

# A Review Paper on Optimization Techniques of Thermal System

Shivam Rajak<sup>1</sup>, Ravindra Kannojiya<sup>2</sup> and Shubham Kumar<sup>3</sup>

<sup>1,2,3</sup>Amity University, Noida

E-mail: <sup>1</sup>shivamjbp0055@gmail.com, <sup>2</sup>ravindra.k36@gmail.com, <sup>3</sup>shbhamkumar075@gmail.com

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**Abstract**—This work represents the study of various optimization techniques used in thermal systems. The thermal system used here is a Vapor Absorption refrigeration system. The optimization of this system has been done using various optimization techniques. These techniques are either traditional one or some heuristic approach such as genetic algorithm, artificial neural networks etc. These techniques have different convergence rate and requires different number of iterative steps to provide the optimized results. The results obtained by these techniques are also little different because it is not necessary that heuristic approach will provide the best solution but they provide the solution which is very close to the best solution and in some case, they provide best solution which has to be further justified. For better convergence rate, an algorithm which is 'algorithm specific- parameter less' can be used. Effect of evolutionary algorithms with respect to optimization for thermal systems has been reviewed here. An effective algorithm which can be tested on mathematical benchmark functions may provide better results for global optimization. In this work, the effect of various algorithms for better performance and real world installation has been studied.

**Keywords:** Optimization, VARS, Evolutionary Algorithms, Convergence rate.

## 1. INTRODUCTION

Modern world is surrounded by thermal systems and our comfort mainly depends upon them either directly or indirectly. Most of the thermal system requires heat energy to function, for example a heating system, refrigeration system and a power plant. This heat is mainly obtained by burning some fuel (usually fossil fuel) releasing a vast amount of green house and other toxic gases in the environment which are harmful for every living being and it is also creating imbalance in nature. In recent years, the world is facing new problem regarding ozone depletion. It was found in many studies that it is mainly caused due to the working fluid in our modern refrigeration systems [1]. We require electricity to light our houses and if we take the present situation of India; about 70% of its electricity comes from thermal power plant which burns coal for producing heat adding to which the coal used by these plants are of low quality; because higher quality of coal is not present in Indian mines; which increases the risk of pollution even further also mining of this coal causes air

pollution and affects the environment and lives in many ways. If we take the case of US about 40% of total electricity produced in summer is consumed by the commercial buildings for air conditioning purpose similarly about 32% of electricity is used for air conditioning in Egypt [2]; which are again thermal systems.

There are some other thermal systems too which uses electricity as input; which is again mainly produced in thermal power plants. So, thermal systems are everywhere and we just can't cease and replace them from use, because it would be too much costly and even impossible task in some cases. So, all we can do is to make them more and more efficient so that they cause less harm to our environment.

## 2. VAPOR ABSORPTION REFRIGERATION SYSTEM

Vapor absorption system is a refrigeration system that uses heat as input. The principle was first proposed in the year 1777. And the first continuous mode system was first introduced by Ferdinand Carre in 1859; in his system, he used ammonia as refrigerant and water as absorbent [3]. This system is different from the vapor compression system by the fact that the compression function is obtained in three different steps by the use of an absorber, pump and generator or reboiler. These systems are used frequently for food storage and other places like that. This principle can also be used using waste heat from various thermal system such as gas turbine, thermal power plants etc. and can provide refrigeration and air conditioning at very cheaper rate.

Vapor absorption system can also use solar energy as heat input, and now a day work is being done in this direction and many systems have been installed around the globe. But the problem is that they require huge investment during installation and there is a need of lot of research and testing for the development and manufacturing of solar absorption refrigeration system equipment [5]. Since, there would be continuous need for refrigeration and air conditioning in future and considering the fact that our resources are limited it can be said that it is justifiable to use such systems. Along with that vapor absorption system can also use biomass or geothermal

energy and moreover the working fluids used are also ozone friendly [6]

