Tracking Jet Engines

Volvo Aero leverages HPC to help track engine part wear, saving customers service and replacement costs.

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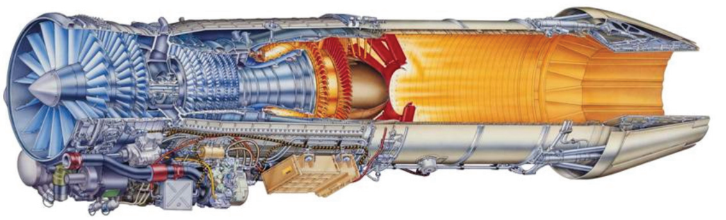


Volvo RM12 engine used in the Gripen fighter

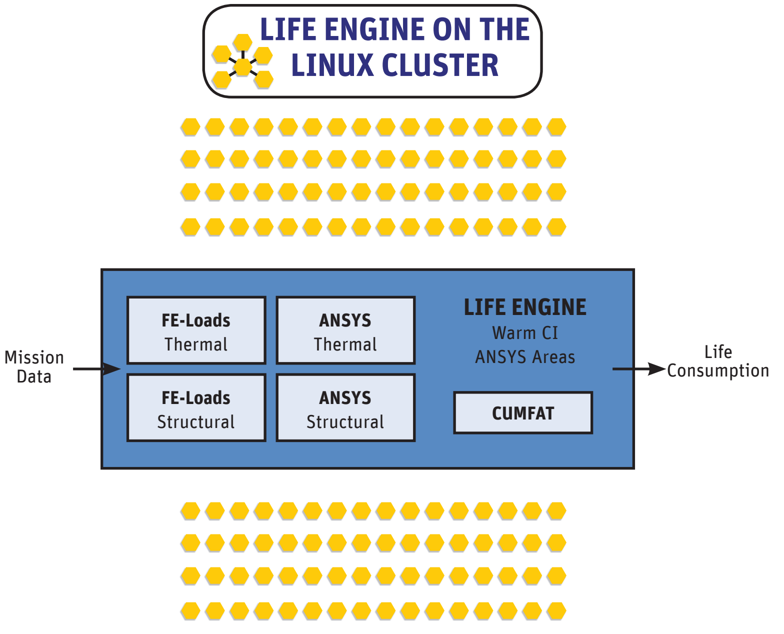
Fighter jets fly a wide variety of missions, and the level of wear on individual engine parts depends upon the types of missions flown. To more accurately predict an engine part's life consumption, designers at Volvo Aero in Trollhättan, Sweden, began collecting data — including time, speed, temperature, pressure and other engine part conditions — about 10 years ago to determine how engine part wear relates to mission conditions. By combining this information with data from current missions and analyzing it using ANSYS structural mechanics software, some proprietary in-house and commercial tools, and a cluster of computers, Volvo Aero is now able to accurately predict when each part in a particular jet engine needs to be replaced or serviced. Using this system, service technicians at external customer organizations can save time, reduce costs and improve safety by treating each engine based on its own unique history.

Volvo Aero develops and produces components for aircraft, rocket and gas turbine engines that have a high-technology content. The company's project to predict component life consumption is called the Life Tracking System (LTS), and it is used for the Volvo RM12 engine that powers the Saab JAS39 Gripen fighter. The specific component that calculates the remaining service life in each engine part is known as Life Engine. At the end of each flight mission, sensitive load data from the aircraft is sent to a server, checked for errors and cleared of classified information. Then the LTS server automatically matches this data with the individual parts present in the engine. The system orders Life Engine to use structural and thermal calculations within software from ANSYS to determine the life consumption for engine parts. LTS stores this data in an online database, and the customer's in-house maintenance system is updated at regular intervals.

Harnessing Data

In the past, Volvo Aero used ANSYS structural mechanics products to calculate engine part fatigue, but each simulation relied on standard duty-profile data from a jet's typical missions. In reality, however, the missions can vary widely — from combat to training to reconnaissance — and they can take place under a broad range of temperatures and conditions. The duty-profile method of calculating fatigue resulted in many cases of engine parts being serviced and replaced earlier than necessary, as well as engines undergoing maintenance more often than required. As a result,

JAS39 Gripen fighter



Life Engine data flow for components requiring thermal stress analysis and failure mode crack initiation. Life Engine automatically calculates temperature and stress time history using ANSYS structural mechanics software. Then the Volvo Aero in-house code, known as CUMFAT (cumulative fatigue), uses that data to predict life consumption.

the jet's owners incurred unneeded expenses that could be avoided by using LTS. On the other hand, the engine parts that are used much more stringently than the duty-profile suggests must be replaced more often, so safety is enhanced with LTS.

As the LTS took shape, the team collected massive amounts of new data (tracking the use of each part during each second of every mission) and quickly realized that the volume of mission data could easily overwhelm the project. For instance, under the old system, the engineering team performed about 100 ANSYS structural mechanics simulations to calculate a component's life. Now, tens of thousands (maybe even hundreds of thousands) of calculations are required, and today's typical models contain approximately 25,000 nodes, including nonlinear contact elements for structural analysis. Because of this increase in problem size, the team needed to develop fully automated analysis processes and to step up processing power; otherwise, the time needed to calculate wear on all parts and all missions would be unrealistically long.

It was clear that Volvo Aero needed to move LTS to a high-performance computing architecture with multiple nodes. Fortunately, the engineering team had access to an existing cluster of more than 200 nodes running on desktop personal computers using the Linux® operating system. Now, LTS assigns each node a life-consumption calculation for each mission, automatically determining free resources on the cluster and available ANSYS Mechanical licenses. The cluster can run up to 128 independent and simultaneous simulations and then upload to a database.

Maximizing Resources

Even though Volvo Aero had been using ANSYS structural mechanics technology for years to perform engine part fatigue analysis, the team did consider other software when constructing LTS. Key to the selection of ANSYS was the program's scalability — both in terms of parallel performance and the business model to support the order of magnitude increase in the number of design-point analyses performed. In addition, the ANSYS parametric design language (APDL) made it particularly well suited for integration with Volvo Aero's automated LTS. Life Engine has been running for several years, and the engineering team continues to maintain integration with new versions of ANSYS software.

To improve efficiency, Volvo Aero uses two types of models: fine model and rough model. Initially, the team runs finer models to identify the life-limiting locations in each component. These models have 50,000 to 500,000 nodes and typically take a week to run for one mission — a large improvement over the four weeks it took in the past. The main challenges are the number of contact elements — about 1,000 — and the need for nonlinear analysis. (Although simulation time with a linear model would be dramatically lower, the results would be less accurate.) For the next stage, the team uses the rough model to do the analysis on a portion of all missions. This typically takes from one day up to a week, depending on the length and complexity of the mission. The local ANSYS channel partner Medeso has worked with Volvo Aero to streamline the analysis process and minimize simulation time.

Volvo Aero has found that ANSYS structural mechanics technology delivers very accurate results in revealing stresses and temperatures for each mission. It is critically important to get these parameters correct to predict how much life will be consumed for a particular engine component. With Volvo Aero's LTS relying on ANSYS software, external customers' service departments can replace and maintain parts only when necessary — and take that benefit right to the bank. ■

The author thanks ANSYS channel partner Medeso in Sweden for their contributions to this article as well as their work to streamline the Volvo Aero analysis process and minimize simulation time.