Applying NITA to an Intake Manifold

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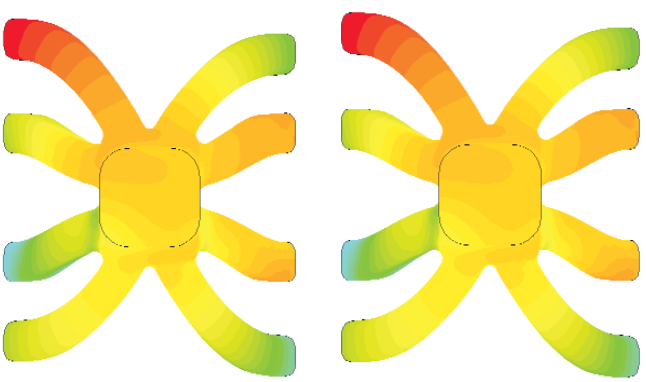
Today, CFD is extensively used to solve a variety of complex, and sometimes computationally expensive transient flow problems. While computer technology has advanced significantly, CFD algorithms continue to be developed and refined to ensure that transient efficiency is improved.

To date, the segregated solver in all versions of FLUENT has made use of an iterative time advancement (ITA) scheme, where a global iteration on the momentum and pressure (and other) equations is performed many times within each time step. The release of FLUENT 6.2 will provide two new second-order, non-iterative time advancement (NITA) schemes: the non-iterative PISO [1] method and the non-iterative fractional step [2] method. These NITA algorithms obviate the need for multiple, global iterations within each time-step. Instead, a number of sub-iterations are performed on the individual equations to ensure second-order spatial accuracy. Because global iterations are more time-consuming (and therefore expensive) than the sub-iterations, the overall computational cost of the new NITA algorithms is significantly less than the fully iterative time advancement algorithm. While the NITA schemes run several times faster than the iterative schemes, the non-iterative fractional step algorithm, which uses the SIMPLEC pressure-velocity coupling corrector, can offer up to an additional 20% improvement in transient efficiency compared to the non-iterative PISO algorithm.

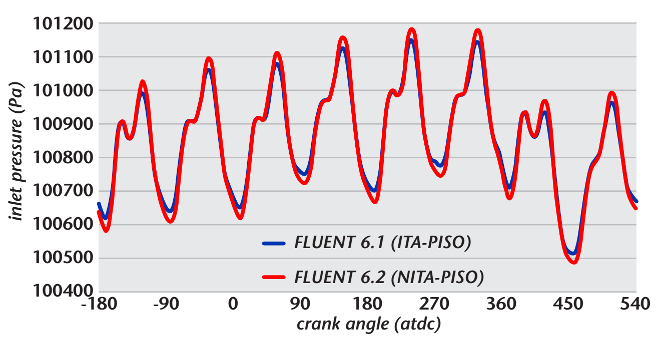
As an example of this new capability, a V8 intake manifold, typical of that used in NASCAR racing, has been simulated. The manifold has one inlet, where the carburetor is mounted, and eight outlets, which are intake runners for the engine cylinders. The mesh contains 155,000 cells, and the boundary conditions – for the inlet and all eight outlets – are prescribed using a transient table. The transient table data, which consists of mass flux and temperature values, was acquired from a 1D engine cycle simulation.

The FLUENT results have been used to provide valuable information about the nature of the manifold flow field, including total pressure losses and flow splits for the manifold runners. They have also been used to draw comparisons between the predictions of the iterative and non-iterative solvers. Static pressure contours illustrate that there are minor differences (~20 Pa) between the flow fields predicted by the iterative (FLUENT 6.1) and non-iterative PISO (FLUENT 6.2) schemes, where the latter was four times faster to solve than the former. Results such as these illustrate that the staggering improvement in transient efficiency can be achieved with insignificant compromise in numerical accuracy. ■

The intake manifold geometry



Static pressure contour comparisons between FLUENT 6.1 (left, using the iterative algorithm) and FLUENT 6.2 (right, using the non-iterative PISO algorithm) in a V8 intake manifold



Average static pressure versus crank angle at the intake manifold inlet boundary, showing good agreement between the ITA and NITA-PISO algorithms

references:

1 R.I. Issa, "Solution of the Implicitly Discretized Fluid Flow Equations by Operator-Splitting," Journal of Computational Physics **62**, p. 40-65, 1985.

2 J.B. Perot, "An Analysis of the Fractional-Step Method," Journal of Computational Physics **108**, p. 51-58, 1993.