Big Chief Indian Motorcycle Engine

BY **MICHAEL TOMAS**

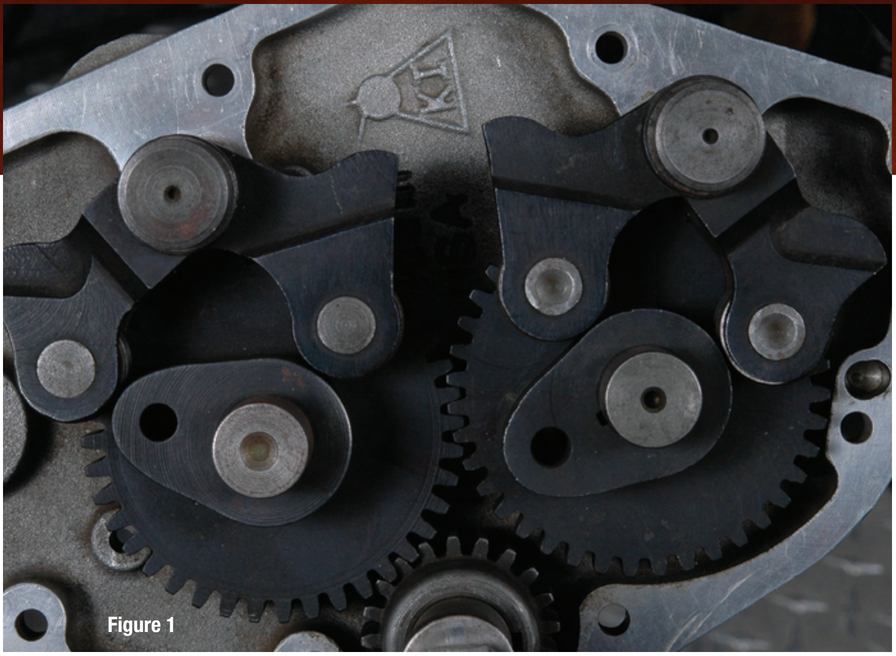
Figure 1

On any given sunshiny day, you will see many riding motorcycles. A love affair with V-twin motorcycles and particularly old American V-twins has created an almost cult-like following for some of old names like Harley-Davidson and Indian. Although Harley-Davidson survived over the years, others like Indian were not so fortunate. But there has been a resurgence of interest and many modern manufacturers have tried to emulate these old (and new) classics. Flathead engines were left in the weeds of history superseded by newer overhead valve designs however, as time went on, fascination with this bygone era has renewed and is alive and well. We at Kiwi Indian MotorCycle Company specialize in Indian motorcycles and offer many improvements to make the engines much more powerful and reliable.

Because flathead Indian motorcycles are now primarily specialty items, not much is known about them by the larger motorcycle community. Even though they share many similarities to other V-twin engines of the same era, they have their own uniqueness. An attempt will be made to cover most of the unique features of the Indian Big Chief engine and give an interested engine builder some tips on what to do for balancing, assembly, specifications and the many improvements that were made over the original design.

Cams and Valve Train

In 2000, Kiwi brought to market the world's first proprietary Indian flathead engine since the original factory closed in 1953. One of the biggest challenges to air cooled flathead engines is their top ends. Excessive heat retention, bore distortion, head gasket sealing and valve train life expectancy are the normal weakness and where development is continually ongoing.

The cam train is very simplistic and minimalistic yet very functional. One cam operates the intake and exhaust valve on the front cylinder while the other cam operates the intake and exhaust valves on the rear cylinder. A male and female cam follower is pivoted above the cam providing the transfer to the pushrod and then in turn to the valve. Different cam profiles can be fitted for different performance or riding styles but they have to be properly mated to the appropriate cam follower. The cam follower center lengths are made in differing lengths to achieve the desired valve timing. The contact surface between the cam follower and cam is transitioned via a roller and axle (see Figure 1). Cam followers are of a male/female forked design and pivot on their own shaft (see Figure 2). Original cam followers were of a forged design and heat treatment was not adequate as it led to them being pounded out which equates to constant tappet adjustments. Modern Indian cam followers are made from billet 8620 material and heat

