

Motivation and Highlights

Motivation:

In the subject of *heat transfer*, we are primarily interested in *heat*, which is the form of energy that can be transferred from one system to another (or one part of a body to another) as a result of temperature difference. The subject of heat transfer deals with the *rates* of such energy transfers.

Using the principles of thermodynamic analysis alone, we can determine the amount of heat transfer for any system undergoing any process. What is, then, the fundamental difference between *heat transfer* and *thermodynamics*? Thermodynamics is concerned with the amount of heat transfer as a system undergoes a process from one equilibrium state to another, and it gives no indication about the rate of heat transfer, how long the process should take, or what is the mode of heat transfer. But engineers are as much concerned with the rate of heat transfer as with the amount. Both parameters are equally important in the design of thermal systems.

Relevance of heat transfer:

Heat transfer is not only an extremely relevant subject in engineering industries, but also an inherently fascinating part of engineering and physical sciences. The main focus of this course will be to acquire an understanding of heat transfer effects and to develop the skills needed to predict heat transfer rates. Let us have a look at the value of this knowledge and what the applications are.

Heat transfer phenomenon plays an important role in many industrial and environmental problems. First and foremost, in the applications of energy production and conversion, there is not a single application in this area that does not involve heat transfer effects in some way or other. In the generation of power from conventional fossil fuels, nuclear sources, magnetohydrodynamic processes, or the use of geothermal energy sources, heat transfer forms the key to the technology concerned. All modes of heat transfer are important, as conduction, convection, and radiation processes determine the design of systems such as boilers, condensers, and turbines. Quite often, the challenge is to maximize heat transfer rates (such as in heat exchangers) or to minimize (as in insulations).

In renewable energy generation, there are many heat transfer problems related to the development of solar energy conversion systems for space heating, as well as for power production. Heat transfer processes are also involved in propulsion systems, such as the IC engines, gas turbine, and rocket engines. Heat transfer problems arise in the design of conventional space and water heating systems, in the cooling of electronic equipment, in the design of refrigeration and air conditioning systems, in many manufacturing processes, and in biological systems. Heat transfer issues also occur in air and water pollution problems and strongly influence climate at the local and global scale.

Highlights:

Classification of heat transfer problems: In the engineering design of any heat transfer equipment or system, the activities can be classified into two main items: (1) *rating* and (2) *sizing*. “Rating” deals with the determination of heat transfer rate for a given system for a specified set of conditions, while “sizing” deals with the determination of the size of a system for a specified heat transfer performance.

Experimental vs. theoretical studies: A heat transfer process or equipment can be studied either experimentally or theoretically. The experimental approach has the advantage that we deal with the actual physical system (or an equivalent scaled down model), and the desired quantity is obtained by measurement as accurately as possible within the limits of the measurement technique. However, this approach can be time consuming, expensive and often impossible. For example, the system under consideration may not be existing at the design stage, or may deal with hazardous substances and hence measurement approach will not be practical at all. The theoretical approach includes analytical approach (for simple and linear problems) and computational modeling (for more complex and non-linear problems). Computational modeling has the advantage that it is fast and inexpensive, but the results obtained must be examined for numerical accuracy and the validity of the assumptions made in the analysis. The development of advanced computational tools in heat transfer and the increase in computing power has contributed immensely to the feasibility of solving realistic engineering problems. With modeling, the lead time in design and development of equipment can be considerably reduced. Experiments still need to be performed for validating the model outputs, but the number of experiments to be performed can be considerably reduced.