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GENERATOR MAINTENANCE SCHEDULING IN POWER SYSTEM BY USING ARTIFICIAL INTELLIGENT TECHNIQUES: A REVIEW

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Abstract - **Power system generator effective maintenance scheduling is very important for the economical, stable and reliable operation of a power system. This represents a tough scheduling problem which continues to present a challenge for efficient optimization solution techniques. Generator maintenance scheduling (GMS) problem refers to finding a schedule according to which the planned maintenance can be performed on the generating units in a power system. To accesses safety and reliability in a power system industry and to increase the ability of failure identification before it occurs inspection planning plays a vital role. Specially creating the maintenance schedule power generator is useful for minimizing cost function and to supply electricity with high reliability. In this paper several optimization methods have been discussed such as heuristic methods, mathematical programming method and artificial intelligent methods and also maintenance types like preventive maintenance, corrective maintenance, planned maintenance, unplanned maintenance and soon, recap of important information from different papers presented. After all this paper gives some indication for future researcher by showing the gap on this area and conclusion drawn from comparison of different authors work.**

Keywords: ***Artificial intelligent methods, Generator maintenance scheduling, Optimization methods, Preventive maintenance, Predictive maintenance***

I. INTRODUCTION

Electric power system maintenance scheduling problem is very important from resource utilization standpoint. An optimal maintenance schedule for thermal generator units is obtained by solving a large-scale optimization problem several methods proposed by different authors. Implemented fuzzy knowledge based algorithm to determine ranked list in components according to their criticality taking in to account multiple criteria (Amalia 2001). Methaheurstic, genetic algorithm and simulated annealing was proposed and compared to solve generator maintenance scheduling problem with the consideration of reliability (Keshav P. Dahal. et al. 2006). Application of benders decomposition in hydro-power plant considering real problems generating companies may face in the liberalized power systems (Igor Kuzle. et al.2010).

Calculation of criterion function, system operation costs and unreliability costs are calculated by a special simulator and cumulative method and application of dynamic programming and successive approximations method was proposed for determination of annual thermal unit maintenance schedules (Rodoljub Tonić. et al. 2010). Modeling System (GAMS) is the utilized for solving optimization problem considering transmission, security constraints as well as crew constraints and system reliability indices such as amount of not supplied energy for maintenance scheduling problem (Ali Badria.et al 2012). proposed a way of identifying an optimized solution for maintenance scheduling of the Web servers through Genetic algorithm (Ravi Sindal et al. 2013). Optimal preventive maintenance schedules of generating units HPSO (heuristic particle swarm optimization) algorithm for maximizing economic benefits and improve reliability (Obodeh. O. et al. 2013). Proposed decentralized methodology to determine unit scheduling and reserve allocation in an interconnected multi _ area power system under wind uncertainty (Ali Ahmadi_Khatir. Etal 2014).

Energy saving generation dispatching was implemented for energy conservation and emission reduction and design annual, monthly, recently and real time energy power scheduling plans (Peng-Fei Liu1. et al. 2015). Hybrid differential evolutionary algorithm was proposed to handle the starting period of each generating unit for carrying out maintenance work with cooperation of lambda iteration approach to assists DE(differential evolutionary) algorithm in finding the accurate starting period and Numerical results obtained by the proposed HDE method are compared with hybrid particle swarm optimization (HPSO) algorithm(G. Balaji.et al. 2015). Generator maintenance scheduling based on minimization of the objective function considering the economical and reliable operation of a power system with the consideration of satisfying the network constraints and detailed description of different optimization techniques (Suraj Kumhar. et al 2016).

For maintenance and operations scheduling problem propose stochastic mixed integer programming approach and introduce number of algorithmic improvements (Beste Basciftci. et al 2017). Bacteria foraging algorithm was presented to solve optimization problem which is dependent on weibull scale factor, reserve cost for over estimating the wind power, and the penalty cost for under estimation of the wind energy (Ambarish Pandda. et al 2017). Optimal generation scheduling of renewable distribution generation for power loss optimization using particle swarm optimization and the effectiveness of proposed method and comparison were performed by DIgSILENT program language (Bounthanh Banhthasi. et al. 2018).

