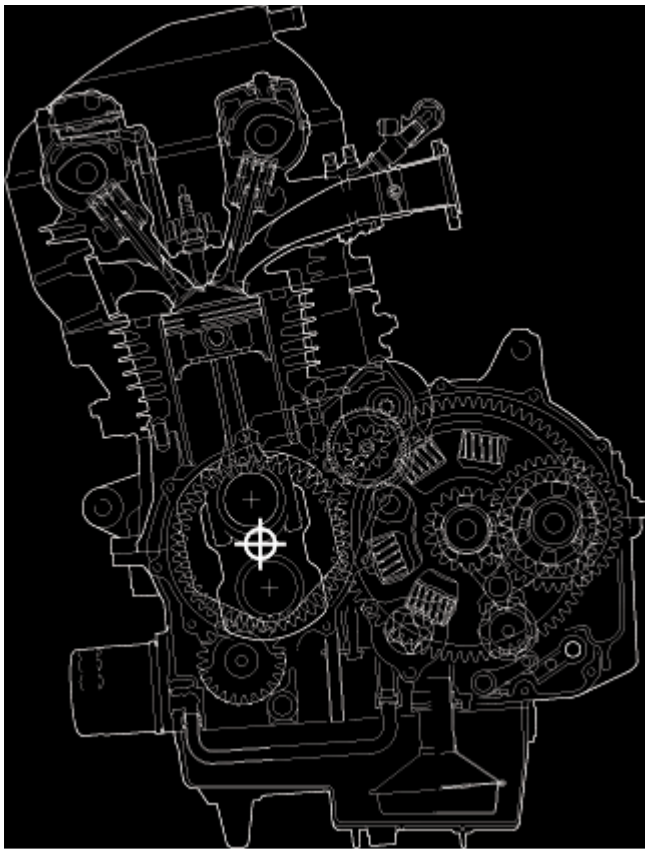
Designing the engine from scratch



Sekiya:
What was it like when you were told to build an air-cooled four-cylinder engine? I'd imagine there would have been many issues such as emissions regulations.

Sugiura:
At first we were given only a broad theme - to build an air-cooled four-cylinder engine - and we weren't sure if the performance and functionality would even be feasible. It was 20 years since the last air-cooled engine had been developed at Honda, and large displacement air-cooled engines would cause severe headaches, especially with heat and exhaust problems (due to stabilization of combustion gas temperature). We would have to build it from scratch.
The first prototype engine was based on a currently mass-produced, air-cooled single-cylinder engine with a proven track record, to which we did the calculations and increased the cylinders. Would we be able to reproduce the reliability of a single-cylinder engine tough enough to survive harsh conditions in emerging countries, by combining four of its single-cylinders, though?

Sekiya:

The biggest problems would be heat generation and dispersion, and as the displacement increases and the engine becomes larger, the requirements would become more critical and complex.

Sugiura:

Temperatures around the cylinders would undoubtedly be higher than a water-cooled engine, so we had to find a method to keep it consistently cool. Pistons and cylinders warp with heat, but keeping the warping even, that's the difficulty compared to water-cooled engines. If we can't do that, the engine won't run smoothly, and would undoubtedly lack durability. We brainsotrmed a lot, and decided to oil-cool the spark plug area. We had to make sure the engine ran smoothly, with oil, and with the wind.

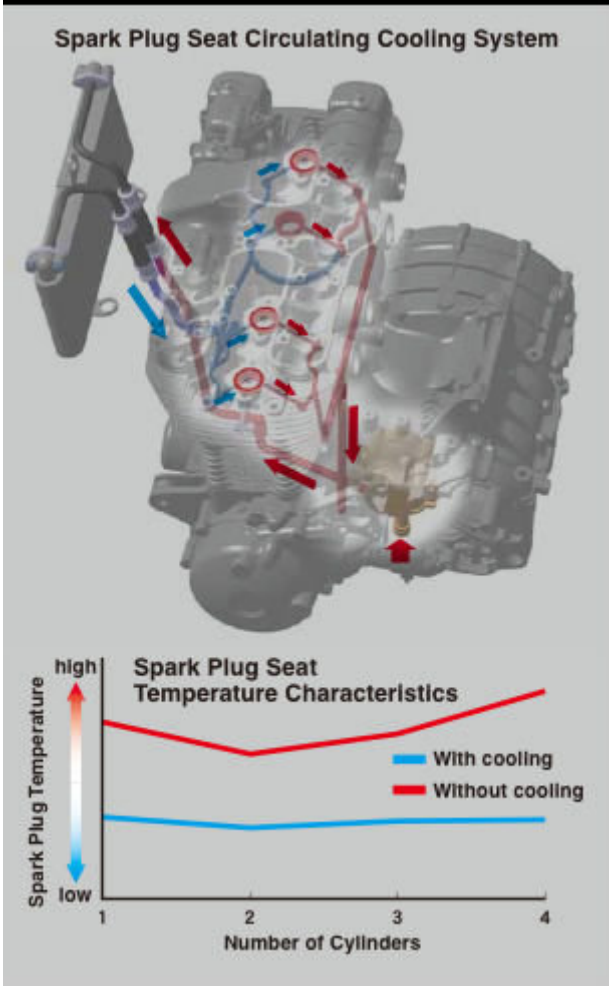
Sekiya:

So the hardware basics had to be worked out even before you could consider the engine's characteristics?

