Arctic Cat makes fast moves in the power sports market

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Riders hop on a snowmobile or ATV not just to get from one place to another but to enjoy the thrill of power sports. As indicated from their market success, the company clearly knows how to give these customers the ride they want – and naturally expect – when they rev up an Arctic Cat vehicle and go where they need no roads.

Arctic Cat is one of the early pioneers in the power sports industry and has firmly established itself as a leading manufacturer of these vehicles. Plans are to double its international business over the next three years, and for the first time ATV sales now account for more than half of the company's total sales. Unlike competitors seeing flat sales or downturns, Arctic Cat has continued to gain market share in the ATV segment every year since it started selling these popular vehicles.

As for snowmobiles, the 2007 line-up has over 75% new models, the most extensive introduction of new vehicles in the company's history – and possibly the largest in the industry for a single year. The new snowmobile designs include an innovative twin-spar chassis that provides leading-edge ride and comfort. The company's product line-up has a range of characteristics targeted toward different types of riders: touring snowmobiles that cruise along quietly, high-performance models that provide speed and lots of sporty acoustic feedback, and mountain vehicles with added pulling power at lower gears. Likewise, ATV models include models for sport, general utility, multi-rider and young drivers.

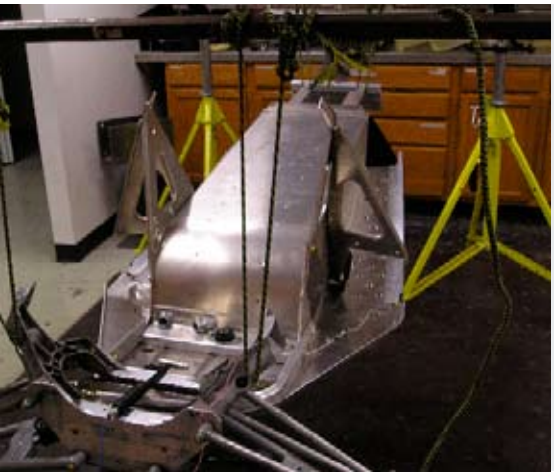
This full line-up of models includes unique designs based on latest technology to attract new buyers and retain them with a steady stream of new products designed around the unique Arctic Cat identity. "Snowmobile customers are intensely brand loyal and driven to purchase machines which capture their imagination with innovation and advances in technology," says Arctic Cat Chairman and CEO Chris Twomey. "Overall, 92 percent of snowmobile customers are repeat buyers – and new, innovative products are what drive them to buy. To maintain a fast, steady stream of new designs, we have implemented product development technologies as innovative as our vehicles."

Leading-edge NVH technology

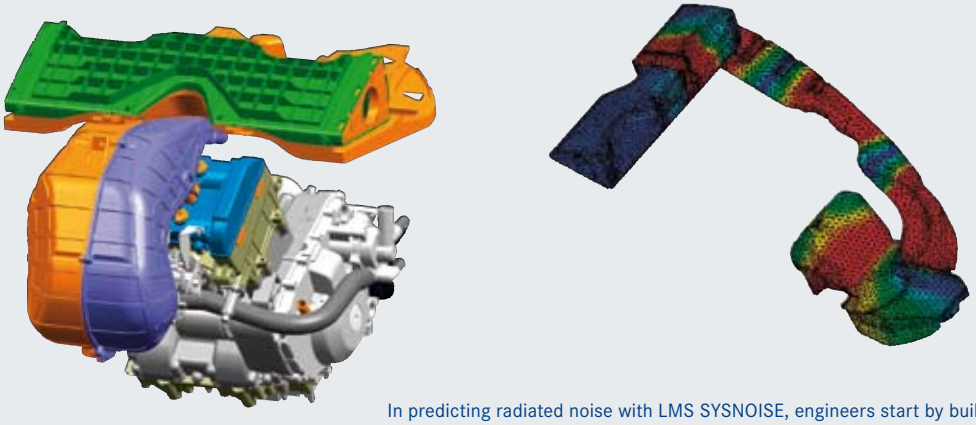
According to Twomey, an essential part of Arctic Cat's ability to develop such a wide range of innovative new vehicle models so quickly is the company's investment in an NVH center that rivals those found at automotive companies and is a first in the power sports industry. The 3,500-square-foot facility has some of the most advanced NVH testing equipment available including a chassis dynamometer for simulating trail and high-performance riding conditions, a semi-anechoic sound chamber, and a sound-quality room for juried evaluations.

NVH Engineering Manager Bala Holalkere notes that running tests and taking measurements such as vehicle sound levels in the controlled environment of the lab overcomes the limitations of outdoor measurements where variables

Arctic Cat engineers put passion into their machines using LMS solutions to design the right sound, feel, ride and handling into a record number of new vehicles developed faster than ever.



