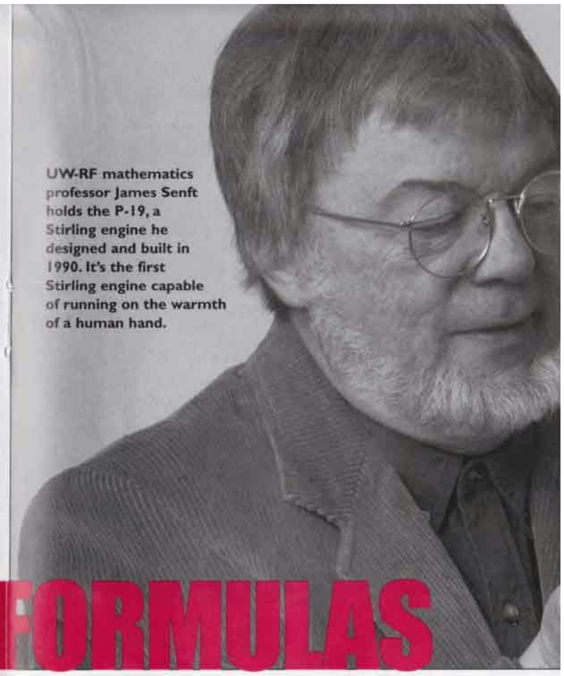
WHAT SETS US APART? **STIRLING ENGINE EXPERT**

OF ENGINES AND FORMULAS

How a life-long fascination with engines led to a new mathematical formula, two U.S. patents, and international recognition. BY MICHAEL WOOLSEY.



UW-RF mathematics professor James Senft holds the P-19, a Stirling engine he designed and built in 1990. It's the first Stirling engine capable of running on the warmth of a human hand.

Resting on the window sill of his North Hall office, a very small solar voltaic engine spins rapidly in the afternoon sun. For mathematics professor James Senft, the fascination with engines began as a boy—building gas-powered model car and airplane engines. "My father was a machinist and I would build my own engines. I owe a lot to my father," says Senft, recalling his youthful days in his father's basement shop.

Senft built his first steam engine when he was in the eighth grade. One day, while perusing a back issue of *Popular Mechanics* magazine at his uncle's house, he became fascinated by an article on the Stirling engine. Not long after, he set off to build his own and has been an expert on the engine ever since.

The Stirling is a heat engine different from an internal-combustion engine. Debuting in 1816, the Stirling has no exhaust valves that vent high-pressure gases. No explosions take place because the energy source that pushes the piston is outside the cylinder, in the form of an uninterrupted heat flow. The vacillating temperature differences from hot to cold force the piston up and down, resulting in work. The repetitive cycle of compression and decompression within the cylinder is referred to as the Stirling principle.

Senft balances the horizontal base of a Stirling engine, model "P-19," in the palm of his hand. The vertical flywheel mounted on top slowly begins to turn. The "P-19" Stirling engine was designed and built by Senft at UW-RF in 1990 to operate with ultra small temperature differences between its warm and cool sides. The "P-19" was the first Stirling engine capable of running on the warmth of a human hand. Senft's innovation is internationally recognized, the result of two decades of research and discovery.

