is press fitted here.

5. Deburring

- Sharp edges and excess material is removed.

6. Washing

- The housing is washed to remove any burrs and other particles.

7. Inspection

- The job is checked manually for any machining defects.

8. Electric Furnace

- The barrel and pipe is fitted in the housing by shrink fit method.

9. Vertical Honing Machine

- Honing of throttle bore done.

10. Washing

11. Sent for Assembly.

Gear Pump Housing

1. BFW SPM (gang Drill)

- Drilling of dovel holes, gear bore.

2. HMT

- Drilling, Tapping and Reaming of remaining holes.

3. Rotary Table Grinder

- Grinding of face and Back side of housing.

4. Boring Machine

- Boring of gear holes is done.

5. Marking

- The part serial number, date and model is marked.

6. Dovel pin fitting

7. Bush pressing by hydraulic press.

8. Heat treatment

- Blackodzing of the housing is done.

9. Sent to assembly.

Injector Barrel Line

1. HAAS VOP-B (BOTTLENECK MACHINE)

- Drilling of Inlet, Outlet and drain.
- Drilling of ball seat.
- Drilling of Dovel holes.

2. Makino Slim3

- RDF hole drilling.
- Drilling of Vent holes.

3. Marking machine

- Part number, date and model is marked on the part.

4. Tumbling

- The part is kept in a tumbler machine which has ceramic stones.
- These ceramic stones give the required surface finish.

5. Rough Deburring

6. Heat treatment

- Hardening
- Blackodizing.

7. Rough Honing

- Honing of barrel ID: This is to aid finishing. Material is removed. Hard polymer oil is used. The spindle with honing tool is rotated and the job is reciprocated linearly on the tool.

8. Face grinding

- Grinding of both the faces is done.

9. Face Deburring

- Sharp edges and any excess material is removed.

10.Lapping

- Lapping of both faces is done for required surface finish.

11.Diamond Deburring

- The deburring tool is coated with small diamond particles.
- This tool is used for deburring of inside of the holes.

12.KADIA(CNC) Finishing

- Final finishing of the barrel ID is done.
- Process: loading-roughing-checking-finishing-checking-unloading.

13.High pressure Machine cleaning.

- Job is placed on a chuck. Coolant is passed through every hole of the barrel.
- Any excess material, burr, dust is removed by this process.

14.Ball plugging

- All periphery holes are plugged except the inlet, outlet and dovetail holes.

15.Ball seat Grinding

- Ball seat angle is machined here

16.Barrel-Plunger Match gauging

- The clearance between the barrel ID and Plunger OD must be in tolerance to facilitate fuel flow.
- Here the Cup side and Adapter side diameters (ID for barrel and OD for Plunger) is checked.
- The taper is also noted.
- The plunger is selected for the barrel and marked.
- The calculations are done by software and Air pressure gauges.

17. Sent for Assembly

Injector Cup Line

1. EDM (Electro Discharge Machining)

- Here the required cup hole is generated.
- 25-micron Tungsten electrode is used.
- Number of holes may vary with model. The holes are equally spaced with specific angle.
- De-mineralized water is used as a dielectric medium.
- EDM machine is Automated gantry type.

2. Laser Marking

- Part number, number of holes, model is marked on the cup.

3. Spray Pattern Check

- The cup is placed on the inlet pipe of the machine.
- An oil is passed through the cup with the designed pressure.
- The opening and angle of the spray is checked manually.

4. ID Grinding- Seiko Seiki Machine

- A cone shaped grinding tool is used for the grinding of the Plunger seat.

5. Microscope Inspection

- Number of holes are checked.
- Surface irregularities are checked.
- For e.g. dents, defects, etc.

PT System Assembly

Injector Assembly

1. Dovel pin placement in adapter
2. Laser marking
 - Part number, date and QR code is marked.
3. O-ring assembly.
 - 3 O-rings are placed on the adapter.
4. Barrel assembly
 - The barrel is attached with the help of dovel pins.
5. Plunger assembly
 - The plunger is inserted manually.
6. Retainer assembly
 - The retainer is assembled manually.
 - The retainer is torqued to the required value.
7. Pressure test
 - The ball seat clearance is checked.
 - Pressurized air is supplied at the inlet.
 - Oil at outlet is checked.

8. Leakage Test

- Here the clearance between retainer and barrel is checked.
- Pressurized air is supplied at inlet.
- Oil is placed on the face. If any leak is present, bubbles are formed.

