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Short Term Optimal Generation Planning of Narmada Hydroelectric Cascaded Power Plant Usage Particle Swarm Optimization

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Abstract: **Narmada River is situated in central India and this river is considered an clamant source of electricity, irrigation and drinking water in Madhya Pradesh, on this river there is a huge five hydro power plant which produces 3470 MW power and this five plant is manufactured and operated by a different companies. We are working to growth of electricity using PSO's optimization technology in this paper. In Travel time and discharge, water storage, power generation is relayed between the water flow, if the travel time of water in the plot is corrected, then we can increase the electricity. Successfully using PSO and its variants in meta-horizontal optimization techniques, this problem has been solved.**

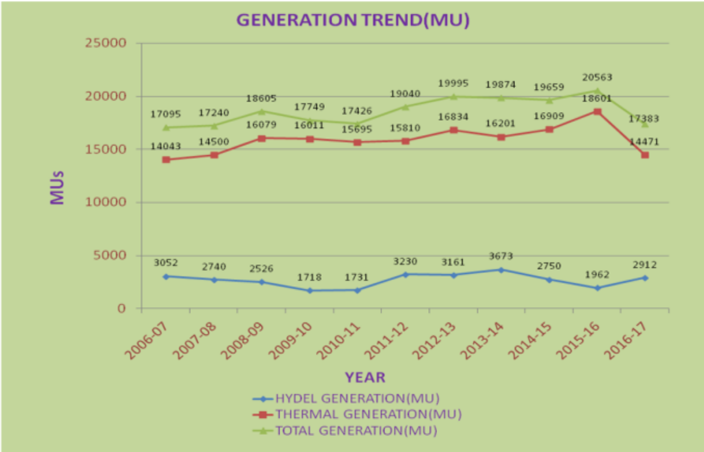
Keywords: **NCHES, DED_PSO, TVAC_PSO, NSAIW_PSO.**

1. INTRODUCTION

Demand for electricity evolution every day in the world and if electricity production is not able to meet this demand, we will use energy resources in a dominant way to satisfy the demand for electricity. Due to the reduction of fossil fuels and changes in the environment, the electrical industries are in danger. For this reason, need to discover alternative energy solutions that can meet the demand for electricity. If we receive encouragement to evolution the production of hydro electricity, then this demand for electricity can be satisfied. In this situation, the evolution in the water level compared to the full tank level reduces the effective prevalence for the upstream project and, ultimately, increase the generation of energy. This requires an effective operational mechanism to open and close gates in the forced ducts of hydroelectric plants.

The short-term planning of the cascaded hydroelectric system means discovering the discharge of water, the storage of water and the leaks of each deposit "j" in all programming periods (for 24 hours) to minimize the deviation between load demand and generation subject to restrictions. The Narmada River is located in the middlemost part of India and this river is considered an crucial source of electricity, irrigation and drinking water in Madhya Pradesh, in this river there is a large hydroelectric plant that produces 2,000 MW and this plant has been produced and managed by a different company. We cannot produce more electricity due to the lack of real suspension between them. This is the reason why all companies must work together in the right direction. The distributed double exponential PSO (DED_PSO) offers a better performance than the other two PSO variants, for example coefficients of acceleration of the PSO time variable (TVAC_PSO) and the novel Auto Adaptive Weight PSO (NSAIW_PSO). in this river there is a large hydroelectric plant that produces 3470 MW power plant and this product is and managed for a different company. We are working to increase electricity using PSO optimization technology in this document. In the time of travel and discharge, the accumulation of water, the generation of energy is transmitted between the water flow, if the time of travel of the water in the plot is corrected, then we can increase the electricity. By successfully using the OSP and its variants in meta-horizontal optimization techniques, this problem has been solved.

The generation of electricity in several hydroelectric and thermal power stations for the year 2006-2017 is shown in Figure 1. The total generation of the hydroelectric power plant is 2912 MU up to year 2017 and the total generation of the thermal station is 14471MU up to year 2017. Over all energy is generated by both hydro and thermal is 17383 MUs. This scenario of power generation in Madhya Pradesh.