To determine chassis compliance, modal tests are done to determine resonate frequencies by exciting the structure to vibrate with an instrumented hammer.



In predicting radiated noise with LMS SYSNOISE, engineers start by building acoustic models based on CAD geometry. The primary focus of their simulation is typically the air intake system, including the plenum, air box and inlet assembly shown here as the colored parts fastened to the top of the four-cycle snowmobile engine.

such as background noise, temperature and wind direction can affect readings, and additional time often is needed for travel to locations with satisfactory conditions.

According to Holalkere, “LMS technology is a key element in Arctic Cat’s NVH efforts.” Vibro-acoustic testing of vehicle hardware is performed using LMS Test.Lab with two high-speed multichannel SCADAS III front end units, each with 20 input channels and two tachometer channels to accommodate data acquisition typically from two microphones, 14 accelerometers and engine sensors. The units each have an integrated suite of built-in tools for test control, measurement, result analysis, data management and report generation.

He explains that LMS Test.Lab is particularly useful in efficiently running repeated tests. Test setup and required signal processing tasks only need to be defined once, after which they are saved in a dedicated template. These procedures can then be performed automatically test after test with highly consistent results. Tests are thus able to be performed very quickly and are highly repeatable, allowing engineers to build up a knowledge base of sound signatures from various vehicle models and different part configurations, for example. This is valuable information for comparing results and working with designers in optimizing vehicle behavior.

Another aspect of LMS Test.Lab that greatly improves testing productivity is on-line data processing. “Data is automatically processed as measurements are being taken, so engineers can see results immediately instead of waiting hours for post-processing,” he says. “This provides greater insight into the noise and vibration behavior of the vehicle, and enables the verification of test data on the spot.

In combination with physical testing, Arctic Cat engineers use two simulation software programs for virtual modeling to predict the behavior of vehicles and subsystems: LMS SYSNOISE for determining radiated sound levels and LMS Virtual.Lab Motion, a multi-body dynamics program for studying the paths and loads of moving parts and mechanical behavior of vehicles.

“Simulation provides the capability to study and optimize vehicle designs early in the development cycle,” says Holalkere. He notes that design of snowmobiles and ATVs must satisfy multiple requirements. The sound of the machine must have a tone and quality geared to rider expectations while complying with government noise limits, structure-borne engine vibration must be minimized for rider comfort, and the chassis and suspension have to provide the required levels of stiffness and damping for smoothing out bumps while maintaining good vehicle maneuverability.

“The challenge is to balance these attributes for the right sound, feel, ride and handling that altogether make up the overall riding experience,” he explains. “By performing this work up front with the predictive capabilities of virtual prototyping, we can identify problems early, quickly evaluate alternatives and refine designs in the early stages

“Efficient and targeted testing with LMS Test .Lab enables our engineering teams to build a valuable NVH knowledge base of existing hardware that helps guide the design of innovative new models.”

of development. In this way, LMS technology helps our engineers design many more products much faster than is otherwise possible."

Shaping sound profiles and quieting noise

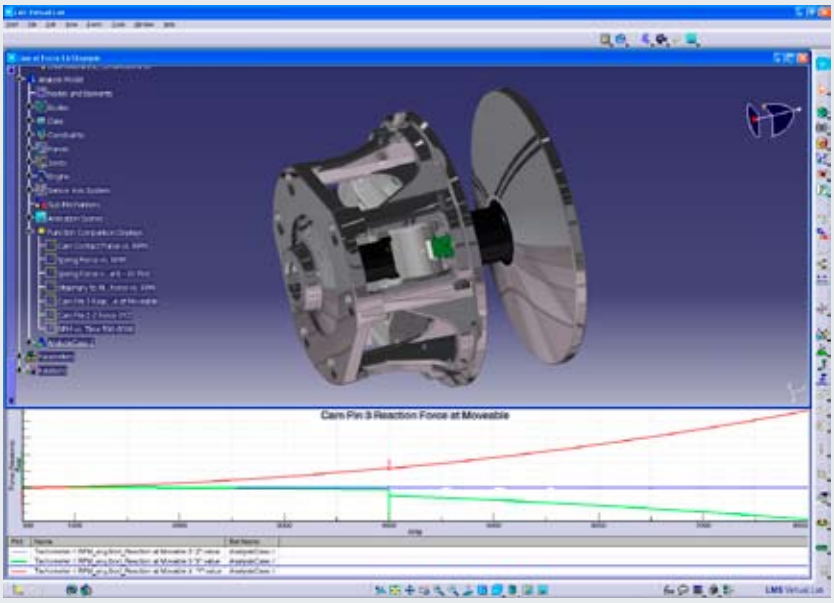
One major issue for power sports equipment manufacturers is ensuring strict compliance with pass-by noise regulations outlined in the SAE J192 standard that specifies a maximum sound level of 78 dB at 50 feet with wide-open-throttle acceleration.

