Honda "Third Era" engines, 2000 – 2008

After leaving the Grand Prix arena in December 2008, Honda published a great deal of information about their "Third Era" engines and their customer and works cars as raced over the seasons 2000 – 2008. This was in a Honda R&D website as "Technical Review: F1 Special" (DASO 1121). This can be accessed after registration. It was brought to the author's attention by a correspondent, Ron Rex, for which I am very grateful. There are 50 papers in this Review, totalling 316 pages.

This Note adds some analysis not given on the Honda site.

Honda began to build Formula 2 and Formula 1 engines in a period lasting from 1964 to the end of 1968, and this they now refer to as "First Era". Some details of these engines have been given on this site in the introduction to the 2nd Pressure-Charged Era (2PC) Egs 69,70,71 plus Additions of November 2013. This was followed by Honda with a further F2 era from 1980 to 1984, which overlapped the 2PC period. More details of this F2 engine are given in Note 94.

Honda refer to their TurboCharged (TC) engines of 1983 – 1988 followed by their Naturally-Aspirated (NA) engines of 1989 – 1992 as "Second Era". Details for the Honda engines which powered the "Grand Prix Car-of-the-Year" in 1986 – 1988 are given in the chapter on 2PC quoted above and of the engines powering CoY in 1989 – 1991 in 3rd Naturally-Aspirated Era (3NA) 1989 -2000. Their 1992 engine is described as SO20 in Significant Other.

In the years 1993 – 1999 Honda kept a "watching brief" on the Grand Prix scene via a separate-but-associated company, Mugen Honda, founded and run by a son of Soichiro Honda. This supplied F1 and F3000 engines to a variety of teams. Their final GP engine of 2000 (used by Jordan and which overlapped the new works Honda engine) was (DASO 1121):-

72 V10 3L; Bore (B) 94.4 mm; Stroke (S) *42.8*;* B/S = *2.2*; Swept Volume (V) *2,996* cc.
Peak Power (PP) *757* BHP; Weight (W) 122 kg; PP/W = 6.2 BHP/kg.

---

*Some data in this Note has had to be deduced or scaled from the Honda review and this is shown in *italics*. This convention is not carried over to the analyses.

During the remainder of the 3L NA formula the works Honda engines were supplied to British American Racing (BAR) over 2000 – 2003, then to a jointly-owned BAR-Honda team 2004 – 2005 before becoming a full Honda F1 team for the 2.4L NA formula 2006 – 2008.

Honda 3L V10 engines, 2000 – 2005

Year	2000	2001	2002	2003	2004	2005
Type	RA000E	RA001E	RA002E	RA003E	RA004E	RA005E
Confign.	80V10	80V10	94V10	90V10	90V10	90V10
B mm	95	95	97	97	97	97
S mm	42.24	42.24	40.52	40.52	40.52	40.52
B/S	2.249	2.249	2.394	2.394	2.394	2.394
V cc	2,994	2,994	2,994	2,994	2,994	2,994
Life Required – km	**400**	**400**	**400**	**420**	**800**	**1500**
[*PP* derived from Fig. 1 of paper F1-SP2_02e; *NP* from Fig. 1 of F1-SP2_06e]						
PP - BHP	*757*	*788*	*859*	*897*	*926*	*938*
@ NP - RPM	*16,500*	*16,750*	*17,500*	*18,250*	18,700	18,700
[Analysis]						
BMPP – Bar	13.71	14.06	14.67	14.69	14.80	14.99
@ MPSP – m/s	23.23	23.58	23.64	24.65	25.26	25.25
[W from Table 1 of F1-SP2_07e]						
W – kg	112	108	111	99	91	89
[Analysis]						
PP/W - BHP/kg	6.76	7.3	7.74	9.06	10.18	10.54
Datum	Datum	+8%	+14.5%	+34%	+50.6%	+55.9%

Some further details of the 2005 RA005E are added here because this was the last Honda engine built before the new 2006 2.4L formula began with very large restrictions imposed by the FIA on what a designer could do (ostensibly to reduce cost – **after** the heavy expense of the new engines! In the author's opinion it was also part of a move long desired by the rule-making body to impose a standard engine and convert F1 racing into simply a Drivers' Championship without troublesome technical interference – like all the junior formulae).

SO29:-2005 Honda RA005E [See Short Glossary of Abbreviations on website]

IVD mm = 41.6; IVD/B = 42.9% (see Note 107 for comparison);
IVA/PA = 0.368; MGVP = 68.6 m/s;
IVL = *13.5* mm; IVL/IVD = 0.325; IOD = 316^0; MVSP = 9.59 m/s.
R = *13*; ASE = 0.642; ECOM = $\left(\frac{\text{BMPP}}{38 \times \text{ASE}}\right)$ = 61.4%.