II. OVERVIEW OF GENERATOR MAINTENANCE SCHEDULING (GMS)

Modern power systems are experiencing increased demand for electricity with related expansions in system size, which has resulted in lower reserve margins making the generator maintenance scheduling problem complicated. Concerns for high reliability, low production cost and energy management in electricity generation plants has stimulated interest in automated production, operation, transmission and schedule maintenance of various machines in a generation plant. The reliability of system operation and production cost in power plants are affected by the maintenance outage of generators. Optimised maintenance schedules could potentially defer some capital expenditure for new plants in times of tightening reserve margins, and allow critical maintenance work to be done which might not otherwise be achieved. Therefore, maintenance scheduling is a significant part of the overall operations scheduling problem(K. P. Dahal, N. Chakpitak, 2007; C.Feng, X.Wang, 2008).

A. GMS Problem constraints

The constraints included in formulations of the GMS problem may vary significantly, it depending on the nature and underlying assumptions of the operations of power utility's. The major constraints employed in the literature includes maintenance window constraints, reliability and availability constraints , load constraints, service contiguity constraints , resource constraints, crew/manpower constraints , exclusion constraints, condition of the engine, spinning reserve, and transmission/network constraints (Suraj K., M.Kumar, Feb-2016; Froger A. et al., 2016; Huang CJ. et al., 1992; Ahmad A. et al., 1998).

B. Classification of Generator Maintenance

Maintenance is classified as different types according to different authors shown in Fig 1. Before and during World War II most maintenance was done in a reactive way, i.e. breakdown maintenance. However, some low-level preventive maintenance, e.g. checking oil levels and doing fault-finding on critical equipment, was performed on weapons systems to increase mission availability (Al-Turki U, 2011; Ahmad R & Kamaruddin S, 2012; Zhan JP, Guo CX, Wu QH, Zhang LL & Fu HJ, 2014; Patel SA & Kamrani AK, 1996; Martin KF, 1994; Gallimore KF & Penlesky RJ, 1988). Most of the time proacctive maintenaces are clasified in to two pland-preventive maintenance (PPM) and planed maintenance as shown in Fig 2.

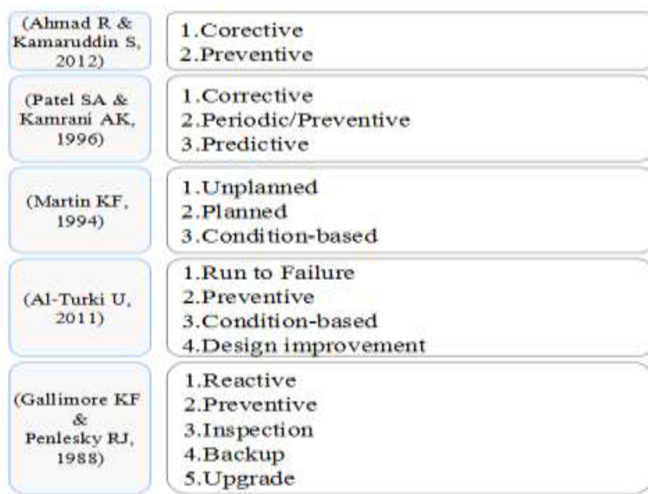

Fig 1: Maintenance classification according to different authors

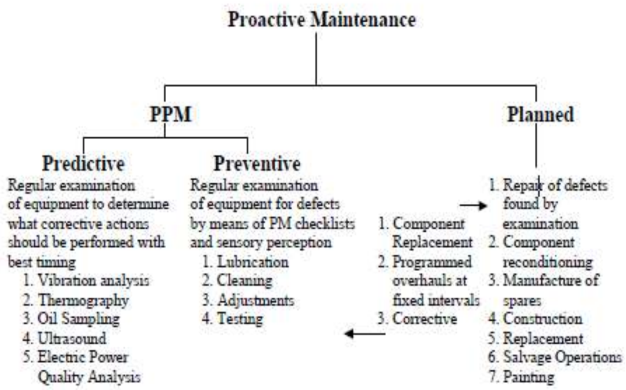

Fig 2: Proactive maintenance Classification

Additionally, it is also classified depend on its maintenance duration, it is divided in to four categories as shown in Fig 3: Bi-annual and annual maintenance is must schedule maintenance which is done by certified technicians.

