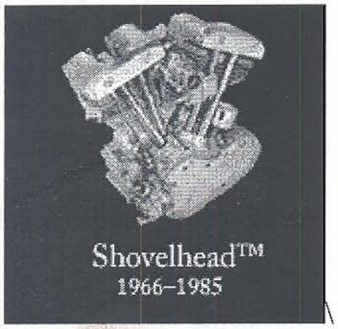
SHOVEL..............TECHNICAL SECTION



Shovel Tech

Shovel-U-tion

Points To Ingition

Pan-Shovel

Shovelheads

Part 1.

Part 2.

Part 3.

Please read disclaimer at the end of this article, thank you.

Shovelheads

Donny:

I just bought a Shovelhead. All the parts seem to be mixed up. One head has a short reach sparkplug while the other has a long one. One cylinder has a hose running from its base over to the guideblock while the other doesn't. The base of one cylinder is thicker than the other one and on it goes. The transmission is the wrong year with mismatched primaries'. The bike seems to run okay. What's going on?

Compilation of questions from newly purchased Shovelhead owners. Yeah, I know. The Shovelhead was the last Harley that every owner seemed to work on never mind their level of knowledge and expertise. The advent of the Evo required the first special tools like torque plates, closer tolerances and a less forgiving engine for amateurish mistakes. The Evo marked a major shift in the type of person riding a Harley. Most owners stopped working on their own bikes. The Shovel was and is a forgiving engine for error that would cause any other engine to blow. As a result many knowledgeable back alley wrenches became accustomed to swapping different year parts and adapting them often quite successfully when doing repairs or ground up builds. Let's examine what happened between 1965 and 1984 with the Big Twins.

Major Innovations

The last year of the Panhead in 1965 was indeed comprised of a strange concoction of new changes foreign to what went before. With a major change like going from the Panhead to the Shovelhead major modifications are quite often made a year or more in advance. Changes that are less dramatic are made in the last 1/2 year before being permanently incorporated the next full year. It allows Harley to have a test period to ensure that everything is as it should be. This change to the Shovelhead and in particular the electric start was Harley's first major stab at appealing to a broader mainstream audience to ensure it's future success. This was followed by a more successful mass audience appeal through innovation, technology and reliability with the advent of the Evo in 1984, the Twin Cam in 1999 and the V-Rod a few years later. Later on we will see a slew of innovations in the last few years of the Shovel being used as a test bed for the introduction of the aptly named Evolution.

The Electric Start

With any major change in design a domino effect occurs. One change leads to another, which necessitates another. The electric start was incorporated into the '65 Panhead. This led to a frame configuration change to allow a different oil tank fitment in the first Shovel in 1966. The modification was necessary to incorporate the large powerful battery required to turn over the engine. The big battery necessitated the change away from the 6-volt system used in 1964 and earlier models to a 12-volt electrical system with a 2 brush 12-Volt generator and a mechanical regulator. The stamped tin, total oil loss, primary covers were basic shrouds to protect the clutch and primary chain from the elements and road dirt. The electric start components were heavy and required support. The electric start motor and housing needed a rigid, strong brace. The bendix, (jackshaft), drive shaft required immovable support on either end in order for the bendix to slide into and turn the ring gear affixed to the outer clutch hub inside the primary system. The turning ring gear turned the clutch hub, which rotated the primary chain; therefore rotating the engine sprocket and in turn the engine. Tin primaries would twist and break sooner rather than later. The heavy aluminum inner and outer primary covers fulfilled the strength and rigidity requirements. The inner acted as support for the starter motor and housing. The starter housing acted as support for one end of the bendix drive shaft while the outer primary ably supported the other end. The shaft rotated easily and securely on caged needle bearings on either end. The inner acted a dual role by supporting the starter solenoid, which engages the bendix gear into the ring gear and allows it to disengage when the finger stops pressing the starter button. The rigidity provided by the inner primaries is well documented in other articles on the Twin Cam 88's. The Twin Cams attached the engine to transmission to ensure no flexing whatsoever. The sealed primary system allowed for the first controls on oil emissions that drive most vehicle design changes today.The oil feed to lubricate the primary chain was now returned to the engine for further use rather than merely dropping to the ground to "mark its spot". This first attempt presented its own problems since the grating chains and sprockets, wearing fiber clutch plates and plastic chain adjuster created a great deal of debris being funneled back into the engine. The "camel hair" oil filter in the oil tank was capable of stopping small rocks but not much else. That is if debris-laden oil didn't flow around the outside of the filter canister missing the filtration process altogether. In 1980 on the Shovel FLT rubbermounts and in 1982 on the FLH and FX rigid mounts, the first folded paper oil filters were used with tremendous success. Now the size of debris allowed through was measured in microns, (one millionth of a meter). The filtering process has gradually improved since then to filtering anything larger than 30 microns in the Evo and 10 microns in the Twin Cam.

