ALPHA Engine Generation for Honda 1.5L L15B7 Earth Dreams Turbo 130kW

Version: 01-12-2017

This engine represents the Honda L15B7 engine found in the 2016 Honda Civic producing 130 kW. Information was captured from SAE Technical Paper 2016-01-1020 for use in ALPHA.

Engine Physical Characteristics

Source: Wada, Y., Nakano, K., Mochizuki, K., and Hata, R., "Development of a New 1.5L I4 Turbocharged Gasoline Direct Injection Engine," SAE Technical Paper 2016-01-1020, 2016, doi:10.4271/2016-01-1020.

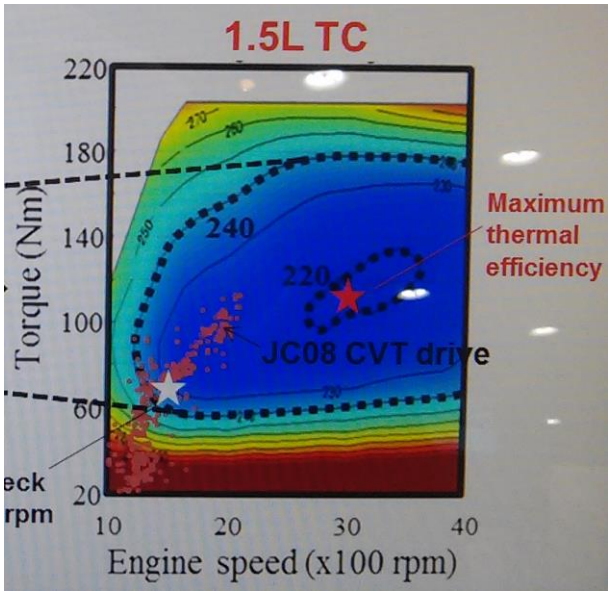
```
engine = [];
engine.name = 'Honda 1.5L L15B7 Earth Dreams Turbo - 130 kW';
engine.combustion_type = enum_engine_combustion_type.spark_ignition;
engine.displacement_L = 1.496;
engine.num_cylinders = 4;
engine.compression_ratio = 10.6;
enigne.bore_mm = 73;
engine.stroke_mm = 89.4;
```

Source: Estimated from similar inline 4 cylinder engines

```
engine.inertia_kgm2 = 0.095;
```

Load Map Image

Source: Photograph of BSFC map presented at 2016 SAE World Congress



This image was digitized by tracing the efficency contours.

```
load('..\data\2016 Honda 1.5L Turbo BSFC image.mat');

image_data.name = 'BSFC Image Points';
image_data.speed_rpm = bsfc(:,1);
image_data.torque_Nm = bsfc(:,2) ;
image_data.bsfc_gpkWhr = bsfc(:,3);
```

Additional Fueling Points

Limited data near idle creates extrapolation that may be too efficient. Point near idle is added, which is estimated from preliminary EPA test data on the 2016 Honda Civic.

```
estimated_data.name = 'Estimated Points';
estimated_data.speed_rpm = 630;
estimated_data.torque_Nm = 7;
estimated_data.fuel_gps = 0.17;
```

Maximum Torque (WOT) Curve Data

Source: Wada, Y., Nakano, K., Mochizuki, K., and Hata, R., "Development of a New 1.5L I4 Turbocharged Gasoline Direct Injection Engine," SAE Technical Paper 2016-01-1020, 2016, doi:10.4271/2016-01-1020.

Points captured from Table 1 in the above paper

```
WOT_data{1}.speed_rpm = [ 1500,    5000,    5500];
WOT_data{1}.torque_Nm = [ 230,     230,     225.7];
```

Minimum Torque Curve Data

Source: None - With no available data the REVS_build_engine function will utilize a default minimum torque curve which is scaled by engine displacement.