9. Spring assembly

- The plunger spring is assembled with the help of a retainer and a lock nut.

10. Top Stand 1

- Spring travel test s conducted by applying dead weight.
- Depth of spring travel is noted.
- To get required spring travel, lock nut is adjusted.

11. Injector Calibration/Testing

- Orifice is fitted on inlet of injector.
- The injector is placed in a machine which replicates cam and follower function.
- The fuel flow at the outlet of injector is measured. (cc/1000strokes)
- The fuel flow is adjusted to the required value by adjusting the orifice opening or replacing the orifice.

12. Top Up test 2

- Travel along hydraulic tappet is adjusted.

13. Screen filter attachment

- Screen filter restricts entry of dirt and other particles.

14. Inspection

Fuel Pump assembly

1. Gear pump assembly

- Gear pump cover and body are assembled with dovel pins and hydraulic press.
 - End play of shaft is checked.
2. Hartridge test (leak test)
 - Here fuel is supplied to the gear pump and flow rate is checked.
 - Working of damper is also checked here.
 3. Class Matching
 - Done for fuel pump housing.
 - Barrel ID and plunger clearance is checked.
 - Throttle bore and throttle shaft clearance is checked.
 4. Laser marking
 - Part number, model, and date is marked on the pump.
 5. Subassembly
 - Actuator housing assembly.
 - MVS assembly.
 6. Child Parts assembly
 - All accessory/small parts are assembled here. (model wise)
 7. Assembly rack
 - All the models are stacked separately here.
 8. SD valve assembly
 - Shut Down valve is fitted according to model with its electrical connections.
 9. Fuel pump Test stand 1
 - Here the pump working parameters are checked.
 - The pump is run at high and low idle.
 - The fuel pressure is cross checked with the required value.

10.STC Test

N/V/K Assembly line

- 1) NHNT
- 2) V28
- 3) K6

NHNT Assembly Line

In NHNT Assembly line two model of engine assemble BIGCAM and N14. There are 12 station they are

STATION-1

Cylinder Block preparation, Crank Gear Subassembly, MB Cap, and Liner assembly.

- Close all oil gallery of cylinder block by inserting plug. 21 plug insert.
- Crank shaft is insert at bottom of cylinder block with bearing.
- Crank gear is mounted on crank shaft with key way by heating the crank gear at 220 deg cell which is expand and after cooling is fit to the shaft.
- Cylinder Liner is press on cylinder block with the help of hydraulic machine. Before that copper ring is inserted for proper fitting.
- Gives Engine serial number.

STATION-2

Camshaft, GCC, RC plate Subassembly, Flywheel housing assembly.

- Crankshaft Gear is mount on Crankshaft by heating the gear to fit properly the machine is used Induction Heating Equipment.
- Subassembly part of gear and the crankshaft is mount in cylinder block.
- Gear Case Cover (GCC) is mount on side of crank gear.
- Flywheel housing mounting.

STATION-3

Piston-Con Rod subassembly and assembly, lubricating oil pump assembly.

- Three part of piston ring are oil ring, stepper ring and two compression ring.
- Piston – Con rod subassembly parts are: Gudgeon pin (connects the piston to the connecting rod), Piston, Bearing (Inserted in bigger end).
- Piston is assemble on crank shaft and Con-Rod cap is bolted by given torque (N14-210 ft·lbf and BIGCAM-170 ft.lbf).
- Lubricating Pump is assemble. In NHNT series Engine Lubricating pump is at outside of block.

STATION -4

Injection Timing Setting, Fuel Pump and accessory drive subassembly and assembly, Water Pump assembly.

- Injection Timing is set for proper spray of fuel (diesel) just after the TDC at compression stroke. It is different for different model. If the timing is not proper given then cam follower is adjusted by adding gasket.
- Fuel pump subassembly parts are support (drives fuel pump), compressor (If needed), fuel pump. Directly connected to crank gear. It drive by idler gear.
- Water pump assembly it is belt drive at timing gear assembly side.

STATION-5

Damper and accessory drive pulley and assembly, oil pan assembly.

- Damper is used to reduce the vibration of engine because if speed is increase multiple vibration is possible. Damper is directly connected to crank.
- Oil pan is mounted on bottom of Engine block.

STATION-6

Cyl Head-injector subassembly and assembly, Water manifold and Thermostat subassembly and assembly.