Source: MPPGCL side

Fig 1

2. DESCRIPTION OF NARMADA CASCADED HYDROELECTRIC SYSTEM (NCHES)

Narmada river is the fifth largest river in India and the origin of this river is amarkantak(in Madhya Pradesh). This river is the largest river of the Western region. at an elevation of 900 m. This river runs 1,320 km and goes to the Khambhat Bay. The flow of the Narmada River in Madhya Pradesh at 1077 km and the subsequent flow of approximately 35 km form the border between the states of Madhya Pradesh and Maharashtra and even during the 39 km flow of the border between Maharastra and Gujarat and the last section of the 161 km flow in Gujarat and its fine river that flows into the Gulf of Khambhat, in the Arabian Sea The hydraulic coupling in the NCHES system is shown in figure 2. The description of the five main hydroelectric plants (RABS, ISP, OSP , MSP, SSP) located in the Narmada river are the following.

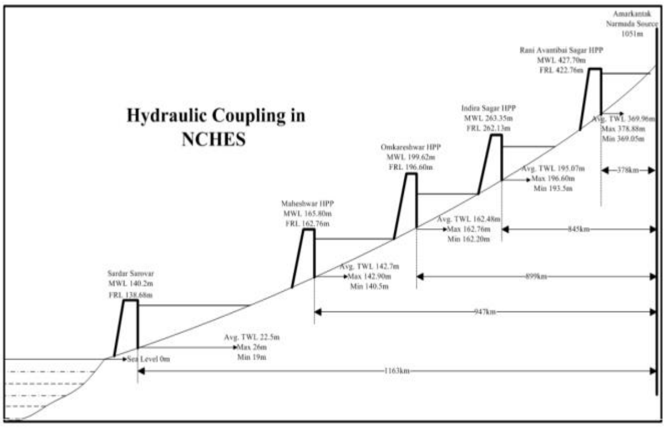


Fig 2: Hydraulic coupling in NCHES

1) Rani Avanti Bai Sagar(RABS) Project: The Rani Avanti Bai Lodhi Sagar (Bargi) project is a major multi-use project on the Narmada River in Madhya Pradesh. The reserved water is used for the generation of hydroelectric energy and for irrigation. The project also has a capacity to generate 100 MW of hydroelectric power. A domestic power of 2 units of 45 MW capacity of the dam and 2 units of 10 MW at the head of the left channel. The height of the dam is 69 m and a length of 5.4 km.

2) Indira Sagar Project (ISP): The Indira Sagar project was a main applications such as land irrigation, electricity production, drinking water supply, flood protection, etc. on the Narmada river. In this project, a capacity of 1000 Megawatts was installed with eight generators, each with a capacity of 125 MW (8X125). The dam description as a gravity concrete dam 653 meters long at the top with a maximum height of 92 meters. The water pipe system consists of a Head Race channel, 530 meters long, 75 meters wide and 50 meters deep, with a water load capacity of 2200 cumec. Pipes of 8 meters in diameter and 157 meters in length each. The flow capacity of each forced pipe is 275 pieces.

3)Omkareshwer Project(OSP):-The Omkareshwer hydroelectric project was a main uses such as land irrigation, electricity production, drinking water supply, flood protection, etc. In this project, over all capacity of 520 megawatts was installed with eight generators, each with a capacity of 65 MW (8X65) each with conventional Francis-type turbines.

4) Mandleshwer Project (MSP):- The Mandaleshwar Hydraulic Power Project is located in Mandaleshwar in the districts of Khargone in Madhya Pradesh. Shree Maheshwar Power Company of Power Ltd. Maheshwar is an energy project on top of the river that will reduce the state's peak power shortage by approximately 25%. This is the last project along the Narmada river that will be built with the margin of M.P. State. The total of a potential power of 400 Megawatts with ten generating units, each with a capacity of 40 MW (10 X 40). The dimensions of the dam are 3420 m long and 36 m high and in the longest dam in the central region.

5) Sardar Sarovar Project (SSP):- This Dam is founded on the Narmada River, at the state of Gujarat, and this river meets the Gulf of Khambhat, in the Arabian Sea. The main uses are to enhancements the efficiency of irrigation, intensive water cultivation, energy benefits, drinking water and flood control. There are two power plants River Bed Power House and Canal Head Power House, the power of SSP must have an installed capacity of 1200 MW in the dam and six units have the same capacity as Francis Tururbines 250 MW (6 * 250 MW) generation Energy . Gujarat will obtain 16% of the power of the SSP, the rest will be divided between Maharashtra (27%) and MP (57%). The concrete gravity dam measures 1210 m in length and 163 m in height at its maximum height.

