I had an Axtell 80 cubic inch motor built for my 89 FLHTC. This interview with Axtell's Ron Dickey convinced me this was the way to go.

An Interview with Axtell's Ron Dickey

PSP: You're known for your big motors, but you also build 80 cubic inch engines. What makes yours different?

We cut a shelf in the cylinder head to accept our high top pro/street piston. This improves the air flow in and out of the cylinder and it also raises the static compression up to a livable 10 to 1 from 8.5 to 1.

PSP: Why is this better than what Harley does?

Harley has a flat shelf and ours is 30 degrees off the same plane. The flat shelf works well at mixing gas but it is obtrusive in letting the fuel flow in and out of the cylinder.

PSP: Is there a good reason to do use the flat shelf?

Yea, it gives an extremely good burn. A flat top piston gives you the least surface area exposed to combustion heat and there is an advantage to that. For the power output that Harley thought was adequate, that's a good way to do it.

PSP: How the fuel burns in the cylinder is important. How does your set-up help?

Quench or squish is mechanically pushing the gas back toward the center of the cylinder from the outside in order to get a good burn. We feel the 30 degree angle is less taxing on the octane rating of the fuel than the flat shelf.

PSP: So you changed the shape of the piston and the cylinder head. What does this make the engine do better?

We're doing the same basic amount of mechanical squish, but we're doing it in a way that is putting less pressure on the engine. Too much pressure can cause detonation. We're providing an easier in and out flow path through the cylinder heads. Instead of tumbling over the stock shelf in the head on the intake side, now the gas can come in and slide along the 30 degree shelf before being forced back into the flame front.

PSP: You changed the piston to match the head because the in and out flow is smoother and increases power?

Yes, but it's a two part deal, you gotta do both. Well, I guess you could cut the head and run a flat top piston back in, but you wouldn't have any squish, no two pieces of metal close enough together to drive the gas back out to the center of the cylinder and create turbulence.

We're not doing it strictly for the compression, although compression helps because we're pushing the molecules closer together at 10 to 1 than we are at 8 to 1. But, the easiest way to increase compression would be to put some extra metal in the open part of the head. We don't feel that is the best way because you've put an obstruction in the flame thrust. You're asking it now to squeeze out of a flat chamber, run over a little mountain, and go find the flame front. That taxes the heck out of the octane rating of the fuel because you're asking the fuel to flow out, but you've put something in the way. So what we've done is to retain the squish and the turbulence without aggravating the mixture any more than we have to because it's this aggravation that causes pre-ignition or detonation.

PSP: Because you're treating the mixture better and getting more turbulence, you can significantly increase compression without getting detonation?

Exactly, we found that with increased turbulence, we could raise the compression more, and so did Harley. If you look at a shovelhead, there was no active squish in the chamber, you got turbulence in and out, but nothing to help in the chamber. Harley went the other way in the Evo and put in a lot of turbulence, while making the chamber smaller. Shovels had an open hemi-head and pretty large valves. You look at an Evo and its got a smaller more compact chamber with smaller valves and we all know which motor runs the best. So Harley decided that efficiency is more important than breathing. They found out that it was better to make the chamber smaller, kick up the valve angle and make them smaller to get a more complete burn. What we're trying to do is maintain the same amount of squish, put in a little bigger valve and get the head to flow better as well.

PSP:: So what does all of this do for engine durability?

Good question. We use a forged piston, so it's stronger and that alone should allow it to last longer than the cast piston, which is pretty long lived itself. A guy running down the road at 65 m.p.h. may be making 15 horse power, all bikes should be happy at 15 horses, so this motor should last as long as stock. The difference is if you want to "hot rod" the motor, these pistons will hold up better...

PSP: OK, but we've changed the shape of the piston and chamber so we can make more compression which makes more pressure and puts more strain on the motor...

You're clickin', you're clickin', but consider this, again if you're going to make 15 horsepower and go down the road, what are you doing? Basically, you're using your carburetor to throttle down the air to support X amount of pressure in the cylinder, so let's turn it into a pressure problem. Let's say that 300 lbs of pressure will give me 15 horses. Technically, we've raised the static compression in the motor so it makes more power, but since it'll use less throttle to make the same 15 horses, the actual cylinder pressure will be the same or less.

PSP: It sounds like what you've done, is to raise the efficiency of the motor without really making any major changes.