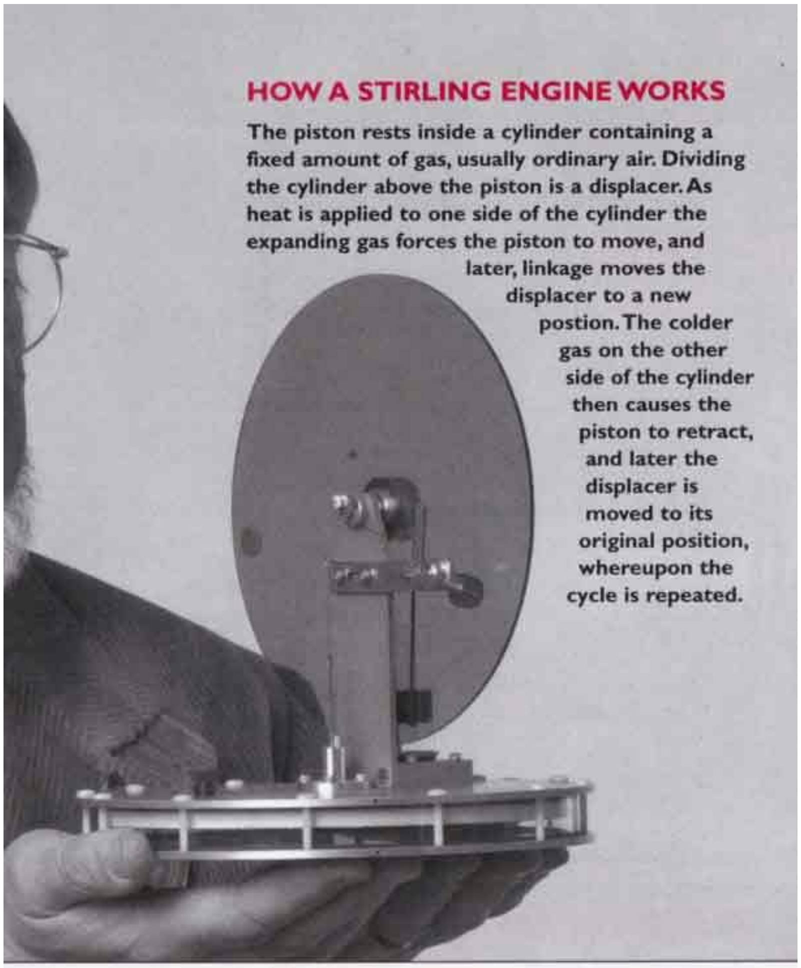
"I got the germ for the idea while doing research for Argonne National Laboratory," says Senft of the low-temperature Stirling engine. He was aware of the low-temperature Stirling engine studies of another scientist, Ivo Colin of the University of Zagreb, Yugoslavia. Following the Ringbom principle—which utilizes the flywheel's energy to aid the lift of the engine's displacer—Senft built a large Stirling engine which passed the low-temperature test.

Senft's work at Argonne National Labs in Illinois led him to a mathematical formula that identifies the "theoretical maximum of the mechanical efficiency that no engine can exceed." Senft explains that each engine has thermal efficiency and mechanical efficiency. Thermal efficiency considers fuel usage. Mathematical formulas for fuel efficiency have existed for many years. However, no one had discovered an effective mathematical formula that represents the limits of an engine's mechanical efficiency until Senft did so in1984. To the layman, the mathematical formula is rather complicated, but its finding is significant in that an engine's mechanical efficiency can be more precisely determined before production.

Senft recalls a company in the early 1980s that had plans to substitute diesel engines for Stirling engines in a proposed machine. He was skeptical of the plan based on the issue of mechanical efficiency. "I didn't know precisely why it wouldn't work," says Senft. But the development of the mathematical formula proved why. Had Senft's formula been known then, the costly project could have been avoided. Instead, it proceeded and failed.

Senft's mechanical efficiency formula took years of work to discover but he wasn't purposefully searching for it. "This is the way scientific research leads you. Like a little kid wandering through a museum, you're led from one discovery to the next," says Senft. The mathematical formula has always been out there, he notes. It just took someone to find it. "These things are bigger than us," he argues.

The Stirling engine saw the peak of its popularity in the beginning of the last century. Very few mainstream industries pay much



HOW A STIRLING ENGINE WORKS

The piston rests inside a cylinder containing a fixed amount of gas, usually ordinary air. Dividing the cylinder above the piston is a displacer. As heat is applied to one side of the cylinder the expanding gas forces the piston to move, and later, linkage moves the displacer to a new postion. The colder gas on the other side of the cylinder then causes the piston to retract, and later the displacer is moved to its original position, whereupon the cycle is repeated.

attention to it today. Yet, the Stirling has found a place at NASA for environments that lack oxygen. The space agency has sought Senft's expertise with projects related to the engine. Today, the Stirling is used to harness the sun's energy to produce electricity.

But Senft doesn't concern himself with specific practical purposes for the Stirling. "It's the journey of discovery that's important," he says. He now holds two Stirling engine-related U.S. patents. Former students in his classes are now working on projects for NASA; some are obtaining their doctorates in physics. His expertise is sought by students worldwide. "Two students from Ireland sent me a CD of some Irish harmonic music in appreciation for my help," says Senft of a recent overseas exchange of information that led to an award-winning project.

However, the core reason for utilizing the Stirling engine in his academic endeavors is to illustrate a practical application of mathematical formulas. The connection between math and machine was instilled in him by his father in their basement shop. He keeps that connection alive in his university classroom. ■