A CASE STUDY:

Conventional use of concentrated solar power and its advances in today's world

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Solar energy exploitation and related new technologies are assuming an increasing interest for industrialized countries where medium-to-long term production of low cost energy with reduced emissions is carried out. Indeed, several solar energy power plants have been designed and are currently under testing in many countries including India also.

Applied research in solar furnaces started at the beginning of the 1950s. Perhaps, the greatest motivation for the use of this peculiar source of thermal energy was the study of the effects of the "new" nuclear weapons on all types of materials and the search for possible candidates for protection. The time profile (Nuclear Thermal Transient) of a nuclear explosion can be easily reproduced in a solar furnace. Military solar furnaces were built in White Sands (New Mexico, U.S.A.) and in the French 'Laboratoire Central de l'Armament' in the Eastern Pyrenees. In the beginning, work was strictly on basic research with wide publications of refractory material phase diagrams ($A1_2O_3$, ZrO_2 etc.), studies on ignition and kinetic studies on refractory materials, crystal growth for use in semiconductors, solar cells and lasers. Another field of study has been the field of thermo-physical properties of materials at high temperatures, such as mechanical properties, spectral emissivity, thermal expansion, thermal conductivity, absorption and diffusion as well as electrical properties. In all these activities, a common difficulty, innate to the energy source, has appeared in the inability to find out the exact temperature on the irradiated surface. Sensors, vulnerable to the incident radiation density, cannot be placed on the exposed surface, since even if they could withstand the concentrated radiation, they would measure their own temperature instead of that of the sample. This has given rise to research into the entirely new field of non-contact temperature measurement (pyrometry) and into new measurement systems determining the flux densities in the focal plane. With the development of different concentrated solar energy applications, solar furnaces have slightly modified the direction of their activities. The follow-up of the solar chemistry of the 1970s, mainly in the hands of French researchers, and the appearance of the volumetric receiver concept in power generating CRS inspired the use of furnaces for the small-scale pre-testing before their full-size implementation. At the end of the 1980s and the beginning of the 1990s, several new furnaces were installed. Chronologically these are:

– 1989: Solar furnace at the Paul Scherrer Institute (PSI) (Switzerland)

–1989: Solar furnace at the National Renewable Energies Laboratory (NREL) (U.S.A.)

–1991: Solar furnace at the Plataforma Solar de Almería (PSA) (Spain)

–1994: Solar furnace at the German Aerospace Center (DLR) (Germany)

Lamp concentrators in the typical solar furnace arrangement but using a set of Xe-lamps instead of the sun as the radiation source were set up at the PSI in 2005 and are under construction in the DLR.

Three typical designs of solar furnaces are presented below.

– A scheme of the arrangement of the 1000 kW solar furnace in Odeillo (France) and with similar in Taskent (Uzbek) can be seen in Fig. 1. The furnace in Odeillo was inaugurated in 1970 and consists of a field of 63 heliostats on eight terraces each with a surface of 45 m^2 as a collector. The concentrator is integrated into the building and has a dimension of 40 m height and 54 m width. Because of its large half angle of the radiation cone coming from the concentrator concentration factors of close to 10,000 can be achieved (Fig. 2).

– Smaller on-axis furnaces with a similar design but using a single heliostat are located in Israel at the Weizmann Institute of Science (WIS), at the Sandia National Laboratories