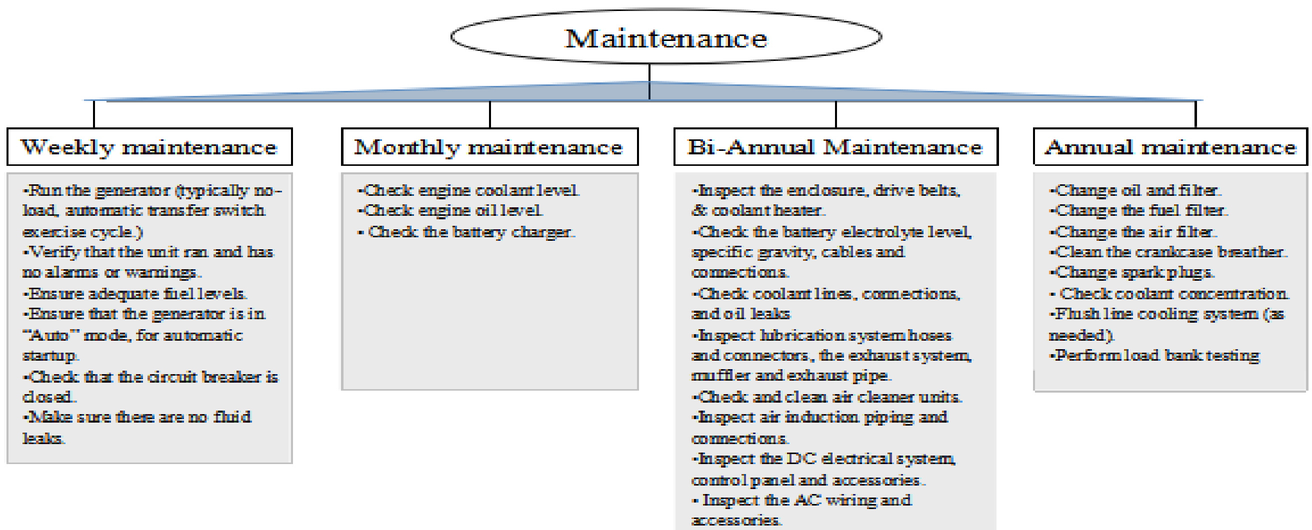

Fig 3: Classification of maintenance according to its duration (All References)

C. Maintenance scheduling optimization problems

Optimization techniques for maintenance scheduling are listed in Fig 4 below. Currently, mostly used techniques are artificial intelligence techniques which are Genetic Algorithm (GA) (Holland, 1975), which was inspired by Darwin's principle of survival of the fittest, and Particle Swarm Optimization (PSO) (Kennedy and Eberhart, 1995), which is based on a simplified social model. Other algorithms that fall into this category include evolutionary programming (Fogel, Owens and Walsh, 1966), genetic programming (Koza, 1992), differential evolution (Storn and Price, 1997), simulated annealing (Kirkpatrick, Gelatt and Vecchi, 1983), tabu search (Glover, 1977), ant colony optimization (Dorigo, Maniezzo and Colorni, 1996), harmony search (Geem, Kim and Loganathan, 2001), and Hybrid artificial intelligent methods.

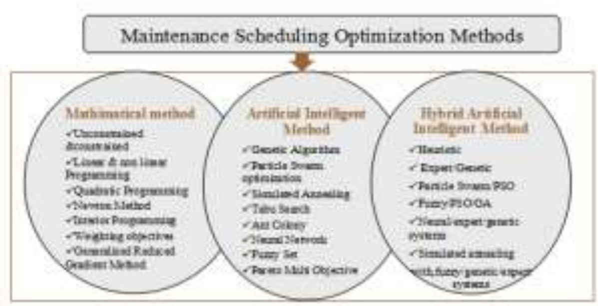

Fig 4: Optimization Methods Used for Maintenance Scheduling

D. Factors that affect Generator maintenance

Generator maintenance is affected by different factors as shown in Fig 5:

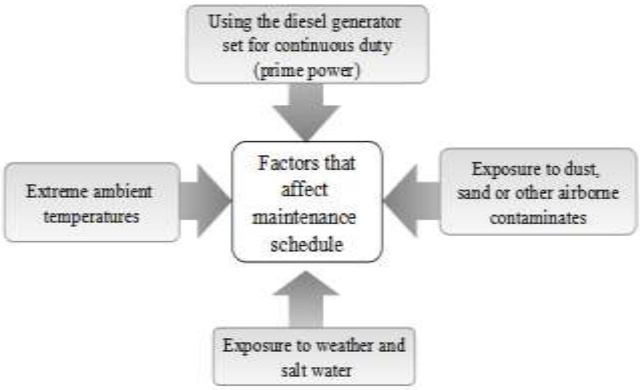

Fig 5: Factors that affect generator maintenance

E. Benefits and Challenges of Generator maintenance scheduling

The main benefits of a maintenance scheduling is: Increase equipment availability and reliability, Improve overall productivity, Increase return on investment (ROI), Reduce environmental impact, Reduce maintenance cost, Higher productivity, Reduce lost time injuries and so on. The drawback of GMS is time consuming and resource intensive, It does not consider actual equipment condition when scheduling or performing the maintenance, It can cause problems in equipment in addition to solving them (e.g., damaging seals, stripping threads).

III. OBSERVATIONS

- Fuzzy relational database model features has great flexibility in handling and evaluation of fuzzy information and in controlling the degree to satisfy individual conditions of a query (Amalia Sergaki, Kostas Kalaitzakis, Aug.2011).
- GA/SA and GA/SA/heuristic approaches are more robust and stable for solving GMS problems than a GA approach (Keshav P. Dahal , Nopasit Chakpitak , June 2006).
- Using genetic algorithm by increasing the number of chromosomes and generation lead to near optimized results (Ravi Sindal, July 2013).
- Based on trial and error principle the most primitive solution is obtained from metaheuristic method (Obodeh, O, Ugwuoke, P. E., Nov. 2013).
- DE effectively utilizes better maintenance schedule in terms of maximizing the profit of generation company's present in the market when compared to that of PSO(particle swarm optimization) (G. Balaji, R. Balamurugan and L. Lakshminarasimman, 2015).
- Over estimation in wind power is better than under estimation (Ambarish Pandda, N.K.Barpanda, Dec. 2017).
- Decentralized technique is accurate when the final result is equal to obtained by centralized procedure (Ali Ahmadi_Khatir, Antonio J.conejo, Rachid Cherkaoui, July 2014).
- All power stations use time-based maintenance, condition-based maintenance and operated- failure tactics. Other tactics like fault-finding maintenance are used by only a few power stations.

IV. CONCLUSIONS AND RECOMMENDATION

A. Conclusion

Generator maintenance scheduling plays a pivotal role in ensuring uncompromising operations of power systems. There exists a tight coupling between the condition of the generators and corresponding operational schedules, signicantly affecting reliability of the system. The GMS model using the reliability objective function mostly solved with artificial intelligent techniques is compared with the classical reliability objective function GMS model. GMS is improved the safety and efficiency of the system in addition to reliability problem. In this paper overall GMS classification with rerated to its duration, optimization methods used for GMS, benefits and challenges of GMS, observations from the overall references are discussed.

B. Recommendation

Note: All recommendations are drawn by considering the references listed in shown below

- Fuzzy logic based method is flexible to accommodate a wide range of applications related to representation and handling of imprecise information and complex system.
- In future work recommended creating an optimal maintenance program, satisfying all numerous transmission power flow and transmission maintenance constraints.
- Recommended to consider unplanned maintenance allowances and deferred maintenance use of heuristic approach for future works.
- Unplanned maintenance allowances and deferred maintenance using hybrid heuristic techniques considering frequency based maintenance outage formulation or multi objective modeling approach is recommended for future works.
- It is also recommended that the design of new power generating plants should consider the importance of maintenance and reliability decisions at the design stage when there is an opportunity to reduce life-cycle

operating and maintenance costs and therefore total cost of ownership (TCO).

- It is recommended that further research should be conducted on closed loop GMS problems. The closed loop approach to GMS problems should be applied in real plant scenario to identify the real-time challenges of implementation such as the physical limitations of the generators.
- It is also recommended that the generator limit and rate of ageing for each generator is investigated to consider the unit commitment of the power plant.

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