The Venting Process

The internally moving engine parts particularly the ascending and descending pistons constantly displace air inside and immediately outside the engine. The oil gives off gaseous materials, which mix with the air. This oilified air must "vent" or go somewhere. Knuckles, Pans, early Shovels, and Iron XL's simply had a hose or fitting running to the outside atmosphere always near the bottom of the engine. If some oil came out with the piston-displaced air or the vapor was an oily mist it was no big deal since it was a dramatic improvement over what went on before with partial and total loss oil systems where oil was deposited on the ground once used. Late-model Shovels, Ironheads and early Evos, (up to 1991), had their vent hose directed up to the carb breather where theoretically the vapors are drawn into the combustion chamber and burned. The use of gravity to help separate the heavier oil from the lighter air also assisted unless for whatever reason, the bottom end had too much oil residing in it's bowels. With this scenario, some of the oil will go up to the breather and either flow out all over the motor or be drawn into the engine, causing a temporary smoking problem as the oil burns. This did not bode well for Harley, as dispelled oil in whatever form was becoming a big issue environmentally.

The Short Valve Guide Venting Fiasco

In late 1979 some rocket scientist at the Factory decided to bore out the valve guide holes in the Shovel heads to accept a fatter valve guide. The previous thinner but longer guides worked fine from 1966 on the intake side and since 1951 on the exhaust side. The new guides were shorter and the metallurgy was changed to cast iron. The valve stems were also hardened to a greater degree.

Smokin'!

The oily mist inside the rocker boxes began working its way down the shortened valve guides and burned in the combustion chamber producing blue and white exhaust smoke. The new metallurgy also began to wear out prematurely exacerbating the smoking problem. The rocket scientists couldn't believe that their ingenious design changes could be at fault so they decided there must be a venting problem where one did not exist before.They felt that there was too much oil accumulating inside the rocker boxes. Furthermore the theoretical venting deficiency wouldn't let enough oil bleed away via gravity downwards through oil return channels. It never occurred to the brain surgeons that all was well before. They designed new additional vents into the engine.The cylinder bases were drilled, threaded and hollow fittings installedLikewise for the base of the tappet guide blocks just below the pushrod tunnels. A hose was attached from the front cylinder fitting to the front guideblock fitting thereby connecting a vent between the bottom end of the engine and the top end. The pushrod tunnels offer lots of venting up into the rocker boxes while the hole bored into the cylinder base connects into the bottom end cavern. The smoking continued.Ahhh! Valve guide seals would surely fix the problem although none were required before. The initial seals worked for awhile but then the smoking started again. Oh yeah, use automotive seals designed for cooler water-cooled engines. Some of these guys stayed in school too long.The hotter air-cooled Harley engine baked the soft rubber seals into hard non-functional ones. By 1982-1983 all was well again with functional seals on guess what....slightly longer valve guides. This also required modified valve springs. Just to be safe the Factory also incorporated additional drain lines from the rocker boxes. The engines stopped smoking. In 1984 on the Evo engines, Harley went back to thinner guides that were also longer although they kept the seals. By mid-1980, the aftermarket high school dropout wrenches that knew their beloved Harley's like the back of their hands easily fixed the initial short valve guide smoking problem. The aftermarket made metallurgical compatible guides and valves. They made the fatter guides just as long as their predecessors and eliminated the valve guide seals.We still use these Ampco 45-bronze valve guides today in late-Shovel rebuilds with no valve seals with nary a problem in the last 22 years. Harley warranty at the time was 3 to 6 months on rebuilds. We have always given a full year since if it is done right there will be no problems. However if the reader prefers using seals, they are still available and work well.

Increased Cubic Inches in Late 1978

All Shovelheads from 1966 to early 1978 were 74 cubic inches or 1200cc. In late 1978, the Motor Company increased the FLH models to 80 cubic inches or 1340cc. Interestingly, the FX, FXE and FXS Lowrider stayed at 1200cc for 1978. In 1979 the FLH Electraglide in both citizen and police models were offered in both 1200 and 1340cc configurations. The FLHC Electraglide Classic was offered only with the larger engine. The 1979 FXE Superglide and the FXS Lowrider were offered with both engine sizes while the FXEF Fat Bob exclusively offered the larger engine. It was still possible to obtain 1200cc engines in at least 3 models in 1980. In 1981 the transition to the 80 cubic inch engine was complete and the venerable 74 was permanently discontinued to many riders dismay.

