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4D printers: integration of multi-material additive manufacturing with intelligent heads to predict the fourth dimension

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3D printing is a relatively known manufacturing process and the inimitable features provided by 3D printing (such as complexity-free geometry and material saving) are also well-known. Similarly, 4D printing should be explicitly underpinned as a novel manufacturing technology and the unique traits empowered by 4D printing should be elucidated too. 4D printing was initially defined as a combination of shape memory materials and additive manufacturing. In our recent review paper, I illustrated the differences between 3D and 4D printing. In addition to smart (not necessarily shape memory) materials and additive manufacturing, "4D printing mathematics" is also required to yield a "4D printed" structure. Furthermore, unlike 3D printers, 4D printers are not available and the 4D printing process is currently accomplished by existing 3D printers in a passive manner. The phrase "4D printer" was used in the related literature. However, I need to clarify that; "4D printer" is not truly established by converting a single-material printer into a multi-material printer, or by incorporating different additive manufacturing methods into one printer. I should add that a "4D printer" must be capable of investigating and predicting the "4th D". Consequently, an "intelligent head" should be constructed and integrated with present multi-material printers. In this plenary talk, I will underpin 4D printing as a novel manufacturing paradigm, illuminate its unique features, and particularly prove its energy-saving feature by deriving its minimum energy consumption limit. Finally, I will embody future 4D printers and their connections to our laws of 4D printing.

Recent Publication:

1. Momeni, F., Hassani, S.M.M., Liu, X., & Ni, J. (2017). A review of 4D printing. Materials & Design, 122, 42-79.
2. Momeni, F., & Ni, J. (2018). Nature-inspired smart solar concentrators by 4D printing. Renewable Energy, 122, 35-44.
3. Momeni, F., Sabzpoushan, S., Valizadeh, R., Morad, M. R., Liu, X., & Ni, J. (2019). Plant leaf-mimetic smart wind turbine blades by 4D printing. Renewable Energy, 130, 329-351.
4. Momeni, F., Morad, M. R., & Mahmoudi, A. (2016). On the thermal efficiency of power cycles in finite time thermodynamics. European Journal of Physics, 37(5), 055101.
5. Morad, M. R., & Momeni, F. (2014). A note on the use of the temperature–entropy diagram in the proof of the second carnot theorem. European Journal of Physics, 35(2), 028004.
6. Morad, M. R., & Momeni, F. (2013). On the proof of the first Carnot theorem in thermodynamics. European Journal of Physics, 34(6), 1581

Biography

Farhang Momeni received his BS in Aerospace Engineering from the Sharif University of Technology in 2014. He finished his BS in three years rather than the usual four years (Sep 2011-Sep 2014), while he was ranked 1st among all B.S. students in Aerospace Engineering at the Sharif University of Technology that graduated in 2014. He published two journal articles in Thermodynamics before his B.S. graduation date. Then, in 2015, he received Direct Ph.D. admission with fellowship award from the Mechanical Engineering department at the University of Michigan-Ann Arbor, where he obtained his M.S. and Ph.D. in 2017 and 2018, respectively.

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