- Subassembly of crosshead valve, injector, and injector clamp in Cyl head. Assemble on engine block.
- Subassembly of water manifold (water form Cyl head to water pump), Thermostat , thermostat housing and assemble on block.
- Thermostat is connected to radiator (it is used when temperature of water is high to cool thermostat is open and radiator cools the water.

STATION-7

Lub oil cooler subassembly and assembly, Rocker housing assembly, PCN (Piston Cooling Nozzle)

Assembly.

- Subassembly of Rocker in Rocker Housing. Assemble on Cyl head with Rocker arm.
- PCN is assemble on bottom on engine block. It is nozzle directly towards the piston to cool by oil.
- Lub oil cooler is assemble. Lub oil filter is connect to lub oil cooler to cool the oil by passing water through elements.

STATION-8

Tappet Setting, Exhaust manifold and Turbocharge assembly.

- Firing order of both model engine is '153624'. It is order of power delivery of each cylinder. Important for Tappet setting.
- Tappet setting is clearance between Rocker and Crosshead which rest on valves. Clearance is measured by filler gauge.
- Two type of Tappet setting are OBC (outer base circle) and IBC (inner base circle) of the cam shaft. OBC for N14 and IBC for BIGCAM
- Turbocharge is assemble compressor to intake and turbine to exhaust (drive the turbo).

STATION-9

After cooler assembly, Water plumbing and Compressor tubing, Corrosion tubing and filter assembly.

- Subassembly of After cooler are intercooler (fins like structure that water pass through), Housing (air pass through in housing intercooler inserted). Assemble to intake of Cyl head.
- Water plumbing pipe to inlet and outlet of intercooler to flow of water.
- Compressor need lubricating oil is transfer.
- Oil filter assembly (to filter the oil before going to engine block.

STATION-10

Fuel tubing and check valve subassembly and assembly, fan hub assembly

- Fuel tubing-two copper tube in install form fuel pump to Cyl head one for transfer of fuel to fuel gallery and second for excess fuel to fuel pump.
- 2 check valve- it is non- return valve of fuel.
- Fuel filter is assembling it is used for filter the fuel before entering the fuel pump.
- Fan hub assembly it is driven by belt.

STATION-11

Engine retorquing, Bypass filter, fuel filter assembly, Air cleaner bracket assembly

- Re-torque all blot by manually because sometimes bolt may be loose by air gun.

STATION-12

Starter motor assembly, alternator assembly, flywheel assembly.

- Starter motor is assembly to crank to start the engine of 24v, 2A
- Alternator is belt drive.

K6 Assembly

Sub Assembly

Crank subassembly: Shrink fitting of crank gear.

Piston subassembly: Sub assembly of piston, Con-rod, Piston rings.

Station 1: Crank Assembly

Crank shaft is assembled with crank bearings.

Fitting of Crank caps by bolting and Torqueing of bolts as required by nut runner.

Station 2

- Core plugging of Oil galleries with hammer gun and anabond adhesive.
- Assembly of cylinder liner with Piston and Con rod by hydraulic press.
- Gear housing plate is bolted to gear side of block with its gasket.
- Assembly of idler gears.

The idler gear (for camshaft) tooth is matched with that of the crank gear for correct timing.

Two other idler gears are assembled. One meshes with the Lubrication pump gear and the other with Accessory drive.

- Cam followers are bolted to cam-box.
- Cylinder Heads are bolted to the block.

- Protrusion of gear housing and block is checked by a dial gauged and reading is marked on the block.

Station 3

- Gear Case Cover (GCC) is bolted to the gear housing with its gasket.
- Cam follower bolts are Torqued by Nut runner.
- Rocker housing is bolted above cylinder head.
- Water transfer tube also assembled to the rocker housing.

Station 4

- Assembly of Flywheel casing and Flywheel.
- Assembly of Oil Pan.
- Marking of Engine Serial Number(ESN).

Station 5

- Lub. Oil cooler assembly.
- Fuel pump assembly on accessory drive.
- Water pump assembly.
- Fuel manifold assembly on cylinder head.
- Oil manifold assembly.
- Fuel filter head assembly.

Station 6

- Exhaust manifold assembly.
- Turbocharger assembly on exhaust outlet.
- Water pump piping assembly.
- Injector assembly with oil transfer tube.

