Notes from an Engine Builder

The gradual evolution of automotive engine design and construction has favored practices, techniques and procedures which, although suitable to modern components, are less than appropriate when applied to power plants of the Edwardian and Classic eras. Modern engineering initiatives have focused on compact design, light materials, serviceability and an accommodation to a greater variety of fuels. However, the rebuilding of vintage engines of the post Industrial Revolution, manufactured not long after the birth of the motorcar, need be addressed within a vintage paradigm if they are to be done successfully. Compression ratios, rod and stroke length, bearing widths, journal sizes, etc. of this era are all reasonably unfamiliar to a modern shop. Indeed, even the machinery once used to address the size and geometric shapes of the often massive components of these engines have long gone to the scrape yard. Yet with some reflection on the original design intent, reconstruction and restoration can advance with success.

Some reflections:

Pistons:

Piston design has gone through significant development in the last century. Originally cast in iron, virtually every car manufacturer had switched to aluminum alloys by the second world war. Only some tractors and stationary engines still use them today. Europe led the technical revolution in piston development, followed by Harry Miller in California whose first business was the manufacture of cast aluminum pistons for racing engines. This has led to a current yield of forged aluminum pistons of the following varieties:

a. 2618 alloy, so called hypo eutectic because of the limited alloying of silicon, has been around for decades. It has a higher expansion co-efficient than the comparable 4032, now forged and machined for both race and production pistons.

b. 4032 alloy, so called hyper eutectic because of its ability to absorb more silicone in its composition at room temp than at operating temperature which allows it to expand less and resist more heat absorption than 2618, HT 6061, or most any other alloy. The development of this alloy came at the time when I was forming my business and was a result of the EPA's mandates to lower pollution.

The subject of pistons is fairly deep but here is an overview of considerations:

1. Piston availability is often a challenge in the restoration of engines of the WW1 era. Modern manufacturers have design limitations based on their production machinery and often can not make pistons whose major diameters exceed 5.5". The process of making these pistons from scratch i.e.: pattern making, pouring, solution heat treatment, turning, pin boring, balancing, etc. is challenging, however, possible as well as demanding.

Patterns and rough machine work for the Blitzen Benz engines.


Cam grinding and crown work.


2. Although cast pistons are still used (Egge), it would be advisable to use a forged piston because it lacks porosity and has exceptional strength. The 2618 is much less brittle than the 4032 and more scuff resistant which plays a considerable role in early long stroke engines. The 2618 also withstands detonation better than the 4032. The addition of coatings on the skirts can also help to inhibit scuff, a modern improvement that can play a significant role in early engines where oil filtration is marginal.

3. Often in rebuilding older engines, it is inadvisable to assume others have machined the compression heights correctly. Going through the extra efforts to insure the math yields the desired CR pays dividends in the end. Just because pistons came with a project doesn't mean they are appropriate for its future designed intent.

It is often a challenge to "do the math" because it involves both empirical and well as theoretical analysis. The math computation is same as computing the CR on Ferraris, Masers, Jags, etc. but fixed head engines follow the procedure one would use in computing the CR on Bugatti, Miller, Bentley (Red Label), Crosely, etc.. There are some tricks:

a. To assess the volume of the piston crown, install o-rings into the ring grooves as a seal and measure the depth of the crown (the distance from the top of the crown to where the crown intersects with the side of the piston. This is easily done with a machinist square.) Turn the piston upside-down and install into the bore until the crown is even with the bottom of the bore. Titrate fluid until it comes up even with the bottom of the block. Subtract this volume from the cylinder volume computed from the diameter of the bore and the crown depth.

b. To empirically find the chamber volume, follow the same procedure as any head. However, it is of some help to engage the use of a borescope or a mirror on an extension to fill the chamber to the prescribed piston depth in the bore.

3. The design of the piston skirt and pin placement plays a big role in controlling cold clearance and potential piston slap. Piston skirts are cam ground so that they are oval at room temp. This design feature is to provide growth at operating temperature so that they "grow" to be round when doing their job. (Choosing the correct "cam" for the pistons was a challenge for me when making the Blitzen pistons and a little old fashion ingenuity went a long way toward success.)

Story: years ago I built a Type 51 Bugatti engine for Richard Freshman who had pistons made for him by Ross Pistons. Well, Ross builds engines for tractor pulls and Chevy 350's. The cam was "CC" and absolutely inappropriate for the Bug……..I refused to use them even as they looked beautiful enough to mount in a show case.

Piston skirt lengths have shortened with reductions in stroke and have been further redesigned to accommodate crank counterweights. (Think Ferrari) The slipper skirt variety has really no place in vintage engines of the brass era. To control slap and insure ring posture to the bore, it would be advisable to continue with a long skirt in a long bore engine.

