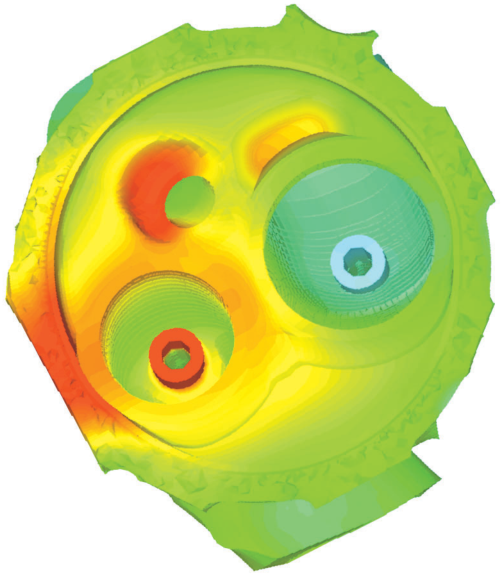
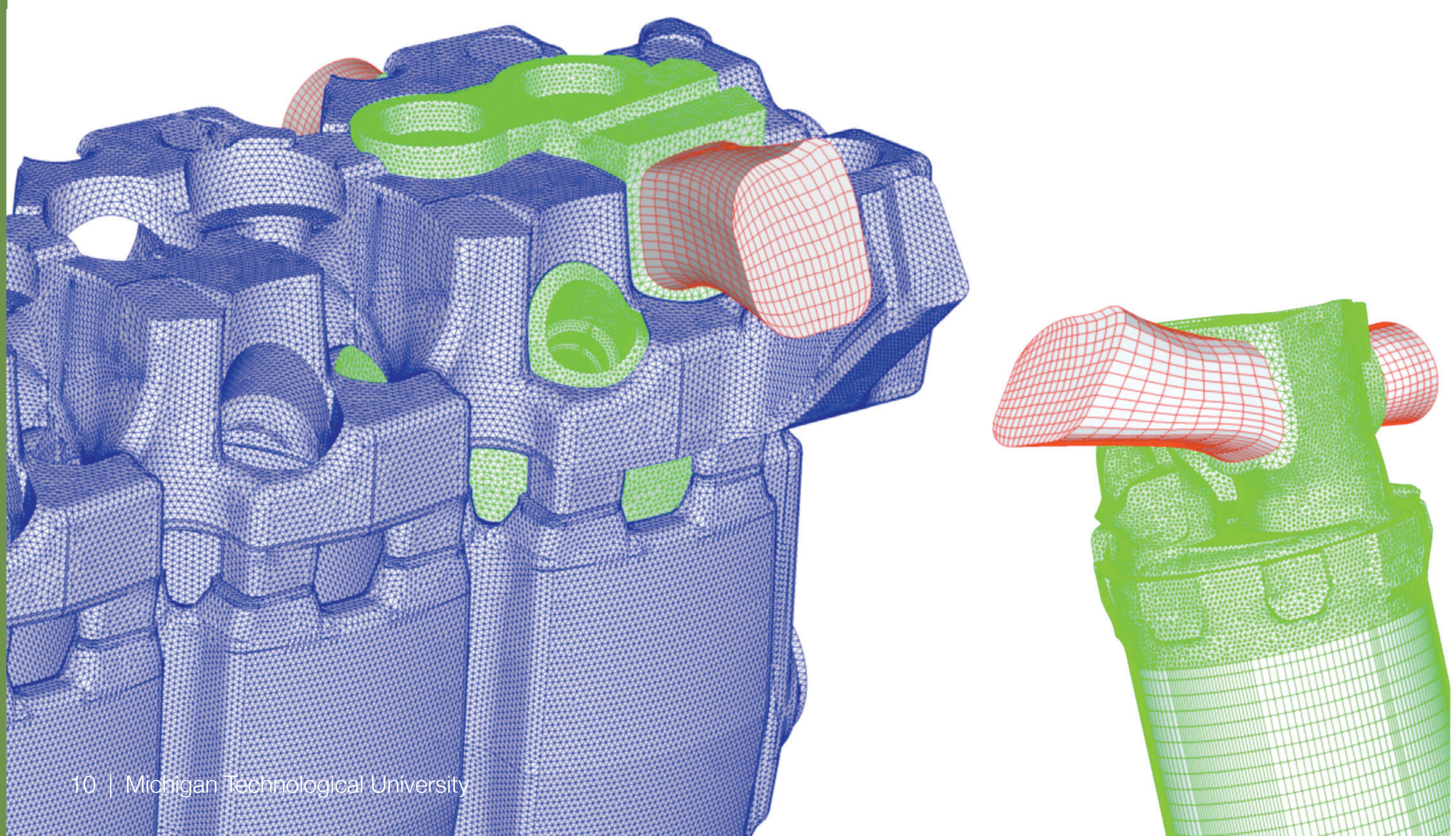
Song-Lin (Jason) Yang
Mechanical Engineering-Engineering Mechanics



Pictured: CFD Model for a 5.4L V8 engine with cooling jacket (in blue), along with a predicted engine head temperature profile.



Virtual engines

Speeding the way with computational fluid dynamics

Throughout aero-vehicle evolution, scientists and engineers have attempted to improve engine efficiency—making engines smaller, lighter, quieter, fuel-efficient, and yet more powerful.

Song-Lin (Jason) Yang has been studying jet engines since 1989, using computational fluid dynamics (CFD) to examine problems in engine fluid mechanics, heat transfer, and combustion.

"When I was in school, CFD was practically unheard of," notes Yang. "Back then, aircraft design was mainly conducted in a wind tunnel, with little or no computational fluid dynamics. Today about 75 percent of jet engine design research is accomplished with computer modeling. CFD is so popular and so powerful that it has become a separate discipline. It is simply faster and cheaper than fabricating hardware and doing experiments. Wind tunnel tests are now used for other steps, including model calibration, validation, and product reliability."

CFD provides guidance to engineers by identifying the performance characteristics of various engine components—information that can then be used to develop, analyze, integrate, and optimize the system performance. CFD uses numerical algorithms to analyze problems that describe the conservation laws of mass, momentum, energy, and chemical species. Computers perform the millions of calculations required to simulate the interaction of fluids with surfaces defined by boundary conditions and geometries.

In particular, Yang is an expert on KIVA code, a modeling and simulation code developed by Los Alamos National Laboratory that simulates multidimensional compressible turbulent in-cylinder flow with sprays. He incorporated a conjugate heat transfer model into KIVA code for the study and control of engine knock and the design of engine cooling systems. To better model the anisotropic turbulent flow, Yang also incorporated a Reynolds stress turbulent model into KIVA code to simulate complex engine flow.

In addition to CFD research, along with his students, Yang developed a thermodynamic cycle analysis code to conduct parametric studies of a dual-spool, separate-flow turbofan jet engine with an interstage turbine burner (ITB). "The ITB serves as a secondary combustor," Yang explains. "It increases thrust and reduces NOx. Almost all commercial aircraft engines have a transition duct between the high-pressure and the low-pressure turbine. It makes a lot of sense to make use of the existing space." Using design parameters such as flight Mach number, compressor pressure ratio, fan pressure ratio, fan bypass ratio, Yang is able to define performance parameters such as specific-thrust and thrust-specific fuel consumption.