Absolutely, if you don't make the engine bigger and the power goes up, you've increased efficiency.

PSP: What do you recommend to the average guy out there who has 60 or 70,000 miles on his bike and wants a motor that will be dependable with good performance?

Probably to make sure that what he desires is what he really needs. I want to spend sometime with him and really find out how he wants to use that bike. Most people are talking horsepower and they really should be talking torque.

PSP: Why's that?

Well, more shops have dynos now and so they all try to make the most horses. What's important is how much torque does the motor make at 3,000 RPM going down the road. The thing is, the bike has gears. If you're making 100 foot pounds of torque at the crank, and your overall gear ratio has a 10 to 1 reduction, you're making about 1,000 ft lbs at the rear wheel minus friction loss. That's the stuff you feel in your butt. So, we'll go to the customer and ask what kind of bike have you got, is there an windshield on it, do you have a sidecar, do you ride two up, what type of riding do you do? We want to figure out what the customer really wants and then we'll explain what we think he needs, sometimes there's some education involved in this. We want to give him torque where he rides. Most people want power away from stop signs or power in the mountains, that's torque.

PSP: So what do you do to an engine to make more torque?

If you raise the cylinder pressure, you're going to raise torque. You can't raise torque without raising horsepower, but you can raise horsepower without raising torque. Let's say you've got 50 lbs of torque at three grand, if you can hold that same torque until six grand, you'll have a lot more horsepower. Horses are a function of time, torque doesn't have anything to do with time. So what we're trying to do is raise and prolong effective cylinder pressure.

PSP: Getting back to the customer, he's got 70,000 miles on his bike and bad base plate gaskets, is he better redoing everything at this point while the engine's down?

Yea, the bikes probably been running for six or seven years now, so yes, you're setting up for another seven years or another 70,000 miles. In your bike as an example, after 70,000, the rings showed they could go another 70, but the pistons said they were getting a little loose and mediocre on the ring seal. There was some carbon on the top that showed the engine was burning a little oil and the squish area was set-up too loose to be functioning much at all. It looked pretty good for 70,000 miles but it was ready for a rebuild.

Unless you plan to take the bike apart again next year, I can't imagine not taking a look at the pistons and doing something. At this point, you can set your odometer back to zero and its cost effective because you're already paying for the top end labor. I'd also look at all the bearings real close.

The bottom end is more important than the top, you can run a long time with bad rings, but not with bad bearings. They're the foundation. Don't short the bottom end, put your money there first, you can always fix the top later on.

I'd like to touch on torque a little more because it goes back to what the customer is going to do. We like to find out if a guy is flexible on gearing, because that's the easiest way to raise torque at the rear wheel. By raising the cylinder pressure, we're putting more force on that piston. We can do that as long as we don't run into detonation or step all over the octane rating. There's a limit on how much we can raise the pressure at low RPM, because there's a lot of time for detonation to occur. That's also where the guy drives, so if he says I want 20 % more power in my bike and won't do anything other than raise the cylinder pressure, we've got a dilemma on how to do that without detonation. If the guy really means "I want 20 percent more push at the rear wheel," that's a heck of a lot easier to do with a small gear change. An extra 50 foot lbs is hard on the motor but real easy on the gears.

Harley is turning their engines slower and slower trying to clean-up emissions, but that's taxing the beejesus out of the motor trying to develop more torque down low. You're basically trying to do more work with less and less mechanical advantage through gearing, this is like picking up a big weight on the end of an ever increasing board.

PSP: What you're saying is, you want to turn more revs not less because it's better for your engine?

Yes, because the amount of load on the cylinders would go down. There's no advantage these days to turning these things ultra low and by that I mean under 2500 RPM. There's a phenomena called "brunneling" where you get a pounding type impulse that will hurt the bearings, Timken has some info out on it. If you've got the Harley turning low enough and the inertia in the flywheels is down enough that it isn't the predominate force in the motor, then the piston is and that really pounds on the bearings. That's why you shouldn't set the idle real low. The more you bring the RPMs up, the faster the piston goes, but if the flywheels are designed right, and the stroke isn't overly long, the flywheels will have enough rotating force to smooth the motor out.