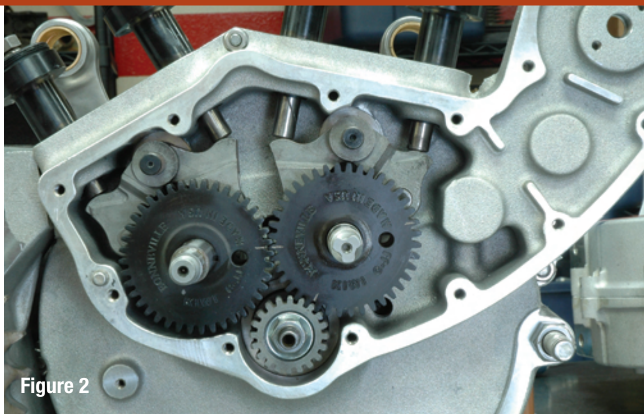

Figure 2

Figure 3

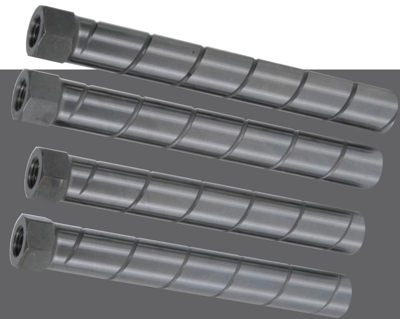

Figure 4

Figure 5

Figure 6

Figure 7

treated to Rc 60-62 for zero wear (see Figure 3). These in turn are mated with pushrods of the same material and heat treatment. Pushrods have been upgraded with an external spiral while the pushrod guide has an internal spiral as these spirals aid oil lubrication by spreading out the oil film and increasing pushrod life (see Figure 4).

Cam Tech

- Cam bushing interference: .0015”-.0025”
- Camshaft clearance: .001”-.002”
- Camshaft end play: .004”-.008”
- Cam to shaft interference: .00075”-.001”

Pushrods & Adjusters Tech

- Tappet clearance: Cold, intake .004”-.006”, exhaust .006”-.008”
- Pushrod clearance: .In guide, .002”-.003”
- Push rod lengths: The long push rods go to the front cylinder while the short push rods go to the rear cylinder

Pistons, Rings and Valves

Pistons have an E cam grind with .008” drop off at the 45 degree points and .015” at the wrist pin access. Skirt taper is between .002” and .003”. While old fashioned piston cam grinding may seem primitive by some of today’s manufacturing methods it has produced the best end result of engine reliability/durability for our Flatheads (see Figure 5). Pin offset is .020” towards the major thrust face which faces towards the rear of the motorcycle. We experimented with a .030” pin off set but it created too much piston noise so we settled on .020” which has worked out well.

Ring sealing has been altered from the original piston/ring pack which consisted of 3x 3/32” wide compression rings and a 5/32” wide oil (see Figure 6). Kiwi’s upgraded piston/ring pack consists of 2x 1/16” wide compression rings and 5/32” wide oil.

Pistons have been upgraded to a solid slipper skirt design from the original

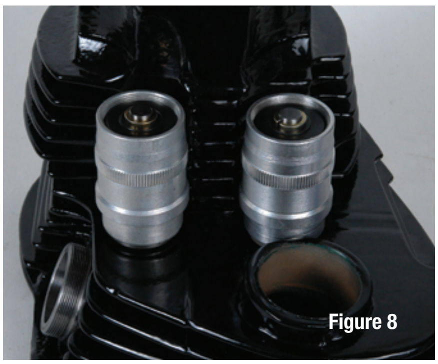

Figure 8

T-slot trunk style and the wrist pin has a .020” pin offset (see Figure 7). As mentioned earlier, the .020” pin offset makes for a nice quiet operating top end. Some years ago we changed to forged pistons over the standard cast type pistons however this turned out to be a disaster. Engines never went beyond 500 miles without seizing. We tried different skirt profiles, low expansion alloys and increased piston to wall clearance, all with no success. We went back to plain old cast pistons and all the problems went away. So today we still continue on with good old cast aluminum pistons.