"LMS Test.Lab is instrumental in improving our turnaround times for noise compliance tests," says Arctic Cat Test Engineer Abhay Rawal. "Efficient set-up, task automation and on-line monitoring mean that in a few hours we can typically complete a pass-by test that otherwise could possibly drag on for days without these capabilities."

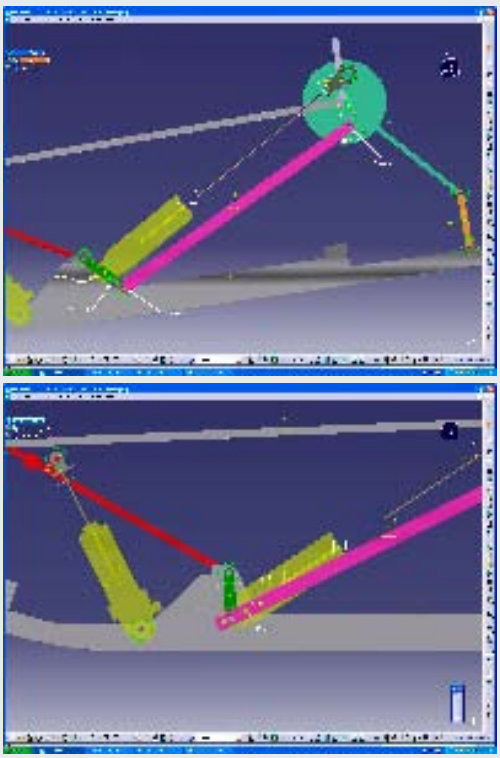
Another critical element is acoustic quality, which defines Arctic Cat's brand value. Engineers aim for a specific tone not corrupted by mechanical clanging or other secondary noise. The goal is an overall linearity in loudness, with amplitude increasing steadily as a function of engine speed. This acoustic behavior is often difficult to achieve with two-cycle and four-cycle engines, which often exhibit sound amplitude fluctuations at various speeds.

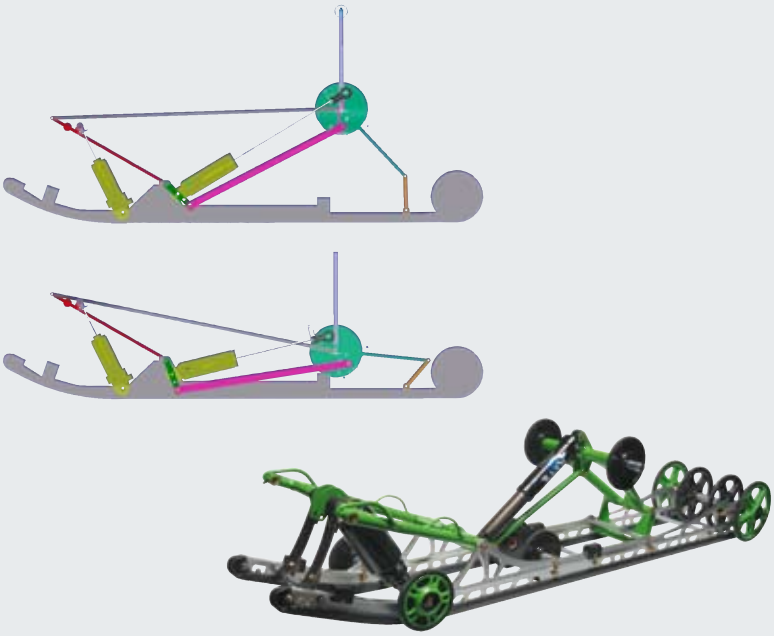
Arctic Cat's process of shaping the vehicle sound profile generally involves comparing a target signature with prototype test data. Frequency analysis with LMS Test.Lab enables NVH engineers to study overall sound quality and identify the influence of various subsystems including the engine, air intake, exhaust as well as gears, tracks and chassis resonances. Using LMS SYSNOISE, engineers can quickly study the impact of various vehicle modifications to muffle unwanted noises and attenuate the desired sounds.