Fuel Properties

Source: Email response from James Kliesch at Honda 6/13/2016

```
engine.fuel = class_REVS_fuel;
engine.fuel.research_octane_number = 91;
engine.fuel.energy_density_MJpkg = 43.1;
```

Source: Estimated from similar EPA test fuels

```
engine.fuel.density_kgpL_15C = .743;
```

Idle Speed

Source: Estimated from preliminary EPA testing on 2016 Honda Civic

```
engine.idle_speed_radps =  630 * convert.rpm2radps ;
```

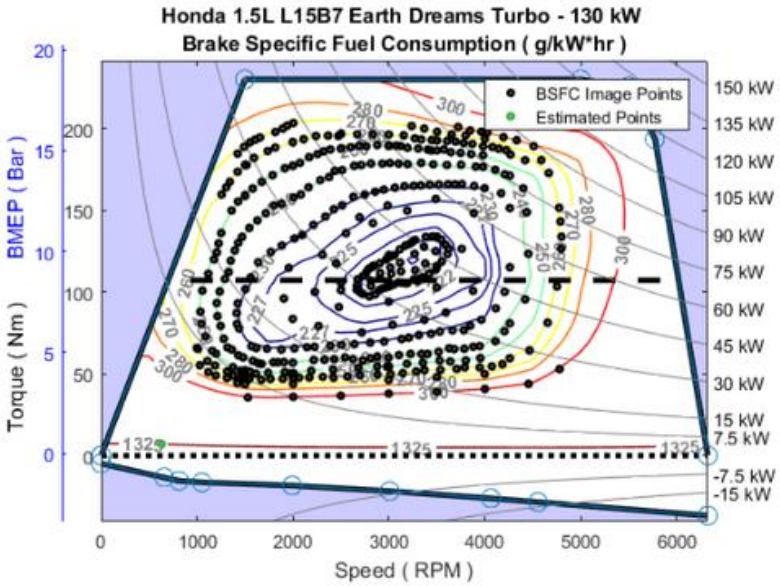
Build Fuel Map

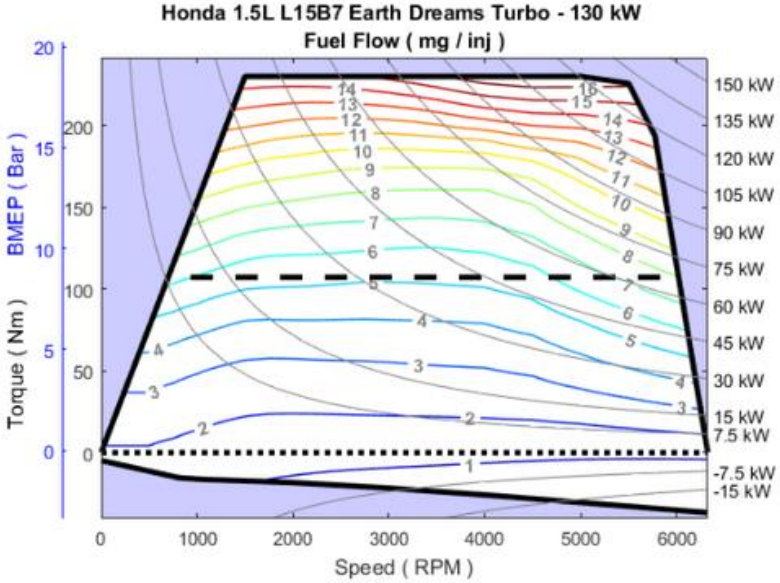
Generate complete REVS engine description using REVS_build_engine.