Valves are made by Eaton from 21-4N, have a .0005” hard chrome, burnished finish and wafer tips added to the ends (see Figure 8). This greatly increases valve train life and constant tappet adjustments are a thing of the past. Flatheads get no oiling to the exhaust valve stems and we have found hard chrome stems to be the most wear resistant by far over other valve types. Our latest development has been to change the valve/seat angle from 35 degrees to 45 which early results show an increase in valve/seat life. Exhaust valve guides take a beating due to operating in a no lube environment. So far the best material is a high end, wear resistant and heat treated cast iron material but we are always out scouting for even better materials.

Both the intake and exhaust valves are the same size, 2” head with a 3/8” stem and 35 degree seat angle (see Figure 9, page 12). In the old days both the head shapes and materials varied but with today’s materials we make both valves the same therefore carrying just one part number. We have been experimenting with a 1-3/4” diameter head exhaust which has increased performance. Valve to guide clearance is .003”-004”. While it may seem excessive, anything less will cause seizure especially with the exhaust. It runs extremely hot and in a dry environment as the oil does not migrate up from the valve chest. Back in the old days Indian experimented with adding oil tubes to the exhaust valves but this just lead to valve stem "coking" (excessive carbon buildup).

Valve Tech

- Valve face/seat angle: 35 degrees
- Valve to guide clearance: .004"
(Less than .004" is not better for Indians and may result in seized valves)
- Guide interference .002"
- Tappet clearance: Cold, intake .004"-.006", exhaust .006"-.008"

Oiling System

The key to Kiwi's engines are the crankcases but the trick was upgrading them while still keeping the exterior original in appearance. Baffles were added to restrict the oil from being splashed directly onto the breather outlet. Bearing/bushing boss surrounding areas were increased as well as gasket sealing surface areas to ensure an oil tight engine. Oiling to the output side bearings has a catchment area so a continual supply of oil is on hand.

Figure 9

The oiling system for the most part is splash feed. The oil pump feeds oil into the end of the pinion shaft (right side main in automotive terms) and is moved to the crankpin via an oil gallery hole drilled in the flywheel. Four exit holes are machined in the crankpin in alignment with each row of rollers (see Figure 10). It is important to note that the four exit holes are to face rearwards so that centrifugal force works for us releasing the oil. The reason I mention this as some crankpins over the years have been manufactured incorrectly with the oil holes facing forwards. This in turn tends to force the oil inwards and leads to oil starvation. From here on out it is splash feed to the top end, cam chest and valve train. The valve train oiling comes from the cam chest and moves up via the pushrod guides. While it is adequate for the intakes, it is

Figure 10

not adequate for the exhausts. Originally valve stem seals were not used however today we fit them to the intakes only. Oil to the top end is splash feed and restricted by baffles manufactured into the top of the crankcases (see Figure 11). In the old days one piece cast iron rings were the choice so the baffles help lower oil consumption. While today's multi piece oil rings are an improvement, they pose their own set of challenges as the cast iron cylinder composition had wide swings of quality. A set of multi piece oil rings can work well in one set of cylinders yet in another it could wear out a top end in 1500 miles. The term playing Russian roulette is the best way to put it when re-using original cylinders as their material quality can vary widely. What may work well in one set of original factory cylinders may not work in the next set. New aftermarket cylinders are harder, more wear resistant and more consistent quality therefore allowing other ring combinations to be used with consistent results. A gentle low tension multi piece oil ring is ideal.