4. The placement of the pin also plays a role in controlling piston slap and is often off set as much as .035"

5. A starting point with respect to pistons and bores is to start with the availability of rings. With modern CNC turning centers, custom pistons can be made to any size. Rings are more problematic. Custom rings often need to be made in batches of hundreds at a time. Soooooo….Start with rings at the available bore size, choose a ring appropriate to the engine vintage and order pistons accordingly. With pistons in hand, bore to the clearance desired.

6. The subject of rings is a disciple as deep and involved as pistons, although few modern engine builders consider the options available. For decades, ring sets used to be available in three varieties: rings for new bores, rings for bores not perfectly reconditioned, and rings for badly worn bores. The design criteria would favor how well the ring followed the bore, how well it registered in the ring land, its ability to vent oil, and its compression strength to resist combustion pressure. Some thoughts:

a. It would be inadvisable to incorporate a chrome top ring in a truly vintage engine of Edwardian design. Low compression and gas pressures would retard ring seating …..although perhaps a good choice for a Fronty or another vintage engine that was shorter stroke and blown. Chrome rings would have great merit, however, if the engine was the subject of a redesign for vintage racing where compression ratios and strokes were substantially altered.

b. It would be inadvisable to use a Flex Vent type. There would be an issue with oil dispersion at the top of the bore due to the vent type being overly efficient. Premature wear would result.

c. It is important to match the design of the rings to the piston. If the pistons are purchased separately from the rings, the piston maker must know where venting is to occur, etc. etc. In other words, insure the piston maker has the rings in hand before he makes the pistons. This is a little different than calling Arias and telling them to make a set of forged pistons to Hastings Part Number…(Unless the FIAT piston is under 5.25" which used to be max diameter Arias could make.)

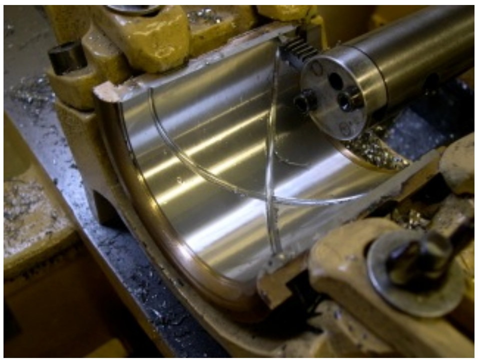
7. Caution is warranted on addressing blocks that have been newly cast . Story: in the "old days" this process used to take some time. The "time" part of the equation was in the aging of the blocks prior to machining. Everybody from Oldsmobile to MG were casting their blocks, putting them outside in "yards" and letting them age before machining. Blocks machined green tended to distort and bores, once round, become oval and scuff their skirts in operation. Caution: bores may be machined round now but depending on how they were cast, how long they were kept hot in their molds prior to de-molding, etc, may not stay as round as you might like. It is often advisable to err on the side of being generous with piston to bore clearance.

Bearings:

Four cautions to a contemporary engine builder engaged in an Edwardian bearing work might be appropriate:

1. Follow the oil. What is often overlooked, especially with installing new and redesigned components into an engine, is how oil might have been dispersed by splash (or pressure) and whether the original intent may be altered by the inclusion of a redesign. For example, using a counterbalanced crank to replace a "bent wire" crank might induce a dynamic that could shield lubrication to a cylinder bore or splash trough to a main bearing (1911 Caddilac). Like playing chess, it is wise to think many moves ahead.

2. Bearings of the past tend to be quite wide. Unless troughs and guides at the parting lines or supplementary oil troughs are included, there is a great risk that a portion of the bearing will run "dry" of a film wedge. As long as the oil grooves remain inboard of the thrust faces, oil loss will be a function of bearing clearance and including a generous feed supply suffers no disadvantage.



3. Often on disassembly, a rebuilder will discover bearings and bushings that have a inordinate amount of wear and on close inspection, the culprit may be found to be inadequate supply. The solution is to disregard any encouragement to "do it the old way," and remedy the fault before assembly.

4. Oil filtration efficiencies on the early engines were marginal; often non-existent. The babbitt material used in these engines were lead based and embedded impurities with ease. Modern babbitt as used often in the 30's were tin based and much harder. Oil filtration had gained acceptance and permitted the use of bearing materials of great wear resistance and were required as compression ratios began to climb.

Some advice based on experiential wisdom of a long time in the trade would be the following:

1. Do the math on CR. It avoids assumptions and avoids disaster.
2. If the bore size is less than 5.8" consider a forged 2618 piston…….or custom machine from a forged round stock.
3. Consider the rings…cast iron, double oil control, and whether one design trumps another relative to the CR and stroke.
4. Investigate how the skirts are getting their oil and design around lubrication.
5. Take notice of bearing width and consider if oil distribution is sufficient.
6. Choose a babbitt material consistent with its ability to embed impurity and at the same time withstand compression loads.

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May 2013