Bore and Stroke

The 1200cc engine had a stroke of 3 31/32" and a cylinder bore of 3 7/16". The 1340cc Shovel's stroke was increased to 4 1/4" while the bore increased in diameter to 3 1/2" The increase in bore does not affect reliability whatsoever since piston speed is not increased. The increase to 3 1/2" was almost equivalent to boring out the 74 cylinder to .060" a safe rebuild modification. Harley made new cylinders for the 80 cubic inch. They were more rigid in that longer cylinder base studs were used to accommodate a much thicker base. The new cylinders could be bored out to .40" oversize for rebuilds. The engine case spigots, (holes) that accepted the cylinders remained the same size. Stroke relates directly to the distance the piston travels from bottom dead center, (BDC), to top dead center, (TDC), in the cylinder and is referred to as "swept volume". The stroke is determined by where in the rotating flywheels the crank pin is positioned. Suppose, for argument's sake, the crank pin that supports the connecting rod bottom end roller bearings and the connecting rods themselves which attach to the pistons via a wrist pin was positioned in the crank, (flywheels), center. In this scenario the piston would not move at all in the bore since the crank pin would rotate with the flywheels but not move from its centerline. The crank bearings would roll inside the connecting rod races but would offer no directional rotational change which would otherwise pull the connecting rod down and then push it up creating a swept volume. The further away from the center of the crank or alternatively the closer to the rim of the flywheels the crank pin is positioned the longer the stroke or how far up and down the cylinder bore the piston moves. The piston in the 1200 moves up their respective cylinder bores on the compression and exhaust strokes a total of 3.9687, (3 31/32"), inches and then correspondingly moves down the same distance on the intake and power strokes. The piston in the 1340 Big Twin moves up their respective cylinder bores a total of 4.250, (4 1/4"), inches and then correspondingly moves down the same distance on the opposing strokes. The four strokes compromise two revolutions of the engine or one complete cycle of bringing the air/gas into the combustion chambers, burning the mixture creating pressure driving the piston(s) down and then expelling the burnt gases. The longer the stroke the more power is created as a larger swept volume of air/ fuel mixture is produced. Increasing the stroke to 4 1/4" is perfectly safe and is as reliable as the shorter 74 stroke. Stroking increases beyond 4 5/8" starts to create reliability and longevity problems because the piston speeds increase exponentially.

Connecting Rods (see correction at the end)

Connecting rods stayed the same length all the way from 1941 to 1973. From 1974 to early 1983 they were slightly shorter. In order to compensate for this, piston wrist pin locations were changed and the skirts made a little shorter. In this way the piston domes wouldn't collide inside the combustion chambers and the skirts wouldn't hit the flywheels. During these years compression ratios were gradually lowered from 8.5:1 down to 7.4:1 on the 1981 80 cubic inch models. This is a long way from the 10:1 pop-up pistons we installed in the seventies but gasoline compositions and octane additives were changing to accommodate newer emissions friendly combustion chamber designs. The Shovelhead was becoming a dinosaur in its own time. The lower compressions also brought less power but were necessary for engine longevity. In 1983 preparing for the Evolution engine's introduction a slightly different shaped connecting rod design was introduced. This increased engine longevity by side thrusting stress reduction. Retrofitting these rods into Shovel rebuilds is a nifty move that astute engine builders will incorporate.

Engine Bearings

Early bottom end bearings that rolled between the crank pin and the connecting rods were used from 1941-1972. They were comprised of 6 cast iron cage halves and 54 needle rollers. Eighteen rollers fit into each set of 3 complete cages. One cage and rollers serviced the male connecting rod, which fit between the two forks of the female connecting rod. Hence the vernacular for male and female rods. In 1973 and later models the number of rollers were reduced to 51 with 17 servicing each connecting rod fork. They were also a little shorter than their predecessors. At the time we all thought the new style introduced to create planned obsolescence but the reality is they are far superior. The old style had more bearings plus more bearing surface since they were longer to service the bottom end. We used to retrofit the older style in the newer engines until we got hip. The reason for less bearings and reduced bearing surface was increased support. The newer aluminum cages were one piece and designed to reduce bearing side drag. The newer bearings were guided to roll straighter in their bore. The older longer bearings were inside cage halves that could shift a little back and forth. This would allow the bearings to cock a little and thereby not be rolling straight and square within their bore. This sidedrag causes premature wear since parts are working against themselves. The pinion shaft bearings inside the right crankcase from 1958-1986 also had loose rollers in cast iron cage halves. The 1987 and later rollers were again shorter but supported in one-piece cages for the same reasons. Sprocket shaft end bearings support the left flywheel shaft as it protrudes through the left side engine casing. Their second function is to set endplay for the flywheels. The endplay goal is to have the flywheels sitting in the middle of the cases so that the connecting rods and pistons are in the center of cylinder bores. The two tapered Timken bearings are press fit onto the sprocket shaft while the two tapered races are press fit into the left engine case half. A spacer separates the races and another spacer fits between the bearings. These spacers determine fitment of the tapered bearings into their mating races. Too tight and the bearings burn out. Too loose and the bearings flop around a bit. Either way they wear out prematurely. The spacers also determine the endplay so the flywheels are held in one position as they rotate. There are two main styles of ready for the future.