The oiling system is a dry sump system so oil is returned via a scraper cast directly into our cases. This scraper has .025" clearance between it and the flywheel and forces oil back to the return side of the pump which in turn is pumped back to the oil tank. The oil tank is housed within the front right side gas tank. The great part about this is the oil is kept cool by air passing over it. The gas also transfers heat away plus the copper oil lines cool both in the delivery and return routes.

Originally, these engines had a breather disc housed in the casting where it screws to the cam cover which was marginal at best. Kiwi has developed a modern PCV valve as a breather. Remove the breather disc and fit the PCV valve onto the end of the existing breather tube. Note the oiling system side of the engine.

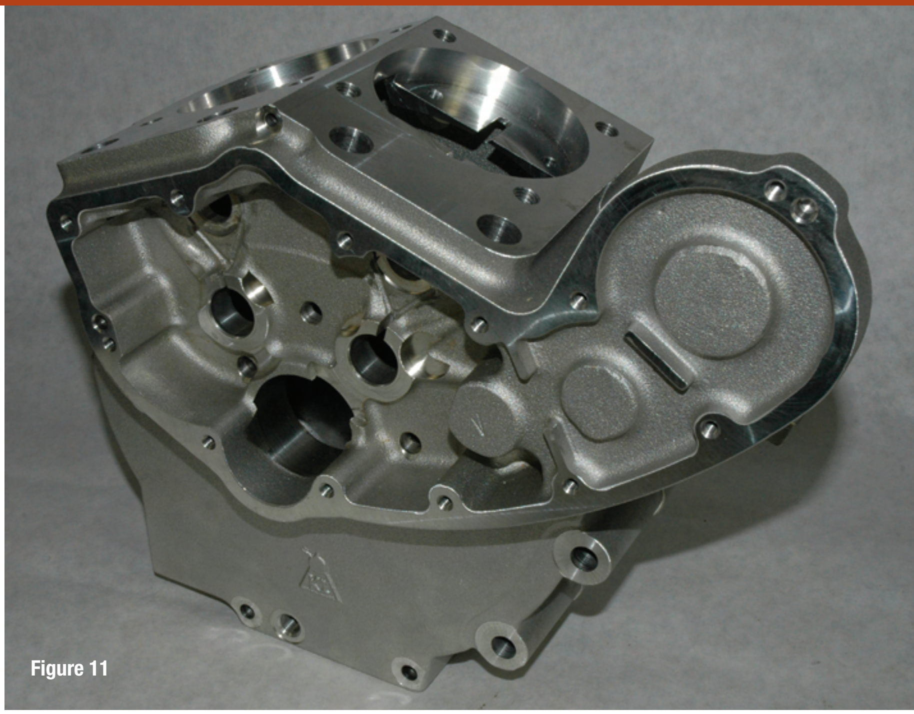
Figure 11

Flywheel, Connecting Rods and Cylinders

Flywheels are made from cast steel with a finished weight of 23 lbs per pair before assembly (see Figure 12). Shaft tapers are held into position with a 6 degree taper and nut (see Figure 13). Connecting rods have been upgraded to a forged H Beam design made from 4340 and are a male/female forked design with hardened bearing inserts that are honed to size. Rods running on four rows of ¼" diameter rollers held into position with retainers on a 1" crankpin (see Figures 14, 15 and 16). Crankpin rollers range in size from .249" to .251" in .0005" increments in order to arrive at the clearance of between .0005"-.001" (see Figure 17). Rod end float of .010"-.020" between the flywheels is achieved by fitting thrust washers which range in size from .047"-.072" (see Figures 18 and 19). Flywheels are aligned to within .0005".

Before fitting pistons to rods, pre fit the cylinders to the cases and adjust the valves just by feel. Now rotate the engine over to ensure there is no binding in any of the valve train and pay attention to valve spring coil binding. If spring coil binding occurs, spring breakage will result.

The flywheel pinion and drive shafts are also supported on the same ¼" rollers. The pinion shaft has two rows while the drive (output) shaft has four rows.

Rod races and pinion/drive housings are made from 52100 material heat treated to Rc60-62 while shafts are made from 4620 material making the lower end bullet proof.