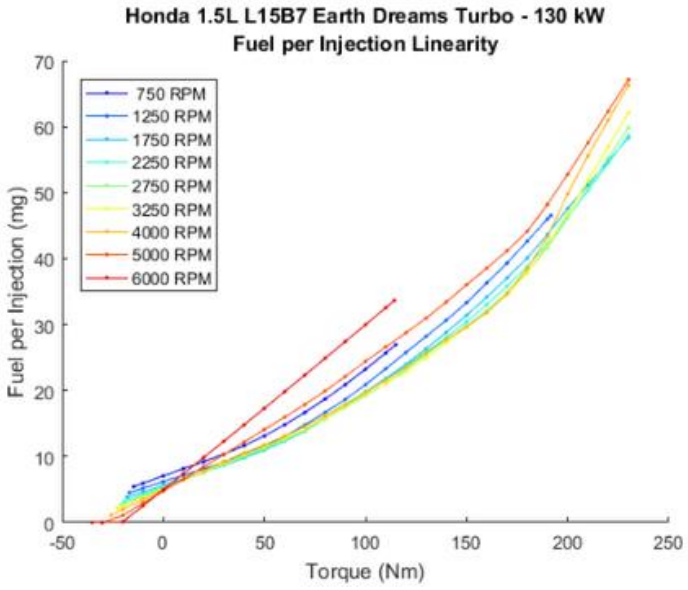
Output grid for fuel map must be specified when source data is not approximately gridded.

```
out_speed = [0, 500:250:3500,4000:500:7000] * convert.rpm2radps;
out_torque = -50:10:230;

engine = REVS_build_engine(engine, {image_data,estimated_data}, 'WOT',WOT_data ,
'out_speed',out_speed,'out_torque',out_torque,'no_point_labels');
```


Honda 1.5L L15B7 Earth Dreams Turbo - 130 kW
Brake Specific Fuel Consumption (g/kW*hr)
BSFC Image Points
Estimated Points
BMEP (Bar)
Torque (Nm)
Speed (RPM)
150 kW
135 kW
120 kW
105 kW
90 kW
75 kW
60 kW
45 kW
30 kW
15 kW
7.5 kW
-7.5 kW
-15 kW


Honda 1.5L L15B7 Earth Dreams Turbo - 130 kW
Fuel Flow (mg / inj)
BMEP (Bar)
Torque (Nm)
Speed (RPM)
150 kW
135 kW
120 kW
105 kW
90 kW
75 kW
60 kW
45 kW
30 kW
15 kW
7.5 kW
-7.5 kW
-15 kW


Honda 1.5L L15B7 Earth Dreams Turbo - 130 kW
Fuel per Injection Linearity
750 RPM
1250 RPM
1750 RPM
2250 RPM
2750 RPM
3250 RPM
4000 RPM
5000 RPM
6000 RPM
Fuel per Injection (mg)
Torque (Nm)

The plots resulting from REVS_build engine show a good match with the input data and reasonable behavior for the extrapolated portions of the map.

Model Calibration Options

These parameters influence particular behaviors within the ALPHA model. They often do not have a corresponding value with test data, but are calibrated to match observed behavior.

Accelerator pedal maps linearly to engine power - default for passenger cars

```
engine.pedal_map_type = enum_engine_pedal_map_type.max_engine_power;
```

Generate description File

```
write_REVS_engine( 'engine_2016_honda_turbo_1L5_130kW.m', engine);
```