If you look at any motor that's really designed for torque, it's a big heavy motor. It's like a truck, big parts... big wrist pins, heavy cylinders... torque takes a lot of strength. If a motor is built for horsepower and RPMs, you'll see a switch over to lighter and smaller. We're taking a torque motor and we're telling you to rev it a little higher, which sounds kinda alien, but all I'm saying is you're cruising down the road at under 2,500 RPM and then you ask your motor to quickly do more work, such as passing a car, that's not a happy motor.

PSP: What are the important things you need to look for in a carburetor and an exhaust system?

If it's adjustable for air density with a PSP:pered needle , that's a pretty good carb, you can adjust to the varying air conditions. But the main thing you need is a set-up where you can adjust the jetting right for one RPM range and it won't affect any others. So it needs to have a fairly complex set of adjustments on it. You know, most people seem to buy carburetors based on what the air cleaner looks like.

A lot of exhaust systems also are bought because of what they look or sound like, but that doesn't mean they're any good at making power. What we'd like to see people run on a high output motor is an exhaust that's big and long. We'd also like people to check the cylinder head exhaust gasket. They'll pay a lot for a high flow head and then put in a stock gasket that compresses down into the port and messes up the flow. One of the most important factors affecting motor output is the exhaust. An exhaust systems only real purpose, besides being a noise reduction device, is to help draw air through the carb.

PSP: What do you think of anti-reversionary pipes?

If you have to use an anti-reversionary pipe, you've either got the wrong cam or pipe. How pressure waves flow through a motor is real complex and difficult to explain. Basically, a high pressure wave will come out through the engine and a low pressure wave will go up through the motor behind it and if we time it right, that low pressure wave will reenter the engine in time to give the intake a pull while both valves are open, getting the charge in motion so we won't have to use the piston to do it. By putting in an anti-reversion cone, you've not allowing that wave to come up the pipe; you've piled it up in a collision with the cone. If the cone makes the inside pipe diameter smaller, you've also restricted that initial positive wave from the blow down cycle from getting out. Therefore the piston is going to have to push some of it out instead of letting the natural air pressure changes pull it out and that robs some of your horsepower.

So if you have a wave that is coming back up at the wrong time, say you have a 3,000 RPM flutter in your carburetor, you could put in an anti-reversionary cone to stop it and probably hurt the power at five or six grand, or you could lengthen the pipe which wouldn't allow the wave to get there at the same time and interfere or you could change the timing on the cam. Technically, the lower RPM you run, the longer the exhaust should be to maintain that wave.

Look at how long the exhaust system is on a Jap bike. You've got a 200 to 300 cc cylinder, you've got a large diameter pipe compared to the cylinder and it curves all the way down the front, around the engine and out by the rear wheel. Then you look at the average Harley with 650 to 850 c.c. per cylinder that some guy has put a set of straight pipes on and then cut them off at 32 or 36 inches, the wave is going crazy flying in and out of that motor.

PSP: So the common practice of cutting your pipe off isn't a good idea?

Well, you'll get a gain at top end because the pumping loss has gone down, but you've got a pressure wave that's going to come back into the engine a lot quicker. You could be lucky and have the wave go clear through the motor and come back into the carb at the right time, which would be an advantage. But the problem with a short exhaust is that you'll probably never get low speed drivability unless you restrict it with a muffler. And of course, the whole thing is a cut and try deal.

The main problem is most commercial exhaust systems don't have a big enough diameter, so they have high pumping losses, shortening the pipe works in that the bike will run better on the top, but the short pipes will kill the bottom and there's no where to go. If a guy will build a new big pipe that cuts the pumping loss down, then he can make it longer because there are fewer losses. The diameter generally will dictate how much horsepower a motor puts out and the length will dictate the torque, so a big long pipe will give you both.

PSP: You read stories of people spending thousands for fancy heads and not really getting much horsepower from them, why?

I think as long as we have the "Y" intake there is limit, you just can't ask the flow to stop, change directions and accelerate... stop, change directions and accelerate... it just can't do it. Again, if a guy hasn't done any work on the rest of the engine like the cam timing, pipes, jetting, the oiling system and the valve train, he's just not going to get it to rev up. So if he had a problem with say too much oil in the bottom end, which is like running in water up to your knees... it becomes a linear problem, the more you rev it up, the more horsepower it takes. He could put on a really good set of heads and see very little gain because of the parasitic losses.

PSP: So if you're not getting the power you expect from your carb and heads, the problem might be something else entirely?