The thrust washers which are heat treated to Rc 60-62 come in sizes of .047", .057", .062" and .072". One starts off with the thinnest thrust washers, pre assembles the flywheel assembly to check its end float, and flywheels are then pulled apart, reassembled with the appropriate size thrust washers and rechecked. There are variables such as taper depth in the flywheels, crankpin taper length which involves custom fitting each set of flywheels. Nut torque is 100 ft lbs. Once end float has been achieved, the flywheels must be aligned which is where old fashioned skill is required. This is accomplished with a lead hammer and a block of wood whacking the flywheels in the appropriate place. Acceptable alignment is to be within .001" per side but we aim for .0005" or less. Balancing is done prior to these steps and is done the old fashioned way by calculating the reciprocating and rotating weights. Balance factor of 60 percent works out nicely.

I find the balance is to get additional performance without sacrificing durability and reliability. The customer has to be happy and what makes him/her happy is that the engine keeps on performing day in and day out trouble free. In the end the engine has to go the distance for the customer. Miles of smiles is where it's at.

Cylinder Tech

- Ring end gap: .015"-.020"
- Piston to wall clearance: .0035"-.0045". This depends on the type of piston, manufacturer and skirt coatings. Kiwi pistons are measured a little up from the bottom of the skirt.
- Pin clearance: In rods .0005". Hone bushings to size. Do not ream
- Cylinder bore finish: 240-280 grit
- Sleeve interference: .003"
- Sleeve protrusion: Below cylinder base flange is 7/32"
- Cylinder base nut torque: 30-35 ft lbs
- Head bolt torque: 55 ft lbs

Boring cylinders: Always register off the cylinder base flange surface as this is the master machined surface. This will then put everything in its correct axis. We use a torque plate that the cylinders are bolted to before boring and honing to simulate them being fitted to the engine so as to ensure accurate bore sizing.

Helpful hint prior to cylinder fitting: Do a pre cylinder fit up to the crankcase with the pistons not installed in the cylinders but with the valve assembly installed. Adjust the tappets and turn the engine over slowly to ensure everything has clearance. Pay close attention that the cam followers

Figure 12

Figure 13

Figure 14

Figure 15

"…the balance is to get additional performance without sacrificing durability and reliability."

Figure 16

Figure 17

Figure 18

Figure 19


Figure 20

clear the case at full lift especially the rear exhaust however this test should be carried out with the cam cover off and no pressure is on the valve train. Also make sure the valve springs do not coil bind. Basically this is just a pre test run to catch something that may have been accidentally over looked.

Head Gaskets and Surfaces

Pay close attention to the head, cylinder and washer surfaces. We highly recommend resurfacing these areas. The weak spots in each gasket are the front and rear center bolts (the bolt holes opposite each other where the valve pockets narrow down to the combustion chamber) and the shallow area above the intake port track. This area develops a low spot starting at the inner edge closest to the cylinder and widens out towards the intake manifold nipple and can consume two-thirds of the surface sealing area over time (see Figure 20). Blown head gaskets are a common weak link with Indians however by taking these precautions and using top quality gaskets you will greatly eliminate the chances of a blown head gasket.

The head gasket that we have had best success with is the solid copper type which has lasted longest against a cast iron cylinder and aluminum head. The most recent revision will be incorporating some embossments into the gasket surfaces and a dual embossment directly above the intake port as this area develops a depression over time.

Head bolts & holes: Some cylinder bolt hole depths vary in the cylinders and some head bolt lengths vary as well so for this reason we advise checking the depth of each bolt hole by fitting a bolt into each hole and measuring its free length. Do NOT take for granted the holes being deep enough. Once in a while the bolt will bottom out at the bottom of its threaded hole and give the impression the head gasket is clamped under pressure when in fact it is not. This will cause a blown gasket.