- Push rod assembly in cylinder head.
- Assembly of Rocker lever, crosshead.
- Tappet Setting: The clearance between the rocker lever and tappet surfaces have to be calibrated for proper timing of intake, inlet and exhaust valves. It is done by IBC(Inner base circle)/OBC(Outer base circle) method. The tappet setting is done in accordance with the firing order of the Engine model.
- Breather assembly.
- Water manifold assembly.

Station 7

- Intake manifold assembly. (Connected to turbo inlet).
- Thermostat valve and housing assembly.
- Crank shaft damper assembly.

Station 8

- Installation of Electrical connections.
- Assembly of Clamps. (For lifting the engine).

N/V/K Testing and Upfit

The testing of N/V/K Engines is conducted in specific Test Cells. The test cells are monitored by the operator. The Test cell program cycle and control is done by a computer software. The testing is done according to the Quality Specification of the Engine model.

Step 1: Setup

- Lubrication Oil inlet.
- Fuel(Diesel) inlet.
- Water inlet from heat exchanger.
- Turbo in.(Air intake)
- Turbo Out.(Exhaust)
- Charged Aftercooler.
- Dynamo is coupled with Flywheel.

Setup 2: Testing

- The test cell is closed and operator enters engine serial number in the software.
- The test cycle varies according to the model of the Engine.
- The test has three steps.
- First, the Engine is started and kept running until working temperature is achieved. The load is gradually increased to the required load and RPM. The required parameters are checked and noted in the Engine test record.
- Next, then load is decreased gradually to zero and the engine is run at High Idle governor setting. The required parameters are checked and noted in the Engine test record.
- The last step is Low Idle test. It is similar to the high Idle test but at Low Idle governor setting and low RPM.

Parameters

- Fuel flow
- Fuel pressure
- Air pressure

- Torque
- Blow-bye
- Water temperature
- Lubrication Oil pressure
- PCN pressure

Step 3: Leakage test

- If any parameters given in the ETR are not achieved by the engine, leakage test is conducted.
- There may be a leakage of water, fuel or oil.
- The lights in the test cell are dimmed.
- A UV torch is used to locate the leakage on the engine manually.
- Diesel or Water leakage appears white under the UV torch.
- Lubrication Oil appears green due to an additive.
- The leakage is fixed by re-fitting or replacement of the specific part.

Upfit

- Upfit area is responsible for the assembly of accessory parts of the Engine, Cleaning and Painting as required by the Customer.
- Upfit Parts: Air filter, Fuel filters, Oil filters, Fan, Hose, Clamps, Governor control panel, Fuel piping, Pulley belts and more.

Painting

- Painting is done in 3 steps.
 - Step1: Washing of the Engine in the Washing booth by water spray.
 - Step2: Blow drying of the Engine to ensure no water particles are left on the surface.
 - Step3: Masking of parts which do not require paint.
- The Engine then goes to the Paint booth. Paint color as per the customer requirement. The paint used is Asian Paints-Protective and Performance series.

KV Assembly

Station 1

- Piston, Cylinder liner, Conrod and piston ring subassembly.
- Crank gear shrink fit on crank.

Station 2L

- Crank shaft assembly with crank bore.
- Crank Cap assembly and torqueing.
- Plugging of Oil galleries with anabond adhesive.
- Crank box cover plate assembly.

Station 3L,3R

- Piston assembly by hydraulic press.
- Con Rod cap assembly.
- Orifice assembly.

Station 4L,4R

- Cover plate bolting on top side of block.
- Torqueing of Con rod cap bolts by nut runner.

Station 5L,5R

- Cylinder Head assembly.
- Lubrication Oil filter head assembly.

Station 6L,6R

- Rocker housing assembly on cylinder head.
- Exhaust Manifold assembly.

Station 7L

- Fuel line assembly on cylinder head.
- Oil Line assembly.

- Inspection: All parts are checked in accordance with SBM. If any shortage present, engine is kept aside and cannot go ahead in the line until the required part has been assembled.

Station 8L,8R

- Gear case housing assembly.
- Idler gear assembly: Teeth are matched with crank gear for correct timing of.
- Flywheel Case and Flywheel assembly.
- Cam shaft assembly.

Station 9L,9R

- Cam gear shrink fitting.
- Injection timing setting.
- Cam shaft end play check by dial gauge.
- Gear case cover assembly.

Station 10L,10R

- Crank Pulley and Damper assembly.
- Cam follower assembly on cam box.
- Cam box cover plate assembly.
- Fuel block assembly.

Station 10L,10R

- Injector assembly with oil pipe.
- Rocker lever and crosshead assembly.