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This is an addition to the Con Rod section above: I had originally made a mistake, which has been corrected.

Computer Slip up.

Donny states in the October 2002 issue of Techline that the 1974 to 1983 connecting rods were longer. My 1981 issue of "What Fits What" by Mike Arman and Kurt Heinrichs states that these rods are 0.030" shorter and that the wrist pins were relocated a like amount. Can you verify this?

Connectiung rods

I apologize. I got it backwards. Good thing I always have it frontward when building an engine. Any good wrench always checks tolerances to catch a slipup like this. I obviously do not possess the same skills on a computer The early rods which are 1973 and earlier are indeed .030, (approximately 1/32 of an inch), shorter than the correspondingly longer 1974 and later con rods. 74 If using the earlier shorter rods with the later pistons, which have their wrist pins, relocated the result will be a reduction in compression. We will sometimes do this in order to cure pinging, (detonation), problems When using the longer rods with the early pistons, compression will be increased. Tolerances must be double-checked in both scenarios.Valve to piston, skirt to skirt at bottom dead center or skirt to flywheel tolerances must be measured depending on which combination is used. In my opinion, increasing compression on a Shovel is not desirable anymore . The combination of current "lean" emission fuels combined with the hemispherical combustion chamber only leads to detonation problems. Detonation is the great engine destroyer. Over the years we have taken apart hundreds of stock Factory Shovels. In most instances they had the correct combination of con rods and pistons. But we have also found both of the above "wrong" combinations used. You have to understand Harley changed stuff around in these years without telling anyone...If the Factory found themselves with a surplus of extra parts, they would sometimes be used. This may have caused warranty problems in some cases but the assembly line workers of yesteryear were very mechanically inclined and knew their beloved Harleys inside and out. They could make these changes with their eyes closed. Have any Shovel riders reading this ever wondered why one seemingly identical FL or FX was way faster or slower to another? Look no further than different combos of con rods and pistons. The high compression bikes were way faster and the low compression ones were way slower.

Donny Petersen

As submitted to American Iron Magazine.

this. One used from 1955 to 1968 and the other used from 1969 and later. Harley dicked around with end spacing numerous times after 1969 which led to different part numbers but they are basically all the same within a few thousandths of an inch. Competent mechanics don't trust preset clearances anyway. They always check to get the end-clearance they prefer through experience.

Ina vs. Torrington Cam Bearings

In the seventies the Factory replaced Torrington caged roller bearings for roller caged Ina bearings. Theoretically this is a great idea but it didn't work out in practice so Harley went back to the Torrington bearings. Differing work loads and stresses dictate the use of different type load capacity bearings. For example, the Ina style cage needle roller bearings work better than anything else on the 5-speed trannie shafts. Deja -vu with the Evos where Harley insistently uses the Ina camshaft end bearings. Harley had many failures with these bearings but always placed the fault on other things. Crane for example supplies Torrington bearings with their cams to ensure the stock Ina ones are replaced. We always replace them with the tried and true Torrington ones as our experience dictates that the Ina design is not up to speed in this particular application. In the Twin Cams we also replace the now larger Ina camshaft end bearings with a correspondingly larger Torrington one because our experience shows adverse wear is evident even at lower mileages.

Conclusion

I thought this article was going to be a snap. Turns out there are a few things I didn't know. It also turns out that it is a much deeper subject than I thought. Next month we'll be looking at Shovel oil pumps, combustion chambers, valve seats, valves, guides, timing gear backlash and carburetors. It's quite remarkable that I thought things never changed with Shovelheads. After writing this and the next articles I have realized that Shovelheads were a period of change for the Factory as they tried and adopted many new designs in getting