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Modular Concentrated Solar Power Design – Economic and Dispatchable (MCSP-ED)

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Why is MCSP-ED

Climate change poses a fundamental threat to the places, species and our planet's diversity of life is now at extremely high risk from the changing climate. The continuing increasing volumes of carbon dioxide and pollution haze in developing countries by burning fossil fuels are real happening every day. Developing clean and renewable energy source helps building a healthy future energy structure, and it is imperative.

Solar electricity generation is one of very few low-carbon energy technologies with the potential to grow to very large scale. Though recent years have seen rapid growth in installed solar generating capacity, great improvements in technology, price, and performance, further advances are still needed to enable a dramatic increase in the solar contribution at socially acceptable costs. Achieving this role for solar energy will ultimately require that solar power design become economic and dispatchable, competitive with coal-fired power station. There are two common grid-connected electricity generation by photovoltaic (PV) and concentrated solar power (CSP) systems. By contrast with PV, CSP plant with thermal energy storage (TES) system can generate power in hours with little or no sunlight, which makes it a potential source of "dispatchable" renewable power. Furthermore, an intelligent control system, as applied on MCSP-ED, gives stable electricity output even with rapid varying sunlight intensity or sudden occurrence of cloud.

What is MCSP-ED

MCSP-ED is a modularized concentrated solar power design, with modularized solar receivers, TES compartments and system components, such as pipes, supporting and heat transfer enhancement structures.

Solar Receiver

As shown in figure 1, the solar receiver consists of a sealed half-spherical container and an annular heat receiving tube. Sunlight enters the receiver through the transparent film layer, hits on the reflective film, and then forms a strong concentrating light, strikes on the top of the annular heat receiving tube. Heat transfer fluid flows into the tube through the outer ring cross section, absorbing the solar heat along the tube and mostly at the top of the tube and then flows out through the inner round cross section. The inter-section structure of the tube should use heat insulation material in principle, to achieve high outlet flow temperature.

