The Road Ahead: *Simulating Scooter and Motorcycle Design*

The Moto Guzzi V85 is equipped with an 80 HP twin cylinder engine.

As a leading manufacturer of two- and three-wheeled vehicles, the Piaggio Group is constantly improving safety and customer satisfaction. Engineers routinely use software like ANSYS Mechanical to optimize engine design. Now, the engineering team is evaluating ANSYS Motion, a multibody dynamic solution that incorporates rigid and flexible solvers.

By **Riccardo Testi**, CAE Analyst, Development and Strategies, Piaggio Group, Pisa, Italy

In the world of urban mobility, the Piaggio Group is an Italian icon. Europe's largest manufacturer of motorcycles, mopeds and scooters, its stylish brands include Vespa, Moto Guzzi, Aprilia, Gilera and Derbi. The company's legacy goes back more than a hundred years, but its approach to engine development is strictly modern: Engineers depend on simulation software to optimize design, ensure rider safety and satisfaction, and help Piaggio compete against Japan's market dominance.

It was not always that way, however. With a long history of successful product launches behind them, Piaggio engineers were reluctant to part with their tried-and-true — yet expensive and

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time-consuming — approach of building prototypes and making adjustments until the design met performance standards. Accepting computer-assisted techniques was a slow and wary process. It was not until the end of the last century that they developed enough trust in finite element analysis (FEA) simulation to try it.

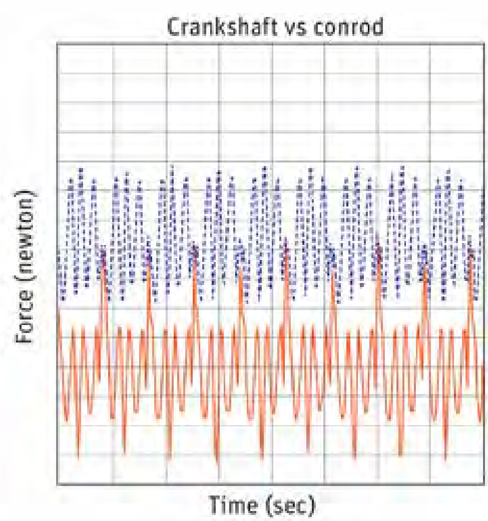
However, as the product portfolio changed over the past decade and engineers sought to better predict the behavior of new components, the adoption of simulation software accelerated. ANSYS structural solutions began to play an increasingly important role in defining component design, analyzing prototype failures and ensuring engine performance.

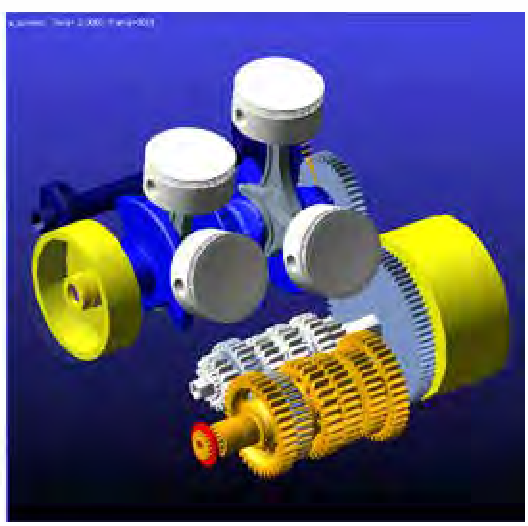
FROM TROUBLESHOOTER TO KEY TECHNOLOGY AND BEYOND

In the beginning, ANSYS software served as a troubleshooting tool that helped with Piaggio’s engine prototyping. Since then, engineers have used it to simulate complex phenomena such as nonlinear frictional load analysis for a crankshaft, making it the key technology used in the development of the company’s best-selling engines. In fact, engineers use ANSYS solutions more than any other simulation products to build virtual prototypes and overcome design challenges. By eliminating the need for multiple physical prototypes, new product development is faster and more cost-efficient.

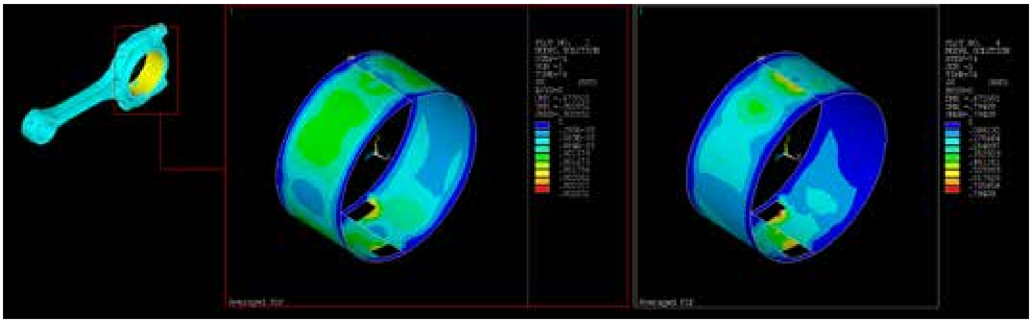
The ANSYS Workbench environment is used across all product lines, from small mopeds to large, powerful motorbikes, for several reasons: Its template-based structure greatly helps in setting up full modeling procedures, it seamlessly integrates with multiple CAE tools, and engineers appreciate its graphical user interface. In addition, they report that Workbench has reduced simulation time by 50% to 70% compared with other software. Currently, engineers are relying on Workbench to design what will be Piaggio’s most powerful four-stroke engine.