Generated engine_2016_honda_turbo_1L5_130kW.m:

```
% ALPHA ENGINE DEFINITION
% Generated 12-Jan-2017 08:44:16
% Honda 1.5L L15B7 Earth Dreams Turbo - 130 kW

% Constructor
engine = class_REVS_engine();
engine.name =  'Honda 1.5L L15B7 Earth Dreams Turbo - 130 kW';

% Physical Description
engine.displacement_L =  1.496;
engine.num_cylinders =  4;
engine.combustion_type = enum_engine_combustion_type.spark_ignition;
engine.compression_ratio =  10.6;
engine.inertia_kgm2 =  0.095;
engine.stroke_mm =  89.4;

% Maximum Torque Curve
engine.full_throttle_speed_radps = [  0.00000000,  ;  157.07963,    ;  523.59878,    ;  575.95865,    ;  604.75659,    ;  662.35245,
         ];
engine.full_throttle_torque_Nm = [  0.00000000,    ;  230.00000,    ;  230.00000,    ;  225.70000,    ;  193.45714,    ; 0.00000000,
         ];
engine.naturally_aspirated_speed_radps = [  0.00000000,     ;  662.35245,     ];
engine.naturally_aspirated_torque_Nm = [   107.14311,        107.14311,       ];

% Minimum Torque Curve
engine.closed_throttle_speed_radps = [  0.00000000,;  68.821823,    ;  85.042913,    ;  109.95574,    ;  208.49703,    ;  314.99702,
        ;  425.58108,    ;  476.99848,    ;  662.35245,     ];
engine.closed_throttle_torque_Nm = [  -4.8652851,  ; -13.405067,    ; -15.417867,    ; -16.374400,    ; -18.332800,    ; -21.750933,
        ; -26.166400,    ; -28.455733,    ; -36.708524,     ];

% Fuel Map
engine.fuel_map_speed_radps = [  0.00000000,        52.359878,       78.539816,       104.71976,       130.89969,       157.07963,
         183.25957,       209.43951,       235.61945,       261.79939,       287.97933,       314.15927,       340.33920,
366.51914,        418.87902,       471.23890,       523.59878,       575.95865,       628.31853,       680.67841,       733.03829,
         ];
engine.fuel_map_torque_Nm = [  -50.000000, -40.000000,      -30.000000,      -20.000000,      -10.000000,      0.00000000,
10.000000,        20.000000,       30.000000,       40.000000,       50.000000,       60.000000,       70.000000,       80.000000,
         90.000000,       100.00000,       110.00000,       120.00000,       130.00000,       140.00000,       150.00000,
160.00000,        170.00000,       180.00000,       190.00000,       200.00000,       210.00000,       220.00000,       230.00000,
         ];
engine.fuel_map_gps = [
0.00000000, 0.027581523, 0.037166842, 0.043499070, 0.045896847, 0.043491096, 0.035426260, 0.021061009, 7.2010220e-05, 0.00000000,
0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, ;
0.00000000, 0.046905840, 0.065005991, 0.079217714, 0.089127679, 0.094309062, 0.094468242, 0.089509592, 0.079511202, 0.064636312,
```

```
0.045003052, 0.020562160, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000,
;
0.00000000, 0.066281654, 0.092868564, 0.11488986, 0.13222757, 0.14494838, 0.15335339, 0.15788476, 0.15899089, 0.15699092, 0.15195320,
0.14364870, 0.13160580, 0.11523661, 0.065790270, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, 0.00000000, ;
0.00000000, 0.085784462, 0.12077312, 0.15040259, 0.17495852, 0.19514356, 0.21189485, 0.22615232, 0.23866042, 0.24979064, 0.25946044,
0.26722270, 0.27244744, 0.27450530, 0.26586785, 0.23456098, 0.17894060, 0.10666316, 0.022839959, 0.00000000, 0.00000000, ;
0.00000000, 0.10546720, 0.14870776, 0.18555755, 0.21702370, 0.24465837, 0.27000437, 0.29442058, 0.31883566, 0.34347269, 0.36793117,