Recommended Break In Procedure

1) Do not allow engine to idle too long upon initial start up. Preset timing and carburetion before starting. After doing an initial quick check to make sure oil is returning to the tank and no oil is leaking, redial in the carburetor and hit the streets as soon as possible.

2) After riding a short distance to properly warm the engine up, accelerate several times through the gears to about mid rpm. This procedure provides rapid seating of the rings to their cylinders. Do a short ride of about 25 miles and let engine cool down. Re torque head bolts. Next time do 50 miles and re torque and do likewise until 500 miles have

been completed. Retorque periodically after that. This depends on the type of head gasket you are using as some settle more than others. We suggest doing very regular head re torquing since it's an easier process than changing out head gaskets. James 75378J Multi Layer Steel and James copper head gaskets settle very little if any. Each time check spark plugs for correct color. They should be a light tan color if the fuel mixture is correct. Spark plug readings should be done as soon as you come off a ride (let bike cool down before removing plug). In other words don't sit in the driveway blipping the throttle as this will change the reading. Do NOT run the engine too rich at any time especially during break in. The extra gas will wash the boundary oil lubrication off the cylinder walls which will destroy your top end. Some old guys say to run them rich in order to help keep the cylinders cool however this does more harm than good and will take out your top end.

3) Avoid operating engine at prolonged high speeds and lugging as overheating and over stressing may cause ring scuffing and piston seizing.

4) Vary speed when riding. Do NOT ride at a constant speed. Acceleration allows the rings to bed in while deceleration allows the rings and piston to cool down from the cool incoming fuel charge. A warm day is better for breaking in rather than a cold day (yes this is a correct statement). A cool day restricts the amount of expansion of cylinders which under certain conditions can increase the chances of a seizure.

5) Use straight 50 wt oil for breaking in. Breaking in is usually pretty much complete by 500 miles but still go tenderly until 1000 miles have been reached.

After 1000 miles you can pretty much ride it like you stole it. NEVER ever run non detergent oils in your engine at any time as this WILL destroy your engine.

Change oil after its initial 50-100 miles of initial break in. Always use the internal Kiwi KI-10605 oil filter. This is most important and will catch any break in debris without restricting the oil flow.

Oil burning: For items and checks that might cause oil burning or leaks other than possibly a top end overhaul check the "Oiling sections" e.g. oil pumps, breather, etc.

Basic Engine Specifications

- 74" (1200cc) 3.250" bore, 4-7/16" stroke
- 80" (1320cc) 3.250" bore, 4-13/16" stroke
- 84" (1400cc) 3.250" bore, 5" stroke
- 88" 3.250" bore, 5-1/4" stroke
- 92" 3.250" bore, 5-1/2" stroke
- Shaft nut torque: Kiwi and Z metal flywheels 100 ft lbs, cast iron 75 ft lbs
- Housing Interference: Pinion and drive .002"-.003".
- Rod Race Interference: .002"-.003".
- Connecting Rod Side Play: Male to female and female between flywheels. 010"-.020"
- Roller Clearance: Crank pin .0005"-.001"
- Roller Clearance: Pinion and drive shafts .001"-.002".
- Flywheel End Play: Between cases, dry (no lube) with engine sprocket off .015"-.020".
- Flywheel End Play: With engine sprocket on, dry and no cork washer fitted. 005"-.010" (see Cork washer tech).
- Flywheel Run Out: Maximum shaft run out is .001" per side, .0005" is preferable.

BY MICHAEL TOMAS

Engine Assembly Tips

Engine sprocket cork washer: After installing cork washer into engine sprocket, sand cork on a flat surface until it is JUST proud (.001”-.002”) of the sprocket. This is extremely important as it will decrease flywheel end float and cause the bottom end to lock up.

Heat Cases: Whenever removing or installing anything in aluminum, it is important to ALWAYS preheat the aluminum to 250 deg F. NEVER fit or remove races in cold aluminum.

22-47 Pinion Housing: Press into case until it bottoms out against its thrust washer making sure the thrust washer is in the pinion housing counter bore. Check carefully. By using 22B19T tool to press in pinion housing it also locates the thrust washer properly.