Sugiura:

Of all the ideas we had for the engine's 'character,' we went ahead with phased valve timing. The engine is based on the CB1300 Super Four, and in the initial prototyping stages, we took its engine and simply modified it to be air-cooled.

We had the prototype tested by a number of people, and the majority told us that it didn't feel like an air-cooled engine, that it felt the same as the 1300SF. We took it from there to give the bike its 'deep rumble,' or growl, but it seemed difficult, especially for the well-seasoned staff, to overcome their ideals and preconceptions based on their past experiences.



The elaborate and luxurious cylinder fins

Sekiya:
You must have had difficulty in realizing the cooling fin design which determines the engine's visual character, especially giving it the air-cooled look. The more the design becomes intricate, the more complex the mold and casting process become.

Sugiura:
It's a simple matter to recreate complex modeling on a prototype, but the difficulty is in designing a form that can be consistently mass-produced. We had problems here. It had been quite a while since we had narrowed-down the specifications and built a mold for a four-cylinder air-cooled engine, so we started off by having discussions with various casting manufacturers. We chose Honda's Kumamoto Factory, and accumulated the technical manufacturing knowhow in a short period.

Sekiya:
Is the engine die-cast?

Sugiura:
The cylinders are high-pressure die-casts, but the cylinder heads are low-pressure casts due to the complexity of the shape. The spark plug seats are cast separately. Packing in the thin fins around the narrow cylinder-head space is a complex design, but the mold is relatively easy to make by electro-discharge machining. The difficulty lies in how to pour the liquified metal in, ensure it completely fills the mold, and get it out cleanly. For example, we wanted the fins to be 2 mm thick, but manufacturing wanted 3 mm.

Sekiya:
Thin, but wide and deep components are difficult to manufacture, so they must have been worried about the finish and production efficiency.

Sugiura:
That's right. We ended up tapering in stages the engine fins, thickening towards the engine, to simplify molding. For some of the cylinder-head molds, one mold was made for each fin, and the resulting slices were stacked up vertically, to allow us to mass-produce the engine.

Sekiya:

A surprising amount of effort and cost must be going into manufacturing the engine. And, the factory has to manage all of the molds.

Sugiura:

I think manufacturing had a lot of headaches. With molding, the more you complicate the design, the less simple it is to build. We've also taken care in hiding the parting lines between the molds, and in the process reducing resonance between the fins, where rubber bushing used to go.

Sekiya:

The beauty is in the details. The CB1100's engine really is the amassment of intricate attention to the detail. Taking a close look at the engine, you can see all the thought that has gone into the design.

How to express the out-of-sync feel

Sekiya:
On the hardware side, phased valve timing gives the engine its characteristic feel around the 3,000 rpm range. How did you create the engine's personality?

Minami:
Basically, straight-four engines run smooth as long as all four pistons move the same way. My initial thoughts were, to give the engine a deep rumble, we'd have to change the movement a bit.
We ended up shifting the valve timing of cylinders 1 and 2, compared to cylinders 3 and 4, and by continuing to change the gap, found the right combustion out-of-sync feel.

Sekiya:
Valve timing is usually changed or made variable to increase output, but your aim was completely different. Maybe the exact opposite of conventional wisdom.

Minami:
Precisely. We took the opposite approach to conventional thinking, so we weren't sure if it would work.

Rigorous testing to ensure output and reliability

Sekiya:
You created a large-displacement air-cooled engine from scratch. Did you have to overcome new challenges to make the engine reliable?

Minami:
Our fundamental goals were output and reliability, and we didn't have any problems attaining the output required for an attractive air-cooled 1100 cc engine. The difficulty was producing an air-cooled engine with the same - or superior - reliability as its water-cooled counterpart.
There was a lot of trial-and-error, but that didn't mean we should produce an engine with old technologies, and anyway, we had a different perspective, as we were going out of our way to produce an air-cooled engine in the water-cooled age. So, we had to continue with the trial-and-error process to establish test parameters.

Sekiya:
What were the tests? The first one that comes to mind is a prolonged continuous operation test.

Minami:
In addition to the usual conditions, we conducted limit tests with heat parameters harsher than those for water-cooled engines, considering the customer's ease of use. We checked, for example, if oil leaked from around the cylinders, or if the seals were intact.
Initially there were problems around the spark plugs - the area that heats up the most - and we found cracks in the cylinder heads. We solved the problems by running the tests over and over again. In other words, it was a process of down-to-earth hard work.

Sekiya:
Was there any key component within the engine, maybe something within the ultra-hot combustion chamber, that made a difference?

Minami:
We had warped valve seats, pistons and cylinder bores, and problematic oil usage.
Around the valve seats, the aluminum-alloy cylinder-heads and valve seats - made of heat-resistant alloys using metals such as steel and nickel - would have differing expansion rates when heated, and if

the cylinder heads and valve seats don't expand in harmony, we'd have airtightness problems in addition to durability concerns.

Again, we conducted test after test, changing the valve seat materials as many times as needed to get it right. The materials we arrived at with the right heat- and friction-resistance characteristics are the finest materials used in any production bike.

Sekiya:

I didn't know that. It sounds more like a high-performance super sports or race model. The structure of an air-cooled engine is simple, but with a high-displacement multi-cylinder engine, it seems to get a lot more complicated. That's why you had to use the materials and design the structure accordingly.