Station 11L,11R

- Turbocharger assembly.
- Turbocharger cooling pipe fitting.

- Fuel pump assembly.
- Fuel line fitting.
- Water pump assembly.

Station 12L,12R

- Rocker Cover Cap assembly.
- Torqueing of bolts by nut runner.

Station 13L,13R

- Tappet setting: According to marking on the crank damper, (e.g. 1R-6R VS), Valve and Injector timings are set in accordance with the firing order.
- The clearance between the Rocker lever and Cross head is set.
- The Intake, Inlet and Exhaust valve timing are thus set.
- Method/Order may change according to the model.
- The crank is rotated by power pack.

Station 14L,14R

- Idler pulley and tensioner assembly.
- Thermostat and water manifold assembly.
- Fan hub assembly.
- Crank damper assembly.

Station 15L,15R

- After cooler assembly.
- Air intake manifold assembly.

Station 16

- Alternator assembly.
- Starter Motor assembly.
- Magnetic switch fitting for starter motor.

- Electric wiring and other connections.

Station 17L,17R

- Lubrication pump assembly.
- Oil pan assembly.
- Alternator assembly with pulley.
- Water pump inlet manifold assembly.

Station 18R,18L

- Oil filter assembly.
- Fuel filter assembly.
- Oil and Fuel supply pipe/hose fitting.
- Pulley belt assembly of Crank shaft and alternator.

Station 19L,19R

- Water pump bypass piping.
- Breather assembly.

Station 20R,20L

- STC (Step timing controller) assembly: It is connected to oil and fuel line inlet. It regulates the flow at Idle condition.

Station 21R,21L

- After cooler water piping.

Station 22R,22L

- LTA piping.

Dry Testing

- Testing is done with the help of Engine leak test machine.
- Pressurized Air is supplied to all oil galleries.
- If there is any pressure drop, it is noted.
- Soap water is sprayed on the engine to detect leak location.

- The specific part is tightened or replaced.
- E.g. Hose clamp may be loose.

KV Testing and Upfit

The testing of KV Engines is conducted in specific Test Cells. The test cells are monitored by the operator. The Test cell program cycle and control is done by a computer software. The testing is done according to the Quality Specification of the Engine model.

Step 1: Setup

- Lubrication Oil inlet.
- Fuel (Diesel) inlet.
- Water inlet from heat exchanger.
- Turbo inlet through Air filter. (Air intake)
- Turbo Out. (Exhaust)
- Charged Aftercooler.
- Dynamo is coupled with Flywheel.

Setup 2: Testing

- The test cell is closed and operator enters engine serial number in the software.
- The test has following steps.
- First, the Engine is started and kept running until working temperature is achieved. The load is gradually increased to the required load in six steps of percentage load. (10%, 25%, 50%, 75%, 95% and 100%). The required parameters are checked and noted in the Engine test record.
- Next, then load is decreased gradually to zero and the engine is run at High Idle governor setting. The required parameters are checked and noted in the Engine test record.

- The last step is Low Idle test. It is similar to the high Idle test but at Low Idle governor setting and low RPM.

Parameters

- Fuel flow
- Fuel pressure
- Air pressure
- Torque
- Blow-by
- Water temperature
- Lubrication Oil pressure
- PCN pressure

Step 3: Leakage test

- If any parameters given in the ETR are not achieved by the engine, leakage test is conducted.
- There may be a leakage of water, fuel or oil.
- The lights in the test cell are dimmed.
- A UV torch is used to locate the leakage on the engine manually.
- Diesel or Water leakage appears white under the UV torch.
- Lubrication Oil appears green due to an additive.
- The leakage is fixed by re-fitting or replacement of the specific part.

Upfit

- Upfit area is responsible for the assembly of accessory parts of the Engine, Cleaning and Painting as required by the Customer.
- Upfit Parts: Air filter, Fuel filters, Oil filters, Fan, Hose, Clamps, Governor control panel, Fuel piping, Pulley belts and more.

Painting

- Painting is done in 3 steps.

- Step1: Washing of the Engine in the Washing booth by water spray.
- Step2: Blow drying of the Engine to ensure no water particles are left on the surface.
- Step3: Masking of parts which do not require paint.
The Engine then goes to the Paint booth. Paint color as per the customer requirement. The paint used is Asian Paints-Protective and Performance Coating series.