48-53 Pinion Housing: Press in until it protrudes .020” above crankcase surface. Use 504006T tool as this allows for correct housing protrusion.

Drive Housing: 1920’s models had different drive housing with no retaining nut threads however they should be retrofitted using the later style 40871 housing and 28B161 nut as this will not allow the housing to move during service.

Original Flywheels: These come in 2 different metal variations. “Z” metal and cast iron. “Z” metal flywheels have a “Z” cast into them and are the most desirable of the original flywheels. If you have cast iron flywheels (no “Z” cast into them) it is strongly recommended to upgrade to either “Z” metal or new Kiwi flywheels. Cast iron flywheels have a tendency to break. Note that cast iron flywheel shaft nuts carry 25 ft. lbs. less toque rating.

Drive Shaft Length: Before assembly double check the drive shaft length along its 7/8” diameter length (from tip of taper to tip of taper, not its overall length). Chief is approx 2.200” long while Scout is approx 2.450”.

Shaft & Flywheel Tapers: Check used flywheel tapers for damage or low spots. If low spots exist it is recommended to replace the flywheels. Tapers must be lapped to their mating shafts with a fine lapping compound. No lapping is required when using new Kiwi flywheels. Upon final assembly do not use oil on tapers. Tapers must always be fitted completely dry.

Flywheel Shaft Shoulders: Make sure shaft shoulder area (area where taper and threads meet) are below the flywheel surface. If shaft shoulder protrudes through flywheel, the nut will bottom out on the shaft and it will not be held securely into its taper.

Shaft to Flywheel Keys: Ensure the keys have clearance between the shaft seat and the flywheel. If there is no clearance the shafts will become cocked and truing will not be possible.

1920’s Flywheel Assembly Upgrades: Late model 74” Chief flywheels, rods, pistons and valves will interchange with early models.

Non Kiwi Flywheels: Some brands usually come without timing or TDC marks. It will be necessary to place marks correctly prior to assembly. Kiwi flywheels are supplied with the correct markings.

Kiwi Flywheels: Kiwi flywheels come with the thrust washer dowel pins not installed. The reason for this is once in a great while in some old odd original cases the narrowest (.047”) thrust washers cannot be used. By not having the dowel pins installed one can then machine the thrust washer recess in the flywheels deeper to allow for use of .047” thrust washers. We recommend doing a pre-mock up fit with the flywheel assembly WITHOUT the dowel pins installed and with the rods on the flywheel and the flywheel in the cases. Some cases maybe out of spec from the factory so for this reason it pays to take this precautionary step.

Replacing Damaged Dowel Pins: Grind old dowel pins flush with surface. Fit thrust washer into its recess and drill a new hole using the thrust washer as a template. Drill hole undersize using the drill bit provided with the 28B308T dowel pin hole reamer kit. Once drilled use reamer to final size the hole. Press in new dowel pin but first make sure no oil or fluid is in this blind hole otherwise dowel pin will hydraulic (stop short) and it will not budge. Dowel pin should not exceed. 045” above t/w seat since the thinnest t/w is .047” (this gives .002” clearance). Make sure original flywheel dowel pins do not sit higher than the thickness of the thrust washer, check closely.

Thrust Washer Seats: Make sure thrust washer seats properly. Before end float can be measured, the flywheel thrust washer seats must be free of any burrs, grooves and are to be perfectly flat. Sometimes the dowel pin locations are not 180 degrees apart on original flywheels therefore the thrust washer notches have to be widened. Check seating very closely.

Check Flywheel Oil Ways: After assembling the pinion shaft in the flywheel blow air through it to ensure the oil ways are properly lined up. Do likewise with the crankpin. After your lower end has been fully assembled, pump oil through the pinion shaft with an oil can and observe oil flowing from the crankpin. This will ensure that all oil ways line up and oil flow will not be restricted.