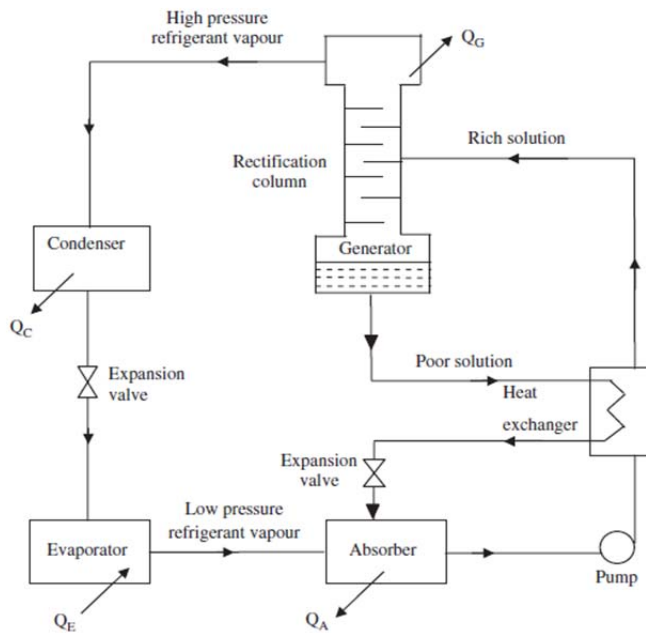


Fig. 1 Vapor Absorption Refrigeration System [4]

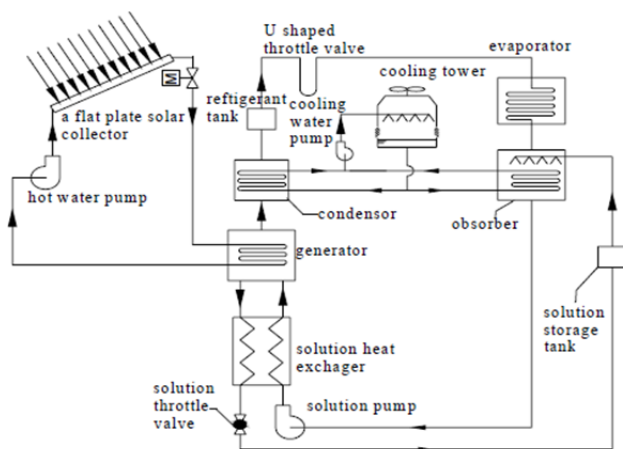


Fig. 2 Solar Vapor Absorption Refrigeration System [5]

### 3. GENETIC ALGORITHM

Genetic algorithm is a heuristic optimization technique that is based on the process of natural evolution. It was developed by Holland (1975, *Adaptation in Natural and Artificial Systems*. Ann Arbor: University of Michigan Press). [7]. Darwin suggested that due to natural selection can result into a being which appears to be well-designed that is the basis of genetic algorithm theory. This algorithm can be used for both constrained and unconstrained function. This algorithm is

named so because of its primary operation i.e. mating, mutation and crossover. In this algorithm, each individuals and organisms are represented by their respective chromosomes and are implemented in the form of data structures as a vector. Here an assembly of individual is population which generate a different new set of individuals at the end of generation. The mating step provide fittest individuals from the existing generations. The mutation ensures introducing new information and preventing loss or fixation of information. The general steps followed by genetic algorithms are

- (1) Representing of possible solutions as chromosomes.
- (2) An objective function called fitness function to evaluate the performance of individual solutions.
- (3) A reproduction function to produce new set of offspring.
- (4) Mutation operator function.

It offers many advantages when compared to other optimization methods. They are computationally simple and are highly efficient even with very large search space of possible solution. This algorithm has been successfully used in optimizing a lithium bromide-water solar absorption cooling system. Here the cooling system was having a special arrangement called evacuated tube collectors. The input parameters taken in this work was storage tank volume, evacuated tube collector area and the mass flow rate of water through generator and collector. This work dealt with two objective functions namely the auxiliary energy and the net profit obtained [8].