Absolutely, there's a weak link there somewhere. Plus I have some problems with flowing cylinder heads and some of the results. To take a head and put it on a flow bench and flow steady state air through it, when that's not the way it is when it's running is kinda odd. If you really want to approximate an engine while its running there needs to be a big pressure drop. It doesn't make any sense to use 22 inches to flow at 600 thousandth of valve lift when the piston speed was up and then use the same 22 inches at 100 thousandth when the motor can't draw that hard on the valve. The piston position just won't allow it. It should be in a linear scale, at 100th maybe we should use four inches of water drop and as we bring the piston speed up, we'll bring the pressure drop figures up as well.

Additionally, we aren't stopping and starting the airflow in these tests, the head is hot and the wave isn't bouncing back and forth like in real life. It's a real tough deal. I'm not saying flowing isn't necessary, because it is and I'm not saying that the way we measure flow isn't good because right now there is no better way. But it really makes a person think, especially if they've just spent a lot of money for heads and didn't get much of a gain.

Another problem is that many of the flow benches can't pull much water drop, so they test at real low levels and then look at a chart that tells them what the head will flow at 27 or 28 inches. It just doesn't work that way. I compare it to buying a race chassis. You want it to be stable at 180, so you test it at 90 and double the result? I don't think so. You take something like air, where a little bump in the port creates a disturbance at 200 feet per second, but in reality the motor needs it at 500 feet per second. That little bump has become a major problem. So if heads aren't actually tested at air speeds that approximate the velocity needed when the engine is running, I'd take the data with a big grain of salt.

PSP: You alluded to this a little earlier, let's talk some more about oil drag.

Well, Jerry Branch says that a Harley Davidson is the only four-cycle engine designed with a two-cycle bottom end, meaning it's awful small on the crankcase volume. By the time you get all those parts in there, there isn't much room for air pressure. Whatever you're displacing on the top, you're also displacing on the bottom. That's like calling up an air compressor salesperson and saying I want to make 15 pounds of air pressure and the guy says no problem, then you say, but I want your compressor to spin at 7,000 RPM and the guys going to say "do you know how much horsepower that's going to take?" So besides the air pressure problem, you take these tight clearances, especially between the flywheels and the inside of the case, then you force a heavy liquid like oil in there, it really drags the motor down.

Car guys... Winston Cup, drag racers, they're all trying to draw negative pressure through the bottom end. They're trying to get the air to naturally migrate away from the moving parts so they don't slow them down. In a Harley, it's really hard to do. Being a dry sump motor is good, but we just don't have the volume down there for the air. We did some testing here on a Sportster and I can absolutely guarantee you that at 6,000 RPM on a 150 hp motor with metered oil that was less in volume than stock, the difference was 15 horsepower. A set of after market parts that would give you 15 clean horses are going to cost a bunch of money. Oil management basically costs you next to nothing.

PSP: So what's the difference in the real world, like in my FLHTC as an example?

That's a tough nut because we need to have a lot of oil going through the motor. An air cooled motor depends on that oil to remove BTUs of heat. What the oil is supposed to do is go in a little cooler than the engine, pick up a BTU of heat, carry it with it back to the oil tank and deposit it and then run back and get another one. So we really can't limit the oil going through the motor because we've just cut down on the number of BTU we can move out.

So we have to give it oil, matter-of-fact, if we're going to generate more power, that means more heat so we're going to have to run more oil. The trick is, we have to take out more than we put in. Commonly on a dry sump or NASCAR system, they'll run around a 3-5 to 1 ratio, meaning the scavenge is as much as five times as powerful as the pressure. On a Harley, it's real poor, I'd guess about 1.25 to 1. The other problem is that the oil is not waiting there near the pick-up, it's just beat to a froth everywhere. And it's that heavy, frothy oil that's slowing down the rods and the crank as they spin.

We have two problems, one we have to increase the capacity to get the oil through the motor to get heat down and two, we have to direct it to where we can pick it up and save horses. We use high efficiency oil pumps and windage trays plus some way to direct the oil away from the flywheel. In your bike, the first thing we'd recommend is a Basiley 2 to 1 oil pump gear. This will supply more volume and pressure at all RPM.