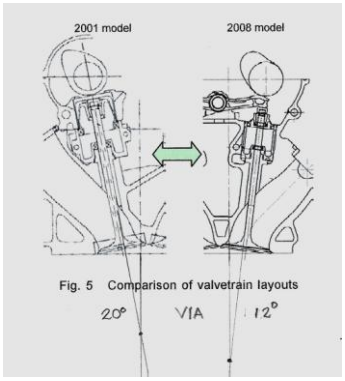
Design features

4 v/c; air-filled PVRS (with improved oil drainage); Finger cam followers (from 2002; previously inverted cup tappets) (see Fig. N121A).
VIA = 12^0 (was 20^0); Small compound (longitudinal) valve angle since 2003 (reduced combustion angle by 5^o).
Titanium Aluminide (TiAl) valves from 2002** (%ages: Ti 53.9, Al 42, Cr 2.5, Nb 1, Ta 0.5, B 0.1); = Stem diameter 4.5 mm (reduced from 6.6 with previous Ti alloy).Together with the finger followers the reciprocating valve gear mass was reduced by 34% from 2000.
Linerless block (from 2003) (Al-alloy with Nikasil coating). Siamesed bores from 2004.
Piston since 2004 Metal Matrix Composite (MMC =Aluminium-alloy with 25% dispersed 3µm SiC particles)** (contributed to a reduction of piston mass from 255g to 210);
PH/B = 0.48; PH/S = 1.16. TiAl gudgeon pin** (stiffer with 17% part mass reduction).
Plain crank bearing SiCu liners with improved heat conduction properties.
Front end-oil-feed crank.
Crank pin (CP) dia. = 34 mm; Main journal (MJ) = 46 mm; Gudgeon pin (GP) = 17 mm
CP/S = 83.9%; CP/MJ = 73.9%; GP/CP = 50%.
Double fuel injectors per cylinder since 2004**.(see Fig. N121B for 2004 layout with 20^0 VIA).
It almost goes without saying that "Diamond-Like Carbon" (DLC) coating was applied to reduce friction wherever there was high rubbing-contact pressure.

See Fig. 121C on P.4.

**Banned by FIA for the 2006 formula.

Fig. N121A



It is assumed that the 2005 design was the same as 2008 shown and that the valve axes were symmetrical

Note the change in cam profiles

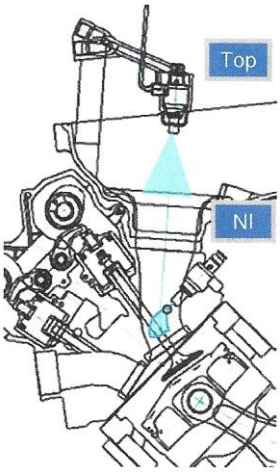


Fig. 15 Injector layout 2

Fig. N121B
NI = Near Inlet.

It is hoped that there will not be any objections to use of pictures here in a not-for-profit site whose intention is to aid study.

The 2014 Formula

The FIA formula for 2006 changed from the 11-year-old 3L capacity, with a maximum number of cylinders since 2001 of 10, to 2.4L with a mandatory 90^0V8 engine. Furthermore, the maximum Bore was to be 98 mm and the weight to be a minimum of 95 kg. The effect of the last restriction is shown by a Honda estimate that 78 kg (18% lighter) was technically possible. Various material bans were imposed, as shown above regarding the Honda 2005 specification. The requirement that engines must last for 2 events without overhaul, introduced for 2005 and assessed by Honda as needing 1500 km racing miles, was continued (grid penalties were applied otherwise).

In 2007 two further significant rules were introduced:-

Maximum("Red line") RPM of 19,000;

Major content of specification to be frozen at end February.

