MECHANICAL ENGINEERING STUDENT SEMINAR

Thursday, September 8th, 2022, at 13:00, D. Dan and Betty Kahn Building, Auditorium 1.
Online: https://technion.zoom.us/j/92778446594

Dynamic-Stall-Driven Wind Turbine for High Water-Pressure and Urban Applications

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Recently, interest in vertical-axis wind turbines (VAWTs) has surged, particularly for urban-scale implementation, due to advantages such as wind-direction insensitivity, low rotational speed and low noise emissions. In this research, we experimentally investigate VAWTs with uncharacteristically large blade-chord to radius ratios. This results in turbines that are, in fact, driven by dynamic stall, and this flies in the face of conventional wisdom, which obsessively attempts to avoid stall. Although insects and small birds exploit dynamic stall for flight, this has never been implemented for wind energy generation. Additional advantages include exceptionally low cut-in wind speeds and exceptionally low rotational speeds that further reduce noise emissions and the probability of bird strikes.

An extensive parametric study was conducted to optimize the turbine, and a semi-theoretical model was developed. The turbine described above was interfaced with a high-pressure positive displacement water pump, which has the unique advantage of fluid-to-fluid (air-to-water) energy conversion. The high-pressure water can be used to: drive impulse turbines (e.g., Pelton wheels), thus eliminating conventional low-to-high rotational speed gearing losses; charging air-batteries that rely on high-pressure water, and directly desalinating water with Reverse Osmosis (RO) technology.

A laboratory-scale (0.8 m^2 swept area) wind pump reached overall system efficiencies greater than 15% (wind to hydraulic power), which is more than twice that of well-known and commonly used American multi-bladed wind pumps. The system was directly interfaced with an RO filter, where salinity, loading, and wind speed were systematically varied. A parametric study of the system demonstrated viable design conditions of operation at the vicinity of peak efficiency for a wide range of wind speeds with no controller required. This results in a practical and inexpensive desalination system, requiring only 0.85-2.5 kWh of mechanical energy per cubic meter of brackish (up to 5000 ppm) water. Moreover, a model based on the parametric study indicated a considerable upscaling potential with a 50% increase in efficiency for a medium size (12.5 m^2 swept area) system.

Note: the seminar will be given in English

Seminars Coordinator: Assoc. Prof. Matthew Suss.