Don't get infatuated by oil pressure. We really don't need a lot of pressure. We need volume. The Shovel never had this type of problem, they usually smoked, Evos never do. Oil pumps are the same, the motors are basically the same on the bottom, we couldn't figure it out. Then we started thinking that the Shovel had one feed going to the top and the Evo has four, the push rods. So we've got 300 percent more demand on the top than before with no more supply.

The way the pump plunger works is that it has to supply excessive oil to the top until pressure begins to develop and pushes the plunger up. It takes about 15 lbs to push it up and uncover the lube hole to the pinion shaft. Until you have the 15 lbs, you're not getting direct lubrication to the bottom end. Anything the pistons and rods are getting is second hand that fell down from the top, already hot and aerated. So, if you raise the spring pressure under the tower, basically, all you've done is shut off the oil to the bottom end and made your oil gauge happy.

The more we thought about it, the more we realized we needed to speed up the pump, so Dan and Wes Baisley made up some gears and we're now spinning the pump at a 2 to 1 ratio. In a dresser like yours, we'll just let the engine use that extra oil to cool better. If we're looking for performance, we'll bleed off some of that feed so we don't put in any more oil, but we get the advantage of extra scavenge.

PSP: How do you feel about synthetic oils? They certainly foam less.

Synthetic oils are good. They're better than a petroleum based oil because they don't break down at high temperatures. This is an air cooled engine and we'll see some really high temps, some caused by combustion and frictional heat which you get with its long stroke and if you think about it, we've got a "sling and hope" oiling system. It flies out of the rods and we hope it gets to the right place. The natural rotation of the flywheels is directing the oil away from the major thrust side of the piston, which is the back, We're throwing it to the front. We've got an antiquated system at best. So there's no reason to gamble, that's why we run a synthetic. We find it real slippery and it won't break down under heat. I don't think you can find a Harley that would kill this oil from heat.

It also means you don't need an oil cooler anymore. A cooler is on the scavenge side of a Big Twin between the motor and the pump, now you're asking the motor to pump 60 percent hot air and 40 percent aerated oil and all you do is slow down the oil return to the tank. We send this oil all over the place, through a filter and then back to an oil bag that's located in the hottest place possible and expect a net gin? I don't think so. If we're worried about oil temps, excessive aeration, and better oil flow, then use better oil. To me that's synthetic.

PSP: You're known for your Axtell DynoMasterMotors, which are bored rather than stroked, why?

Well, we'll do whatever the customer wants, matter-of-fact, I think a majority of our business includes stroking. That said, we noticed with our dyno over the last few years that our stroked motors didn't put out any more power than an 80 ci and since we know some of the major draw backs of using a longer stroke, it just got us to thinking. We finally decided that power was directly tied to inlet valve size, how much air you could flow into the motor. You can't get a bigger inlet valve over a stroker, but you can over a big bore cylinder. So what we do is get a big intake valve by boring, then determine the engine size with the stroke.

PSP: So you're saying that stroking just moved the horses around?

Yea, it's basic math, if we stroke the motor 10 percent bigger, we don't get a always get 10 percent more power. Normally, we get about the same power 10 percent earlier in the rev range, which isn't that bad a thing. If a guy's running down the road and cracks the throttle, he's got power immediately because it's at a lower RPM and it feels good. Remember, most people are really buying torque.

Then we said, "How can we make torque without a longer stroke?" Torque is cylinder pressure minus losses, so we thought, "Wait a minute, a bigger valve will give us a longer burn and we've got more torque." This means we didn't have to stroke and the customer didn't have to buy as many parts. He didn't need new flywheels or rods and we didn't have to worry about the rod angle to the wrist pin. Boring makes the engine work simpler.

Look at the car guys. They've all gone to fuel injection, multi-valve heads and over square engines to get in more fuel and to control the burn in the cylinder. They're all making more torque and more horsepower without making the engine larger. We decided to try to do the same and settled on a 88 ci Sportster and a 97 ci Big Twin as our test beds and we've been improving them for 15 years. Now we can get both torque and horsepower out of them. We're not sitting still here either. Matter-of-fact, we're really excited about our new engine combination for the big twin that we call the 42.

It has a four-inch bore and stroke. Using a longer than stock connecting rod, we can keep enough piston skirt to retain reliability and ring seal and still fit this motor in FL frames. This bore allows larger valves, which will easily make 1.5 horsepower per cubic inch and provide an engine that will live.