0.39152306, 0.41357964, 0.43355019, 0.46478444, 0.48221148, 0.48808821, 0.49518128, 0.50706569, 0.52154607, 0.53504405, ;
0.00000000, 0.12526602, 0.17659085, 0.22008510, 0.25820449, 0.29343002, 0.32780625, 0.36303230, 0.40002912, 0.43854242, 0.47769562,
0.51661018, 0.55480204, 0.59192433, 0.66183315, 0.72691512, 0.79575059, 0.88443372, 0.99286957,  1.1167767,  1.2511807, ;
0.00000000, 0.14475831, 0.20384456, 0.25391127, 0.29865370, 0.34166698, 0.38571781, 0.43267291, 0.48291017, 0.53538414, 0.58879557,
0.64227486, 0.69567107, 0.74894123, 0.85618600, 0.96709352,  1.1023073,  1.2751858,  1.4807942,  1.7137308,  1.9681011, ;
0.00000000, 0.16401251, 0.23054080, 0.28780867, 0.33918688, 0.38982168, 0.44455055, 0.50450573, 0.56808162, 0.63392785, 0.70069842,
0.76808048, 0.83552496, 0.90376196,  1.0467797,  1.2010086,  1.4090165,  1.6682926,  1.9712964,  2.3125514,  2.6855737, ;
0.00000000, 0.18463950, 0.25913332, 0.32357994, 0.38163004, 0.43884396, 0.50573821, 0.58000797, 0.65557777, 0.73328200, 0.81212101,
0.89348038, 0.97348818,  1.0556807,  1.2318652,  1.4275349,  1.7179891,  2.0644369,  2.4647130,  2.9131893,  3.4031390, ;
0.00000000, 0.20766855, 0.29119372, 0.36322869, 0.42899508, 0.49395419, 0.57174116, 0.65872143, 0.74467873, 0.83049127, 0.92184189,
1.0160649,  1.1088194,  1.2043802,  1.4080170,  1.6480312,  2.0312874,  2.4639698,  2.9612793,  3.5153666,  4.1201118, ;
0.00000000, 0.23365960, 0.32803710, 0.40878399, 0.48217344, 0.55405471, 0.64021743, 0.73156492, 0.83449353, 0.92909502,  1.0322692,
1.1326346,  1.2435686,  1.3529327,  1.5679430,  1.8705838,  2.3484578,  2.8672445,  3.4611313,  4.1185471,  4.8356043, ;
0.00000000, 0.26270884, 0.37013072, 0.46287176, 0.54365913, 0.62484673, 0.71902070, 0.82400725, 0.93249953,  1.0420791,  1.1469384,
1.2610787,  1.3780958,  1.4996770,  1.7456552,  2.1059753,  2.6601240,  3.2759906,  3.9641532,  4.7219485,  5.5485608, ;
0.00000000, 0.29474089, 0.41677579, 0.52326968, 0.61579490, 0.70404961, 0.80759025, 0.92571453,  1.0451941,  1.1635457,  1.2842727,
1.4073699,  1.5323526,  1.6659630,  1.9365448,  2.3530627,  2.9804028,  3.6913217,  4.4696733,  5.3246565,  6.2577826, ;
0.00000000, 0.32960918, 0.46748604, 0.58847536, 0.69501203, 0.79442633, 0.91678277,  1.0535955,  1.1865113,  1.3133627,  1.4423843,
1.5801083,  1.7190031,  1.8574292,  2.1575366,  2.6293908,  3.3211078,  4.1138160,  4.9768779,  5.9258114,  6.9619194, ;
0.00000000, 0.36704989, 0.52230647, 0.65905130, 0.77741554, 0.89448281,  1.0351989,  1.1863464,  1.3292868,  1.4687905,  1.6008193,
1.7506075,  1.9072443,  2.0714493,  2.3878944,  2.8964799,  3.6891473,  4.5428494,  5.4854262,  6.5247738,  7.6594262, ;
0.00000000, 0.40662323, 0.58074328, 0.73510486, 0.87010291,  1.0028509,  1.1548103,  1.3169256,  1.4713606,  1.6154690,  1.7569979,
1.9256925,  2.0938072,  2.2740371,  2.6409511,  3.1681525,  4.0706923,  4.9765114,  5.9958309,  7.1211481,  8.3485099, ;
0.00000000, 0.44784983, 0.64222442, 0.81717512, 0.97109990,  1.1139477,  1.2732711,  1.4485715,  1.6210742,  1.7806446,  1.9327182,
2.1031118,  2.2822806,  2.4711641,  2.8747138,  3.4623676,  4.4341081,  5.4149979,  6.5091042,  7.7146452,  9.0270927, ;
0.00000000, 0.49043322, 0.70550522, 0.90149299,  1.0735129,  1.2264070,  1.3986972,  1.5880357,  1.7805087,  1.9617730,  2.1289795,
2.3011242,  2.4823087,  2.6828527,  3.1374751,  3.7904283,  4.7910097,  5.8583655,  7.0259345,  8.3049379,  9.6928089, ;