NVH Analyst and Design Engineer Mark Claywell explains that the LMS acoustics prediction software provides greater insight into finding ways of modifying the design to change the sound profile. Considerable attention is focused on the intake system in which ambient air enters a small port and is drawn into the engine through a circuitous plenum and air box chamber. Often several feet in total length, the relatively thin-walled intake system can reverberate from combustion pulsations. The multiple internal compartments and complex, winding shape of the system – contoured to fit tight vehicle packaging requirements



LMS Virtual.Lab Motion represented the masses, inertia and interrelated physics of this CVT clutch, providing engineers with detailed load data on individual components for redesigning the assembly.





In redesigning a snowmobile suspension from a torsion spring to a coil spring configuration, Arctic Cat engineers studied stiffness and load-carrying capabilities using Virtual.Lab Motion to quickly perform multiple iterations of a suspension analysis that included different pivot locations, linkage lengths, motion ratios, and spring rates.

– make the task of predicting noise generation difficult.

"In the past, manual calculations would be used in trying to figure out the best shape of the intake as well as the size and placement of resonators inside the air box. Then physical prototypes would be built, tested and modified until an adequate sound profile was achieved," says Claywell. "LMS SYSNOISE enables us to compress the time to evaluate an intake design from a week to a few hours. Moreover, the final sound is closer to our target profile because we can go through many more change iterations than is practical otherwise."

Feel, ride and handling – becoming one with the machine

Arctic Cat engineers utilize LMS Test. Lab in combination with LMS Virtual. Lab Motion in studying structure-borne-transmission of engine vibration and trail bumps, and the maneuverability of the vehicles in making turns. By studying various rider demographics, Arctic Cat applies the LMS tools in quantifying these otherwise subjective characteristics. Target requirements then can be cascaded from overall system-level behavior to development of subsystems and components in an approach similar to that used in the automotive industry.

A major strategy in Arctic Cat's rapid introduction of multiple new models is to use common part types wherever possible, with 80% of the company's 2007 vehicles having the same chassis, for example. "We put considerable effort into ensuring chassis performance is optimal in meeting the requirements of a broad range of vehicles," says test engineer Abhay Rawal, who notes that throughout much of the power sports industry this is a "black art" involving considerable engineering experience, manual calculations, guesswork and trial-and-error iterations.

In Arctic Cat's process, LMS Test. Lab is used in quantifying chassis compliance – essentially an inverse measure of structural stiffness. Modal tests determine resonate frequencies by exciting the structure to vibrate with an instrumented hammer. Results from these dynamic tests are then correlated with static tests where the structure is bent and twisted under various torsional, vertical and lateral loads. From these measurements, Abhay readily determines the compliance level of the chassis.

"The goal is to strike a balance of stiffness for optimal maneuverability without having compliance so low

that riders feel excessive bumps and vibrations," explains Abhay. "LMS Test.Lab is a valuable tool in quickly determining the critical chassis compliance level by performing tests so efficiently and accurately."

NVH Product Development Engineer Dale Hahn explains that LMS Virtual.Lab Motion is used in an increasing number of simulation projects at Arctic Cat involving mechanical performance of vehicles. In a recent redesign of a snowmobile suspension from a torsion spring to a coil spring configuration, for example, the software was used in quickly predicting the stiffness and load-carrying capabilities of the new design to help engineers better understand the ride and handling.

In another example, the software was used to model a clutch for a continuous variable transmission (CVT) for studying the vibration and reliability of the assembly. "Since the unit operates on centrifugal force, using LMS Virtual.Lab Motion is of considerable value in accurately representing the masses and inertia of these complex components – as well as all the interrelated physics of the mechanism. In a few hours we obtained detailed load data that could not have been produced from weeks of prototype testing."

Business value of NVH engineering

According to Roger Skime, Arctic Cat Vice President of Engineering and International Snowmobile Hall of Fame inductee, NVH engineering is an integral part of the company's product development process and business strategy.

"Efficient and targeted testing with LMS Test .Lab enables our engineering teams to build a valuable NVH knowledge base of existing hardware that helps guide the design of innovative new models. The predictive capabilities of LMS Virtual.Lab simulations enable engineers to change new designs up-front in development to achieve the right performance, before any hardware is built. Simulation saves time and money in development and lets us deliver the required sound, feel, ride and handling for our vehicles," says Skime.

"This combination of test and simulation is where the future lies in NVH for the power sports industry, and Arctic Cat is proud to be leading the way with advanced tools that leverage the expertise of our dedicated and talented engineering staff in developing some of the most innovative and popular snowmobiles and ATVs on the market." ■

LMS INTERNATIONAL
Researchpark Z1, Interleuvenlaan 68
B-3001 Leuven [Belgium]
T +32 16 384 200 | F +32 16 384 350
info@lmsintl.com | www.lmsintl.com

Worldwide

For the address of your local representative, please visit www.lmsintl.com/lmsworldwide

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