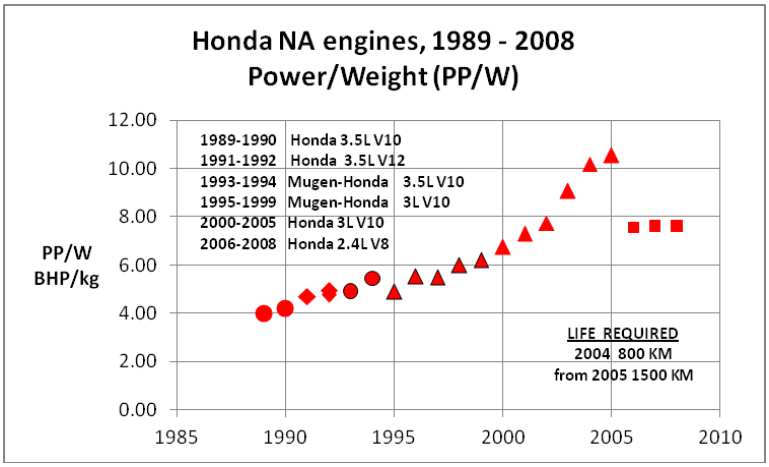
These 2006 – 2007 restrictions were novelties in Grand Prix rules (since 1908 regarding Piston Area, see The Sporting Limits).The steady trend of the FIA towards controlling **everything** was commented on by Honda in stating that the regulations (for chassis and engine) had doubled in letter content from 1990 to 2000 and **trebled over 1990 to 2008!**

Honda 2.4L V8 engines, 2006 – 2008

Year	2006	2007	2008
Type	RA806E	RA807E	RA808E
Confign.	90V8	90V8	90V8
B mm	97	97	97
S mm	40.52	40.52	40.52
B/S	2.394	2.394	2.394
V cc	2,395	2,395	2,395
Life Required – km	**1500**	**1350**	**1350**
PP – BHP	*718*	*724*	*724*
@ NP – RPM	*19,500*	*18,500*	*18,500*
BMPP – Bar	13.76	14.62	14.62
@ MPSP – m/s	26.34	24.99	24.99
W – kg	95	95	95
PP/W – BHP/kg	7.56	7.62	7.62

Advances in Power /Weight ratio over 1989 -2005

The chart below illustrates the truly remarkable advance ln PP/W produced by Honda over 1989 to 2005, which was slowed by the FIA life rules in 2004/05 and halted in 2006.



Conclusions

Although far from powering a "Grand Prix Car-of-the-Year" the Honda racing engines development story over 2000-2008 provides very many technical details of fairly-recent practice beyond the basic review of this website. It has been summarised in this Note 121 for that reason. This generous publication of data is in Honda's tradition set with the RA168E of 1988 (DASO 20) and the RA122E/B of 1992 (DASO 69) which were used as sources for the website chapters quoted above.

It must be presumed that the successful CoY engines of the same period (Ferrari, Renault, Mercedes) displayed even more ingenuity than the remarkable efforts of Honda. These were only rewarded with one victory in 9 years (the 2006 Hungarian GP won by Jensen Button) even though BAR had the 1997 Champion as driver over 2000 -2003.

It will never be known if the double-diffuser car designed for 2009 under the technical direction of Ross Brawn would, with Honda's own engine, have succeeded in that year if they had not retired in December 2008. As it was, with financial assistance from Honda, fitted with a Mercedes engine and re-branded as a "Brawn" it powered Button to the Drivers' and the team to the Constructors' Championships.

Fig. 121C
2005 Honda RA005E
90V10 B = 97 mm; S = 40.52 mm; B/S = 2.394; V = 2,994 cc
938 BHP @ 18,700 RPM

www.allf1.info/engines & Honda

P.S.

Further aborted technical advances

Honda made two technical advances to save mass in the engine "Bottom End" which are worth describing although the FIA ensured that one was short-lived and the other was not ready before it was banned:-

- Hollow connecting-rods.
  Honda had in 2000 used for con-rods a Ti-alloy (SP700) of 25% higher fatigue strength than the "workhorse" Ti6Al4V to reduce mass. To further improve the part, a hollow rod was then developed using 2 pieces diffusion-bonded. The process involved the machined pieces being heated to 70% of melting point then pressed together at 40 Bar in a vacuum for 5 hours. The joint disappeared. The assembly was then finish-machined.
  A much stiiffer rod with 8% lower mass than the previous I-section rod resulted, translateable to higher RPM. It was used in 2003 and 2004. The FIA then banned it.
- Hollow crankshaft
  Starting in 2004 a Honda programme produced a V10 crank in which the 34 mm pins had a 6 mm wall thickness. The joining process was Friction-welding. Five pieces were preheated and forced together in turn (rotating x stationary) at 1,900 RPM under a 10 tonne load. The joint strength was equal to the base material. The interior passage was cleaned to be suitable for oil-flow by barrel-finishing.
  The crank mass for the intended 2005 application, with added tungsten counterweights, was reduced by 7.8% from 10.3 kg for the solid assembly to 9.5.
  It was not ready for 2005 and the 2006 FIA rules banned multi-piece welded cranks.