Fig. 1 Solar Receiver Design

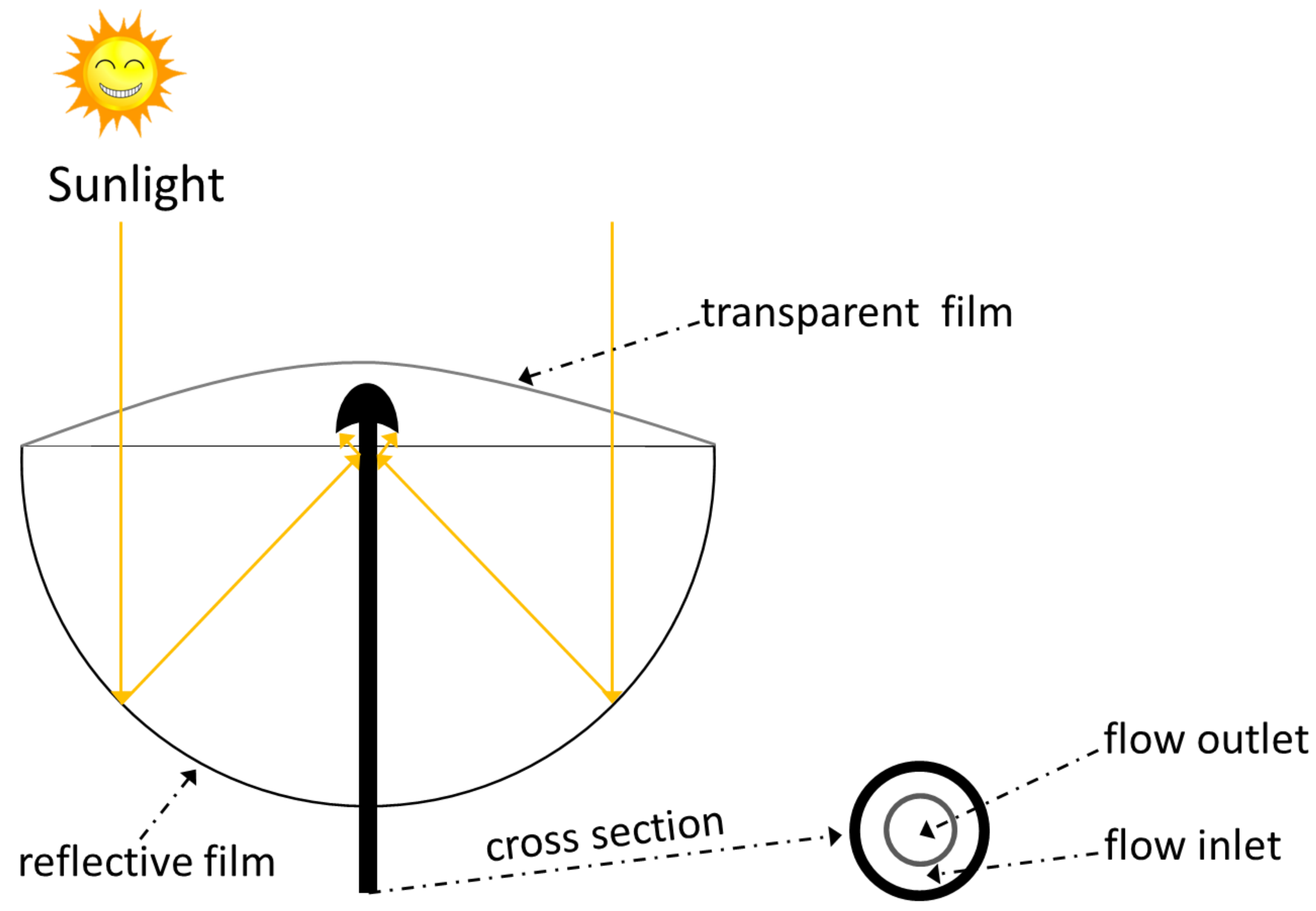
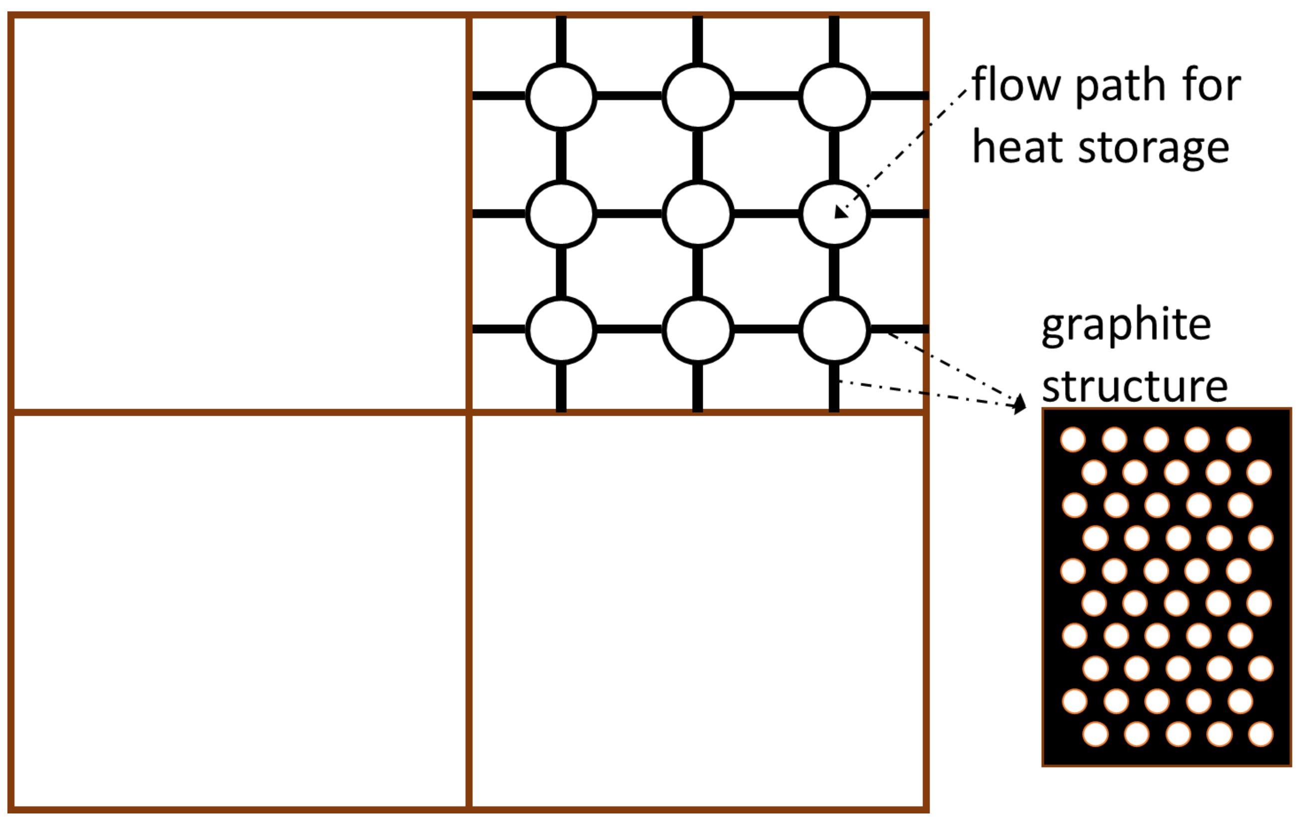


Fig. 2 TES System Design



TES System

As shown in figure 2, TES system consists of four separate compartments. These compartments are built based on ground pool with heat insulation treatment. By contrast with fabricating heat storage container, this cheap design makes possible to store more hours' heat without cost too much. In this design, the heat storage medium adopts phase change molten salt. To fully make use of the latent heat from liquid state to solid state, it's better not pump the molten salt somewhere else, this design puts heat transfer tube inside the TES compartment and a lot of graphite plate with many holes are used as structure component, also enhance the heat transfer. Therefore, the selection criterion of the molten salt should be as follow,