Looking even further down the road, Piaggio is evaluating ANSYS Motion multibody dynamics (MBD) software and providing test cases that have shown very promising results.





ANSYS Workbench fretting fatigue study helped determine component wear damage by simulating the exchange of forces between the conrod and the crankshaft while the engine is running.



Engineers customized ANSYS Workbench to assess whether a metallic body will break when it is subjected to time-varying, erosive forces.

THE NEED FOR SIMULATION

Whether the engine capacity is a relatively low 50 cc or a much higher 500 cc, the forces the components exert influence the overall behavior of the vehicle. Many of those forces are difficult to replicate in a lab setting, making simulation the only option.

For example, as Piaggio works to increase market share in the Far East, where bumpy roads are the rule rather than the exception, there is no other way to test vehicle performance than on a virtual landscape. It would never be practical or cost-effective to ship prototypes back and forth or to build a sufficiently bumpy test track. Consider the task of proving suspension reliability. In the past, a rider had to jump the bike off an incline and hope for a soft landing, an undertaking so dangerous that the practice was eventually abolished. Simulation eliminates risks while providing critical insight and information. Simulations can also take into account environmental variables such as wind gusts or downpours that can affect rider safety, giving drivers more control in most weather conditions.

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INTEGRATING SOFTWARE FOR POWERFUL PROBLEM-SOLVING

Of course, bad roads and heavy rains are hardly the only forces engineers must contend with. As an example, loading conditions can mean life or death for a component but are difficult to measure — historically, even the finite element method (FEM) has its shortcomings when computing load. The new ANSYS Motion solution can make a difference. With rigid and flexible solvers in a single MBD solution that integrates with other ANSYS products, it helps engineers overcome some of the most significant challenges to safe and enjoyable vehicle operation.

As a theoretical example, consider a motorcycle running at a high speed on a windy day. To predict safety, engineers would perform multiphysics simulations: create a full dynamic model of the bike in ANSYS Motion, use ANSYS CFD tools to simulate the action of the wind and then integrate the resulting simulation data into the model. Engineers could evaluate all the physical conditions (fluid dynamic, structural and multiphysics) acting on the bike's critical components in ANSYS Motion and assess its stability in the wind. After using the loading data to assess the components' structural integrity, engineers could streamline the workflow using an ANSYS Workbench project to get results and create a procedural template for future analyses.

While that is a just an illustration, a comparison between a competitor's results and ANSYS Motion's provided a real-world view of an investigation into motorcycle noise.

ANSYS Motion
ansys.com/motion

TEST CASE PROVES ANSYS MOTION MERITS

Handling, response and acceleration are all part of the appeal of motorbikes and other two-wheeled vehicles. Although it may seem surprising, for many riders, noise is too. Whether it's the sound of a revving engine signaling strength and performance or the nearly undiscernible hum of an electric powertrain, noise is integral to the buying decision and the riding experience.

But not all noises are desirable. When the Piaggio R&D team discovered an unusual acoustic emission during quick clutch engagement and disengagement, they knew something was not right. Pinpointing the cause, which they believed was related to the way pins and slots engaged in the gears, required simulating the vehicle's translational inertia. To do that, they modeled a virtual engine using a well-known MBD product.

Engineers began their inquiry by recording sound pressure peaks and torque transmissions during clutch cycles. Next, they integrated experimental boundary conditions into the model: low engine torque, low engine speed, negligible vehicle acceleration and quick clutch releases. After singling out flexible elements such as the shaft, tires, wheel hub dampers and clutch dampers, they created an auxiliary FEM model with contact between the gears. The simulation supported their hypothesis that the problem was in the gear box.

The next step was determining what to do about it. Options included reducing the angle of the gear slot, inserting a cam coupler or altering the shaft design. By simulating various alternatives that took into consideration the coupler's behavior during the clutch engagement/disengagement cycle, engineers learned that reducing the slot's angle reduced noise.

The results from the competitor's product and ANSYS Motion matched: ANSYS Motion revealed the same problem and the same solution. But that is where the similarities ended: Engineers found ANSYS Motion's features to be more efficient, and they appreciated its tight coupling with the set of FEM features that ANSYS provides.

THE EVOLUTION CONTINUES

Product development is a journey: Nothing springs fully formed from the mind of an engineer. The tools that engineers use are also ever-changing and improving. Evaluating ANSYS Motion against a long-standing software solution suggests that it may represent the next step in the evolution of MBD. Λ

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