Dynomation-5 Update 5.09

Quick Overview:

Motion Software is pleased to introduce Update 5.09 for Dynomation-5. This program update includes many enhancements; the most significant is a new ability to analyze Air/Fuel Charge movement through the intake passages, into and out of the cylinder, and discharges into the exhaust system. By simply glancing at this new data displayed in tables and graphs, you can quickly determine how cam timing affects fuel usage, efficiency, and engine performance.

This update also includes other new features and changes to improve Dynomation-5 accuracy and usability. Some of these "fixes" include:

1) Improved *Frictional Models* in the Wave-Action simulation extend accuracy over a wide range of engine sizes.

2) Improved *Induction Air Temperature* modeling for plenum and Individual Runner intake systems.

3) Display of both *Intake Manifold Pressure* and *Port Pressure* (at minimum port area) in Wave-Action simulation.

4) Improved accuracy and stability for *Forced-Induction* modeling in the Wave-Action simulation.

5) Wave-Action simulation *Recalibrated* to dyno-test and simulation baseline test data. Some engines may show a few percent lower power than previous versions of Dynomaiton-5, however, overall prediction accuracy should be improved.

6) Enhanced and more accurate reporting of MEP, HP, and other data in the tables.

7) Improved *Intake-Modeling* accuracy in Filling-And-Emptying (FE) simulation.

Using Dynomation-5.09 Charge-Flow-Analysis Features

The most significant enhancements to Dynomation-5 include the calculation and display of rpm-based, *Charge-Mass* flows within the engine. While similar to crank-angle flow data, the new rpm-based data reflects the "total" (end-of-valve-event) mass retained or discharged from each cylinder at the conclusion of exhaust and induction cycles. This accurately reflects the Fuel-Charge Mass in the cylinder at the beginning of compression and during power strokes. This data dramatically shows how changes in cam timing, intake flow, and other engine parameters can affect the fuel retained and lost from each cylinder throughout the rpm range. This new data is displayed in both tables and graphs:

- **Trapped Mass**: Total Charge Mass retained in each cylinder at the end of the intake cycle, measured at each rpm point in Pounds or Grams.

- **Lost Charge Mass** (Displayed in ProPrintout table only): Total Charge Mass that entered each cylinder but then escaped through reversion flow back into the intake tract *and/or* discharged with exhaust flow before the end of the exhaust and intake cycles, measured at each rpm point in Pounds or Grams.

- **Percentage Of Charge Lost To Reversion:** Percentage of Total Charge Mass that entered each cylinder but then escaped in reversion flow back into the intake tract, measured at each rpm point.

- **Percentage Of Charge Lost To Exhaust Flow**: Percentage of Total Charge Mass that entered each cylinder but then escaped with exhaust flow, measured at each rpm point.

- **Percentage Of Charge Spoiled By Exhaust Gasses**: Percentage of Total Charge Mass "spoiled" by exhaust gasses that moved *into* the cylinder (rather than out) during the exhaust valve event, measured at each rpm point.

- **BSFC (Brake Specific Fuel Consumption)**: A standard measure of the fuel used by the engine during a specific time period to produce a known (brake) power level, measured at each rpm point in Pounds-per-Horsepower-Hour or Grams-per-Kilowatt-Hour.

- **Fuel Flow Rate**: A standard measure of fuel consumption during a specific time period, measured throughout the rpm range in Pounds-per-Hour or Grams-per-Hour.

- **Fuel Conversion Efficiency** (Not shown in ProPrintout table): A standard percentage measure of the efficiency at which fuel energy is converted into usable power output, measured at each rpm point.

These mass flow measurements are calculated during every Wave-Action simulation and are displayed in the tables (*Standard* and *ProTools Tables*). These new measurements also can be plotted on the top-right (rpm-based) graph by right-clicking the graph and assigning the ***Y1*** (normally Power) and/or ***Y2*** (normally Torque) to any Charge-Mass variable. Particularly powerful and easy to interpret are the *Percentage Flow* values (*Lost to Reversion*, *Lost to Exhaust*, and *Spoilage Flow*). Percentage charge flows clearly show where charge flow inefficiencies occur in any engine design.

