"Scientists report solving one of the oldest problems in mechanics"

Being able to accurately predict the life span of physical bodies, both living and non-living, has been one of humankind’s eternal endeavors. Over the last 150 years, many attempts were made to unify the field of classical mechanics — the science concerned with the behavior of all physical bodies in the universe — and thermodynamics, the science concerned with the relationships among all forms of energy in the universe, in order to create a generalized and consistent theory of evolution of life-span.

Until now, none of these attempts had been successful.

Simply put, classical mechanics only provides response of physical bodies to external disturbances, but does not take into account changes, like aging, which happen in the physical body over time. Thermodynamics, on the other hand, provides information about changes happening in a physical body over time, but does not give any information about the response of a body to external disturbances. As a result, it is not possible to predict the life span of a bridge or define the relative age of a living organism based on its past experiences using computer simulations, alone.

Professors Cemal Basaran, Leonid Sosnovskiy and Sergei Sherbakov believe they have succeeded in solving this problem based on a novel idea they call “tribo-fatigue-entropy”. The theory has the potential to predict life span of all organic and inorganic bodies based on their anticipated future experience scenarios and past experiences.

Dr. Cemal Basaran is a professor at University at Buffalo, Dr. Sergei Sherbakov is at the Belarussian State University and Dr. Leonid Sosnovskiy is a Laureate of the State Prize of Ukraine, and Honored Scientist of the Republic of Belarus.

The field of classical mechanics is based on Sir Isaac Newton’s work in “The Principia,” published in 1687. In this work, Newton introduced the world to three universal laws of motion, which describe the relationships of any object, the forces acting upon it and the object’s resulting motion. It is these three laws that make up the foundation for classical mechanics, and all subsequent theories of mechanics are derived from them.

But classical mechanics still cannot account for the past, present or future of any aspect of a physical body. For example, classical mechanics can be used to calculate the amount of sagging (deflection) on a bridge caused by its traffic load. The stiffness of the bridge will naturally degrade over time from use, just as all other physical bodies’ age. When the sagging (deflection) of the bridge is measured on its first day of service, the amount of sagging is being predicted using classical mechanics equations.

Yet once the bridge reaches its final days of service, the actual amount of sagging at that point will be much larger than what had originally been predicted with the classical mechanics equations. The bridge will collapse due to fatigue, without any mathematical warning from continuum mechanics equations as to when that collapse would happen.

The degrading stiffness of the bridge, and the resulting increase in sagging, occurs continuously, according to the laws of thermodynamics. Unlike classical mechanics equations, which assume a physical body's stiffness does not change over time, the laws of thermodynamics do govern the past, present and future of any physical body's energy.

Around 1850, Rudolf Clausius and William Thomson (Kelvin) formulated both the First and Second Laws of Thermodynamics. Because the field of thermodynamics governs the past, present and future of all physical bodies, the aging process and life span of any physical body can be modeled in accordance with the laws. Still, thermodynamics alone cannot convey the response of a physical body under an external force at any given moment – something classical mechanics equations are able to achieve.

Attempts to unify the fields of classical mechanics and thermodynamics have been exhaustive since 1850. The objective has been to map out the aging process of a physical body using classical mechanics equilibrium equations while also predicting its life span. All past attempts were based solely on the use of physical experiments, which would reveal the aging rate and life span of any physical body first. The experimental data would later be used to create a life-span expectancy model.

The new theory, introduced by Professors Basaran, Sosnovskiy and Sherbakov, does not rely on such lengthy experiments, and instead uses significant time- and cost-saving calculations.

Professors Basaran, Sosnovskiy, and Sherbakov report the new theory can now predict the aging and life span of any physical body based purely on mathematical calculations and without the need for any prior life-span testing. Professor Basaran was the first person to propose using irreversible entropy – a quantity representing the energy already consumed, and scientifically spoken of as the degree of disorder in the system due to spent energy – and its generation rate, or how fast energy is spent, as a measure of aging (fatigue-life) in 1997. All physical bodies die when their irreversible entropy generation rate reaches zero, according to the laws of thermodynamics.

At the University at Buffalo Electronic Packaging Lab, Professor Basaran had experimentally verified his theory extensively since 1997, as other researchers around the world have done. The unified theory, however, lacked a mathematical proof. Professors Sosnovskiy and Sherbakov recently proved this theory mathematically and also experimentally in the journal *Entropy*, 2016, 18, 268; http://www.mdpi.com/1099-4300/18/7/268

The new unified theory, now referred to as Mechano-Thermodynamics by researchers, does not need any prior life-span determination test data to predict the life-span of all physical bodies. It does, however, stipulate that calculations must define a physical body by its irreversible entropy and its generation rate, in addition to classical mechanics variables, such as displacement (sagging), as used in the bridge example.

All required unknowns can be calculated with the new unified theory. Any physical body's age can be defined between zero and one – age is "zero" at birth, while age is "one" at death, when the physical body breaks down. This scale means a 20-year-old who has died in a car crash would be age “one,” while a 95-year-old who is alive would be age “0.9.” This way of calculating age removes time as its determinant, because time is not a consistent measure of the age of a physical body. With the zero/one scale, every physical body is born at zero and breaks down, or dies, at one.

The age of any physical body, according to the new unified theory, can be calculated using the irreversible entropy and its generation rate in conjunction with classical mechanics equations. For example, to calculate a bridge’s sagging due to traffic, engineers must calculate the sagging (deflection), as well as the irreversible entropy and generation rate. As a result, the aging of the bridge will be accounted for in the classical mechanics calculations.

Because the spent energy amount increases and the energy spending rate changes continuously, the bridge’s sagging will increase continuously. And according to the laws of thermodynamics, all physical bodies die when their irreversible entropy generation rate becomes zero. Therefore, the unified theory equations can predict the life span and impending failure of every single object in the universe.