0.00000000, 0.53422950, 0.76956626, 0.98403973,  1.1754345,  1.3470023,  1.5356233,  1.7356492,  1.9398883,  2.1404696,  2.3334121,
2.5185478,  2.7012727,  2.9039484,  3.4272459,  4.1301200,  5.1632556,  6.3096048,  7.5470526,  8.8915974,  10.343050, ;
0.00000000, 0.57909088, 0.83502980,  1.0675823,  1.2778867,  1.4763098,  1.6815716,  1.8918249,  2.1028860,  2.3175378,  2.5373061,
2.7471484,  2.9490128,  3.1644451,  3.7019296,  4.4481793,  5.5705754,  6.7724669,  8.0739463,  9.4741167,  10.975098, ;
0.00000000, 0.62486215, 0.90320038,  1.1574510,  1.3881570,  1.6074850,  1.8325744,  2.0609649,  2.2814184,  2.5000505,  2.7299385,
2.9675022,  3.2082879,  3.4481338,  3.9541913,  4.7436231,  6.0067282,  7.2500130,  8.6090796,  10.051871,  11.586396, ;
0.00000000, 0.67140236, 0.97432751,  1.2543450,  1.5126480,  1.7490695,  1.9931069,  2.2443333,  2.4790364,  2.7056504,  2.9445026,
3.1949711,  3.4499966,  3.7124030,  4.2430150,  5.0740786,  6.4234314,  7.7487211,  9.1548341,  10.623987,  12.174937, ;
0.00000000, 0.71845057,  1.0477649,  1.3554849,  1.6380372,  1.8957127,  2.1621337,  2.4309294,  2.6864934,  2.9365891,  3.1934526,
3.4661684,  3.7426026,  4.0313053,  4.6246656,  5.5262288,  6.8619232,  8.2739922,  9.7114676,  11.189397,  12.739701, ;
0.00000000, 0.76551535,  1.1219387,  1.4598491,  1.7762045,  2.0585435,  2.3379156,  2.6353599,  2.9084696,  3.1833393,  3.4763448,
3.7863149,  4.1040610,  4.4370140,  5.1300621,  6.1120274,  7.3533403,  8.8379901,  10.277589,  11.747232,  13.281002, ;
0.00000000, 0.81233327,  1.1958318,  1.5642167,  1.9171030,  2.2437655,  2.5464777,  2.8591641,  3.1682497,  3.4870956,  3.8152360,
4.1542210,  4.5478733,  4.9360805,  5.7744157,  6.9662487,  8.0350873,  9.4330896,  10.851637,  12.297474,  13.800673, ;
0.00000000, 0.85885527,  1.2691316,  1.6667068,  2.0505719,  2.4191010,  2.7769811,  3.1135598,  3.4675174,  3.8433281,  4.2309900,
4.6319007,  5.0708222,  5.5659087,  6.6415676,  7.8096496,  8.7968335,  10.072013,  11.435373,  12.841096,  14.302046, ;
0.00000000, 0.90505726,  1.3416833,  1.7678561,  2.1835546,  2.5893896,  2.9850751,  3.3707973,  3.7735237,  4.1971025,  4.6418516,
5.1107629,  5.6162660,  6.1759350,  7.4087582,  8.5873571,  9.5916771,  10.750584,  12.029943,  13.379963,  14.789745, ;
0.00000000, 0.95100759,  1.4137585,  1.8684059,  2.3157013,  2.7569486,  3.1938357,  3.6323327,  4.0839690,  4.5580139,  5.0605701,
5.5967684,  6.1721374,  6.7893430,  8.1312469,  9.3486142,  10.390422,  11.453927,  12.633337,  13.916215,  15.269110, ;
0.00000000, 0.99684478,  1.4856512,  1.9687065,  2.4473998,  2.9243056,  3.4038158,  3.8921402,  4.3951664,  4.9222696,  5.4835287,
6.0854151,  6.7278572,  7.4047275,  8.8386082,  10.106528,  11.186999,  12.166792,  13.240959,  14.451562,  15.745168, ];

% Fuel Properties
engine.fuel = class_REVS_fuel;
engine.fuel.density_kgpL_15C =  0.743;
engine.fuel.energy_density_MJpkg =  43.1;
engine.fuel.research_octane_number =  91;

% Idle Speed
engine.idle_speed_radps = class_REVS_dynamic_lookup;
engine.idle_speed_radps.axis_1.signal =  'veh_spd_mps';
```

```
engine.idle_speed_radps.axis_1.breakpoints = [  0.00000000,  10.000000,       ];
engine.idle_speed_radps.table = [   65.973446,     ;  65.973446,     ];

% Pedal Calibration
engine.pedal_map_type = enum_engine_pedal_map_type.max_engine_power;

% Calibration Adjustment Factors
```

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