TOOL ROOM

- 1) Tool design- Design of jig & fixtures
- 2) Tool planning
- 3) Tool Crib- Tool regrinding
- 4) Tool Stores- Tool storage
- 5) Tool Room- Production tool required (job production not mass production)
- 6) Industrial Engineering- Layout of workspace

Tool Room: Turning line, Jig boring, milling operations, assembly, grinding, raw material cutting, heat treatment, machine spare parts

Strategies in Tool Room

- 1) Process improvement
- 2) Quality improvement
- 3) Safety improvement
- 4) Ergonomics improvement
- 5) Cost saving
- 6) Cycle time reduction
- 7) Cost saving
- 8) Second shift elimination

TRR- Tool Room Request

Stoppages- Jig and fixtures or supports for production breakdown or maintenance.

TOOLCRIB

- 1) Moslow machine: Helical point grinding by using helical tool sharpener. Angle plate is adjusted in machine and accordingly sharpening process is performed.
- 2) Christen machine- Sharpening of conventional point
- 3) DSW- To remove extra material at the end of sharpening is removed by Carborundum wheel.
- 4) Levcher Turning Tool Grinder- Carbide tool grinding by diamond wheel.
- 5) Ecogrind 5 axis CNC- reaming tool, cutting edge are sharpen (only for carbide tool).
- 6) Wasinco Optical Projector grinding machine- Injector bore cutter sharpening by carborundum wheel.
- 7) Walter tool- machining of hobbing tool.
- 8) Praga machine- Injector Bore cutter sharpener, gun drill sharpener, ORS cutter sharpener, splitting cutter (face milling) sharpener, Grooving tool sharpener.
- 9) HMT (revolving center job)- big drill re sharpening.
- 10) Stan comport Broach grinding- Broaching tool sharpening
- 11) Ewag micro drill point grinders- Drilling small thin tools.

Quality

MQA

- 1) surface finish instrument- surface finish of the component is checked.
- 2) Contour instrument- Contour of the objects is checked
- 3) Surroundings- roundness, squareness, perpendicularity, etc. of the gauges is checked.
- 4) Thread measurement- to measure effective diameter of thread or thread pitch
- 5) Precimar ULM- all kinds of properties like surface finish, contouring, etc. can be measured
- 6) Vacuum gauge- to check vacuum of vacuum produced
- 7) Pressure gauge- to check pressure produced

Gantry type CMM is used to check the overall dimensions of the component. The probes are changes as required.

PPI

- 1) Relay board (Genset) used to check whether circuit is correct
- 2) Tachometer's rpm counting is checked.
- 3) Belt checking of flywheel- Calculate belt tension
- 4) Oil pressure gauge working needle of the gauge is checked
- 5) Water temperature sensor's needle is checked
- 6) In electrical fuel pump the armature of which is responsible for opening and closing of the valve is checked.
- 7) Harness connections are checked on set-up by running simulation software.

WAREHOUSE (KV and N/V/K)

General – Indirect materials (materials which are used as supportive or not installed directly in assembly)

Imported – Parts which are imported

Domestic material – Materials which are procured from outside but not imported

Preservation – good quality, good condition, right way, right time is preserved of the parts

Parts procurement procedure – When the goods are received at the dock they produce goods paper at GRR office and the ASN (Advance Shipment Notice) no. is scanned and all the information is uploaded in the system.

- 1) Red channel material – quality of the procured goods needs to be checked at the time when goods are received.
- 2) Green channel material – no quality issue with the materials procured directly sent to storage.

Parts needed on any of the shop floor is uploaded on the system and then approved by warehouse to send the required parts.

KIT PARTS

All the parts in kits warehouse is mentioned in software called Oracle. Yearly 2 times all the parts in warehouse are checked at December end and March end. A kit is provided with the engine to be given to the customer which contains parts to be fitted later also spare parts, etc.

- 1) Export- kit which is exported with engine
- 2) NPY- non poka yoke parts- parts which are assembled in engine like screws, hose, flange
- 3) LK- loose kit- contains oil coolant, filter, hose, flange
- 4) Literature- It contains manual, warranty manual, catalogue. which is provided with the kit.

Imported Stores, Spares

- Imported parts are stored
- Crank shaft crack testing performed here.
- There are two types of parts which are imported.
- Red channel: these parts need quality check
- Green channel: these parts are sent directly to storage.

Spares

- Spare parts required in the company are procured and stored here.
- These parts are supplied to IPDC as required.