Aligning Flywheels: This is an acquired skill and should be left to someone with experience. Flywheel shaft alignment is to be within .00” however .0005” is preferable. When truing flywheels it requires solid hits with a lead hammer (flywheels sitting on a block of hardwood) since anything else will damage and leave marks on the flywheels. Don’t even think of using another type of hammer. It does take great skill to properly fit, balance and align flywheels. Exercise caution because during operation flywheels are turning at a high rate of RPM’s and extreme forces are at work. Anything overlooked or not in proper spec will have severe implications.

Aligning Flywheels Between Centers: When aligning flywheels between centers, do NOT tap wheels while they are still being supported between centers. This can result in a broken or bent pinion shaft.

Piston Pin Diameter: The correct diameter is .750”. Pay close attention as some replacement pistons on the market come with 19mm diameter pins which is .749” (.001” smaller).

Valve Guide Added Lubrication: Some engines may require added lubrication to the pushrod guides and valve guides. The exhaust guides can do with more lubrication so it may be necessary to drill a 1/8” diameter hole in the crankcase approx 1/4” directly under the exhaust push rod guides. Some engines will require a hole to be drilled under the intake pushrods as well.

Sump Oil Scraper Pickup: This was used in 1947 and in early 1948 models. We strongly recommend to retro fit earlier sump pick up style engines with this scraper. It does require a little crankcase machining however this is easy and self explanatory if you use the scraper as a template. It is recommended to do this modification at the time of engine overhaul. The clearance between the flywheel and scraper is to be 1/32”.

Magneto Hole Plug: Always replace this plug at time of overhaul. When removing this plug, support the surrounding area otherwise case damage can result. This plug must be expanded once it is fitted in order to work properly. Apply sealant before fitting plug to case otherwise an oil leak will exist.

Magnetic Drain Plug: When fitting magnetic plugs to crankcases make sure they do not bottom out against the flywheel which can happen in some rare occasions. Kiwi magnetic plugs are of a very high grade and do not degrade with heat. Not all magnetic plugs are created equal. Do not be alarmed with some light metal fuzz found during the initial engine break in as this is normal. Magnetic plugs only capture metallic particles so aluminum, carbon and other particles are left free to roam therefore a filter should be used. Use the Kiwi internal oil filter (p/n KI-10605) which fits inside the oil tank. This filter works and it will increase the life of your engine. If you have any doubts cut it open after some use and you will see firsthand. Indian engine oil DOES need filtering just like any other engine.

Check Case for Defects: Carefully and thoroughly inspect the cases all over. In some cases the left or right cases have been changed out and become mismatched. This can create some alignment problems with the bottom end and cylinder surface area. Check the small triangular area between the cylinders where the #10 tie bolt goes through. Sometimes this hole is not centered and breaks through the sides into the cylinder spigots. When this happens, an oil leak will develop. Sometimes it may be necessary to correct with a high quality type plastic steel (Devcon) or welding (if welding, be aware of distortion). In some real bad cases it will be necessary to seal the #10 tie bolt and hole with a high quality sealant at the time of final assembly. Whatever the case is, check this area very closely and correct it. An oil leak here is impossible to fix afterwards.

Michael Tomas was born and raised on New Zealand’s (North) Island in the small town (1500 population) of Wellsford in 1960. He started his apprenticeship in automotive machining after completing his secondary education at Rodney College in Wellsford at the tender age of 16. In 1988, Mike’s passion for classic Indian Motorcycles drove him to start Kiwi Indian Motorcycle Company in Riverside, California. His intent was to satisfy the need for high-quality American-made products for the classic Indian market. Kiwi Indian grew so quickly that Mike moved into a larger 2,400-square-foot facility only two years later. It was only ten years until the business outgrew the building again, when he purchased and opened his current 11,000-square-foot facility. For more information, contact Mike (Kiwi) Tomas, Kiwi Indian MotoCycles, Riverside, CA. Call (951) 788-0048 or go online, www.KiwiIndian.com.