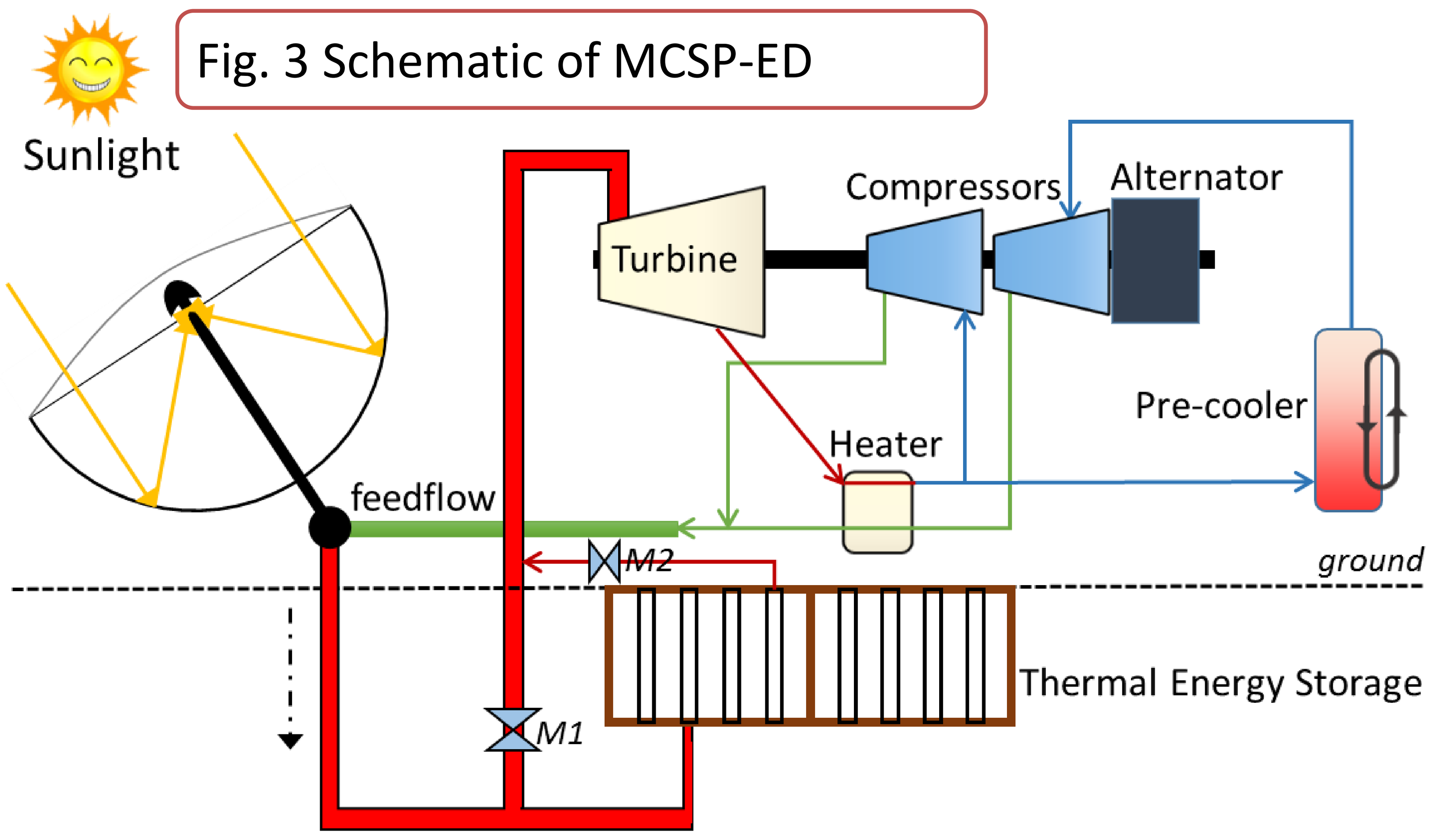
a) stable chemical properties
b) high boiling point
c) high melting point, but ensure can be sufficiently melted by the solar heat transfer fluid
d) large latent heat from liquid state to solid state
e) large heat capacity

The graphite components are modular designed with many holes on the plate, thus increases both the heat transfer area and the useful molten salt storage volume.

How MCSP-ED Works

As shown in figure 3, the solar light is absorbed by the solar receiver, heat the feed flow to high temperature. At normal operation period, the valve M1 is fully opened and M2 is entirely closed. The high temperature fluid flows into the turbine drives the alternator to generate electricity. The fluid out from the turbine flows into a heater to heat up part of the feed flow. After cooled by the feed flow, part of the fluid directly flows into a compressor and another part of fluid flows into compressor through a pre-cooler, that inside the cooler the cooling medium can be water or air. While there is oversupplied solar heat, we can adjust the mass flow through the TES system by increasing the opening of valve M2, decreasing the opening of valve M1, or combine. While there is little or no sunlight, the valve M2 would be fully opened and M1 is entirely closed to generate electricity by using the storage heat in the TES system. What's more, with intelligent control system and sensor technology, this design is promising to give stable electricity output even with rapid varying sunlight intensity or sudden occurrence of cloud merely by adjusting the two valves M1 and M2.

Fig. 3 Schematic of MCSP-ED



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