A Multi-Objective Optimization approach to Parameter Identificaion of Photovoltaic Cells: An Overview

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The last few decades acted as an eye opener for the world which was completely dependent on the use of fossil fuels for the purpose of supplying of energy solely. Due to the growing energy demands in almost all the sectors, the extraction of these resources increased largely and resulted in the shortage of their stock. Also, the consumption of these fuels produces a large amount of toxic gases which are alarmingly dangerous for the environment. The two main problems have forced the human race to seek a substitute for them so as to ensure that none of the two mentioned criteria are violated. The alternative source or the renewable energy resources possess all the essential qualities and has shifted the focus of the world towards itself completely. Out of the renewable resources, solar power has got the maximum ability to serve as the fuel for the generation of power as it is abundantly available. Solar energy is converted into useful electricity directly using the semiconductor physics where the photovoltaic technology is incorporated. The PV cells are integrated together in the form of panels which the serve the purpose of production of electricity from solar energy.

PV cells consists of silicon semiconductor where the conversion of energy takes place, hence it becomes essential to determine the output or the performance characteristics of the cell. For the proper knowledge of efficiency, the intrinsic parameters are to be calculated. The intrinsic parameters are not provided by the manufacturing company and needs to be extracted by using appropriate mathematical model. The intrinsic parameters also play an important role in future design of the panel with the required characteristics. These parameters do change but slightly over the years of operation of the cell and may happen due to some harsh operating conditions under which the panel is exposed. Therefore, the mathematical model chosen must be able represent the cell appropriately. There are numerous methods considered for the modelling of PV cells out of which the most used ones are single diode model (SDM), double diode model (DDM), three diode model (TDM) etc. SDM consists of one diode in it along with the other components of resistances representing different losses. DDM consists of two diodes connected in parallel for the modelling and TDM consists of three diodes connected in parallel. Besides them there are some less explored models for the PV cell which are modified double diode model (MDDM) and reverse two diode model (RTDM). MDDM consists of an extra resistance connected in series with one of the diodes. RTDM consists of a diode in the load side of the mathematical model.

The current voltage relationship drawn out from the models described above are non-linear in nature. The presence of non-linearity is self-explanatory so that the analytical methods cannot be employed for the accurate solution of these equations. With the increase in the diodes, in PV cell model the complexity also increases and TDM and RTDM are the most complicated model of all. Numerical methods need to be employed for the solution of these equations. Direct numerical methods may sometimes face the problem of local maxima and local minima which may result in inaccurate answer. The solution obtained from these methods largely depends on the initial value chosen for the variables. Hence, a new class of methods known as metaheuristic algorithms are to be employed for the solution of non-linear equations. These are optimization algorithms where the random population is initialized in the beginning and during the subsequent iterations the results get better and better till final outcome is obtained. Optimization techniques includes obtaining desired results for a given set of problem under certain conditions. Optimization techniques are mainly divided into two categories: single objective and multi-objective. Single objective optimization involves obtaining the optimal results for only one problem function. Multi-objective optimization (MOO), on the other hand, includes the problems where there are more than one objective function and a result which is optimal corresponding to all the objective functions must be satisfied. The fact is most of the problems in engineering are multi-objective in nature, the same goes for parameter extraction of PV cells. But in literature, the parameters have mostly been extracted using single objective optimization and very few works can be found involving the multi-objective approach. The single objective approach deals with the objective of minimization of errors generated from the nonlinear equations whereas the multi-objective approach considers the minimization of error as well as the maximization of power. Therefore, it can be safely concluded that multi-objective approach is certainly better method for the parameter estimation of PV cells and can be adopted in near future.

Keywords: Photovoltaic (PV) cells; parameter identification; diode models; multi-objective optimization (MOO).

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