For example, if you are simulating an engine primarily for optimum power, an overall design that limits reversion flow will maintain higher charge density in the cylinder. If charge is allowed to "revert" into the intake track, it will not be available to produce power during the following compression and power strokes. Reversion flow into the intake typically occurs at the end of the intake valve event, when the piston is moving up the bore and the intake valve is still open. This phenomenon often shows-up at lower speeds, when the induction system may not generate sufficient charge-flow energy to keep air and fuel moving in the "right" direction; into the cylinder. In these cases, piston motion forces inducted charge to change direction and move back into the intake tract. The result is lower volumetric efficiency and a reduction in power output. However, reverted charge is not necessarily "lost energy," since it is still present in the induction tract and is available during the next induction cycle to potentially contribute to trapped mass and power output.

Reversion can also be triggered by *Exhaust Spoilage* flow. At the beginning of valve overlap, when the intake valve is just opening and the exhaust valve is closing, if sufficient pressure exists in the exhaust system or if the intake valve is opened too soon, exhaust gasses can reverse flow and move into the induction system. This is a particularly potent power killer. Not only is charge reverted, but it's partially "spoiled" by exhaust gasses. So, after overlap, during the remaining portion of the intake cycle, this spoiled charge is drawn back into the cylinder and lowers power output (similar to EGR power loss).

On the other hand, if induction-flow momentum is sufficient to drive unburned fuel through the combustion space and into the exhaust tract (during valve overlap), it is truly lost as an energy source. This increases fuel consumption, but it has benefits in high-performance applications. Charge *Flow To Exhaust* helps drive out residual exhaust gasses and optimizes the trapped mass to produce peak power. Once again, it is obvious how tuning for power and economy are often at different ends of the engine-design spectrum.

All of these phenomena are easily seen and analyzed by reviewing the *Percentage Charge Mass* data in the last three columns of the ProTools table. As you look down the columns, through the rpm-test range, reversion flow often comes-and-goes as the engine moves into and out of tune. *Exhaust Spoilage* flow may occur at high engine speeds with large-displacement engines as exhaust-system pressure increases. *Charge Lost To Exhaust* flow can also come-and-go as the induction system moves through its tuning peaks. This complex interplay of mass flows can be readily visualized just by reviewing the data in these columns.

Using Dynomation-5.09 Fuel-Flow Data

In addition to Charge Mass analysis, *Fuel-Flow* data is also calculated in Dynomation-5.09 and is displayed in tables and can be shown on the rpm graph. Fuel consumption data (*BSFC*, *Fuel Flow Rate*, and *Fuel Conversion Efficiency*) indicates the efficiency of fuel-energy conversion into usable mechanical work.

One of the most commonly measured and quoted fuel-efficiency parameters is *Brake Specific Fuel Consumption* (BSFC). BSFC has units of *Pounds per Horsepower-Hour* (also *Grams per Kilowatt-Hour*). This variable indicates the amount of fuel required to produce specific engine output over a measured duration of time. Typical values for spark-ignition engines operating at optimum efficiency run around 0.40 to 0.45, with lower numbers indicating higher efficiency. BSFC values are widely used because they are applicable across a wide range of engines, from 50cc 2-stroke engines, to large Diesels, and even turbine engines! BSFC for each of these engines is directly comparable, giving a clear measure of the overall fuel efficiency within a diverse range of powerplants. BSFC for IC engines simulated in Dynomation-5 are highest when the engine is run at wide-open-throttle (as is typically the case in Dynomation-5) and engine speed is near the torque peak. BSFC will increase (efficiency decreases) in other operating ranges.