### 4. NEURO LINGUISTIC PROGRAMMING

It was first developed by Richard Bandler and John Grinder in 1970's at California, it is a behavioral science change technology. Its name actually represents the view that a person is a whole mind-body system with a specific patterned connection between internal experience (i.e. neuro), language and behavior (i.e. programming) [9]. Its principle is based on what psychotherapists do and by what means they are able to produce change. The first results were methods of how to build rapport, how to ask relevant questions, using anchors to utilize resources, how to change perspectives, using different thinking styles and how to utilize hypnotic language patterns. After some time, NLP adopted, and learned a lot of other models from different areas like cognitive science, pedagogy, sport-psychology and became a collection of useful tools and models. It gained popularity in the business community and in most European business trainings elements of NLP are used. NLP modeling was used by Serio F. Mussati and group for the optimization of LiBr-H<sub>2</sub>O absorption refrigeration system. Three objective functions were optimized in this work namely the total exergy loss rate, total heat transfer area and total annual cost of the system. [10].

## 5. ARTIFICIAL NEURAL NETWORK

Human mind performs various action like sorting, classifying, calculating etc. These all are achieved by the inter connection between the various neurons in brain, this connection between different neurons of brain is called neural network. Nowadays same concept is being used in modern computational and programming world and termed as an artificial neural network. This concept was born because of the scientific research and interest in the field of artificial intelligence in somewhat mid-1950s [11]. It consists of a large number of interconnected processing units, such that the output from one is the input of another. It is very powerful pattern recognizer and also a classifier and can deal with complex problems which would take very long time when solved classically [12]. One more interesting fact about such systems is that their success chance is unpredictable when they are let to learn by themselves, they require some training and after that some of them become great computing system and others don't perform that well.

Artificial Neural Network has been used widely in absorption refrigeration systems. Here three such works is presented. The first work is of Abtullah Tagcu and Oguz Arslan. They have utilized the artificial neural network technique to optimize absorption refrigeration system which is aided by geothermal energy [13]. The second work is of Arzu Secan, he applied Artificial neural network model on ammonia-water refrigeration systems. Here in this work coefficient of performance (COP) and circulation ratio are estimated with temperature (generator temperature, condenser temperature, absorber temperature) and concentration (poor and rich) values [4]. And the final work is of J.A. Hernandez and his team, in they found the optimal COP of a solar intermittent refrigeration system by both direct and inverse ANN. Here the input parameters used were solution concentration, cooling water temperature, generation temperature, solar radiation, ambient temperature and generation pressure [14].

## 6. FUZZY LOGIC

It is a type of logic which may have many truth values and here these values are real and lies between 0 and 1. It is totally different concept from the previously popular Boolean logic where only two integer truth values i.e. 0 and 1 were present. This concept of fuzzy logic is more applicable to real world problem than Boolean logic because of many reasons because in real world there may be a condition which is neither completely true nor completely false. The term was introduced firstly in 1965 with the concept of fuzzy set theory by Lotfi Zadeh. But fuzzy logic was actually being studied since 1920s with a different name as infinite-valued logic mainly by Lukasiewicz and Tarski. Although there was there are some major differences in both theories related to inferencing and conjunction as described by Sukhamay Kundu and Jianhua Chen [15]. Fuzzy logic has already been applied to wide range of fields including artificial intelligence and modern smart controllers. It is a three-stage process firstly all the input

values are fuzzified, next fuzzy output is calculated using these inputs and finally the output is de-fuzzified in crisp output. Adnan Sozen and his team utilized the concept of fuzzy logic for the prediction of a solar driven ejector-absorption cycle. They predicted the performance of the cycle by avoiding all the complex mathematics and using fuzzy logic controller at various operating states. The deviation in COP, exergetic coefficient of performance, and circulation rate were not more than 2%, 5% and 0.2% [16].

## 7. PARTICLE SWARM OPTIMIZATION

Like various evolutionary algorithms, this technique uses a population of particles to proceed the search with each particle corresponding to a particular candidate solution to the give problem. This optimization tool was developed by Dr. Eberhart and Dr. Kennedy in the year 1995. This technique was inspired by the social behavior of bird flocking. In this technique particles change their current position by flying in a multi-dimensional space until an unchangeable position is obtained [17]. In past, few decades particle swarm technique has proved its worth and has been successfully applied to various fields and proved itself to be faster and cheaper tool as compared to its predecessors. There is another reason of particle swarm being so attractive which is its less number of parameters to adjust. It works with wide variety of applications and slight variations in the technique increase its range tremendously. In short particle swarm is a great and complete technique. The particle swarm technique was used by Bahram Ghorbani and team along with NLP techniques for the optimization of refrigerating cycle. [18]

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