Another useful fuel consumption measurement calculated by Dynomation-5.09 is *Fuel Flow Rate* (in *Pounds per Hour* or *Grams per Hour*). This parameter simply indicates the gross fuel flow consumed by the engine. Since fuel pumps are commonly rated in Pounds-per-Hour for maximum fuel delivery, a direct comparison Fuel Flow Rates is an easy way to confirm that pump capacity is sufficient for any particular engine application.

Each type of fuel has a unique energy content and heat-release potential per unit mass. This is measured in a standardized test where a specific amount of fuel is burned and the heat release is measured by a calorimeter as combustion products cool to ambient temperature. Since this heat-release content can be directly compared with work produced by the engine, it can be used to determine the *Fuel Conversion Efficiency* of the engine, sometimes referred to as the Thermal Efficiency. This is the "third" in the efficiency measurements, along with *Volumetric Efficiency* and *Mechanical Efficiency* (already calculated and displayed by Dynomation-5 in pre-5.09 versions). Fuel Conversion Efficiency will range around 30% for most automotive engines.

Dynomation-5.09 Practical Usage Tips

- The new Charge-Flow data variables in version 5.09 are quite sensitive to IVO, EVC and the amount of valve overlap (when both the intake and exhaust valves are open). Slight changes in IVO, EVC, and overlap duration often can have dramatic effects on charge reversion or fuel lost to exhaust flow. While searching for optimum charge-flow characteristics, try changing individual valve events (IVO, EVC) to optimize flow characteristics while keeping an eye on power output to find the "sweet spot" in engine efficiency for your combination.

- Some Dynomation users have been unsure how to use the *SIMPLE* induction models provided in the *Induction* drop-down menu. There are two SIMPLE induction models: One for Plenum induction systems and another for IR (Individual Runner) engine configurations. Here's the bottom line on Induction choices: *The SIMPLE model is the best option when you begin your engine-development efforts.* The SIMPLE models use data directly from the simulation (particularly the Wave-Action simulation) without modification. Other (non-SIMPLE) induction models "impose" manifold characteristics upon simulation results to help you evaluate how an engine might perform with various induction systems. Keep in mind that manifold choices *do not* lengthen, shorten, or change any of the (Wave-Action) Intake-Runner characteristics specified in the INDUCTION Component Category. If you begin your engine design with a SIMPLE induction choice, you will be working directly with "raw" simulation results. When your engine design has progressed, try other manifold choices to see how they are likely to affect engine performance.

- Dynomation-5 lets you to use one set of intake and exhaust valve sizes during flow-bench testing ("test" valve diameters are entered in the P*ort Flow Dialog* box along with port flow and lift data), while using different valve sizes in the simulated engine (entered in the CYLINDER HEAD Component Category). This feature can add versatility to your flow bench data; since you may wish to explore what power differences are possible with different (usually larger) valves in the engine without having to obtain new flowbench data. This is a handy feature, but there's a gotcha! If you use valves sizes that are significantly different from those used during flow-bench testing, engine simulation accuracy will suffer. If the differences are only 0.010- or 0.020-inch on a 2.000-inch valve, accuracy will be good. On the other hand, if the valves in the engine are substantially different from flow-bench data, say 0.100-inch on a 2.000-inch valve, prediction accuracy will be reduced. *If you wish to maintain the highest simulation accuracy, use the same size intake and exhaust valves in the simulated engine that were used during flow-bench testing.*

- If you are getting strange simulation results, it may be due to an incorrect data entry that you just "can't see," no matter how many times you scan over the Component screen. Do a ProPrint printout to help you review your engine data. And don't forget to give port-airflow data a close look. Make sure your pressure drops are correct. Also, if the engine file was originally created in a previous version of Dynomation-5, try recreating the engine from scratch in 5.09. If that solves the problem, send the earlier-version engine file as an email attachment to: support@motionsoftware.com and we'll try to iron-out the incompatibility issues.
- If you are having difficulties building an engine in Dynomation-5 or the simulation results are not what you expect, please contact our support team. We want to help you get the most from Dynomation-5.09!