3. EQUALITY AND INEQUALITY CONSTRAINTS

The constraints needs be met during the optimization procedure are detailed below

1) System active power balance: The total potential generated by all the entrusted units besmeared must meet the load demand.

$$D = \sum_{i=1}^{N} p_i - P_{loss} \qquad 1$$

The loss of potential (P_{loss}), which depends on the physical geographic network and the potential level generated (pi), must be minimal to minimize the generation expenses.

1) Spinning reserve: Sufficient spinning reserves are demanded to enhancement the reliability of the system.

$$\sum_{i=1}^{N} P_i^{max} \geq D + P_{lodd} + R \qquad 2$$

The freeze quantity or a pre determined percentage of the maximum load urge or the size of the enormous generator is used as a rotation reserve. A oversize moratorium of thread makes a system more authentic; however, the operating expense will enhancement. Mainly, the rotation reserve is met in the unit's commitment scheduling.

2) Generation limits: the units are presented in the system it has a some generation range, which is characterize as

$$P_i^{min} \leq p_i \leq P_i^{max} \qquad 3$$

This constraint prohibits a uncostly unit to generate potential more than its maximum limit as well as an precious unit to generate potential scanty than its minimum limit.

3) Ramp rate limits: For every units, the generation production is limited by ramp up/down rate at every hours characterize as:

$$P_i^{min}(t) \leq p_i(t) \leq P_i^{max}(t) \qquad 4$$

where $P_i^{min}(t) = max(P_i(t-1) - RDR_i, P_i^{min}$

$$P_i^{max}(t) = min(P_i(t-1) - RDR_i, P_i^{max}$$

4) Economical Dispatch problem pondering banned operating region: In exercises, the production output of p_i unit i must prevent the unit from operating in the unaccredited field. The permissible operating zones of unit i can be characterize as

$$P_i^{min} \leq P_i \leq P_{i,j}^{u} \qquad 5$$

$P^l_{i,j-1} \leq P_i \leq P^u_{i,j}, \quad j = 2,3, \ldots\ldots, Z_i$ 6

$P^l_{i,Z_i} \leq P_i \leq P^{max}_i$ 7

where $P^l_{i,j}$ and $P^u_{i,j}$ are lower and upper bounds of the j^{th} banned region of unit i, and Z_i is the number of banned regions of unit i.

5) Network losses: In the economic dispatch, mechanism impairment are taken into calculated as functions of generated outputs and B multipliers matrix.

$P_{loss} = \sum_{i=1}^{N}\sum_{j=1}^{N} p_i B_{ij} p_j + \sum_{i=1}^{B} B_{i0} P_i + B_{00}$ 8

[B_{i0} = i^{th} element of loss coefficient symmetric matrix B

B_{ij} = ij^{th} element of loss coefficient vector

B_{00} = loss coefficient constant].

6) Initial status: in the Initial status must be understand, as Economical Load Dispatched is a section of unit commitment problem.

4. OVERVIEW OF PARTICLE SWARM OPTIMIZATION

Particle swarm optimization is a population-based stochastic search algorithm that represents the most recent development in the meta-heuristic optimization category. It was introduced for the first time by Kennedy and Eberhart in 1995 as a new heuristic method. In PSO, different "particles" representing the candidate solution form the "swarm". These particles fly into the space of the problem and try to find the optimal solution in space. The position and velocity of the particle i are represented as the vectors of

$X_i = [X_{i1}, X_{i2}, X_{i3}, \ldots\ldots\ldots, X_{id}]$ and $V_i = [V_{i1}, V_{i2}, V_{i3}, \ldots\ldots\ldots, V_{id}]$ in the PSO algorithm.

Let $P\_best(i) = [X_{i1pbest}, X_{i2pbest}, \ldots\ldots\ldots, X_{idpbest}]$ and $G\_best(i) = [X_{i1gbest}, X_{i2gbest}, \ldots\ldots\ldots, X_{idgbest}]$ be the best position of particle i and global best position respectively.

The inertia weight w is linearly decreasing as the iteration proceeds and obtained as:

$$\omega = \omega_{\max} - ((\omega_{\max} - \omega_{\min})iter) / iter\_\max \qquad 9$$

A. Double Exponential Distributed PSO (DED_PSO):

The Laplace distribution is sometimes also called double exponential distribution. that a possible valid choice for the weighting coefficients in the PSO rate update equation is between 0.72 and 0.86. This can be achieved through the double exponential probability distribution also called Laplace distribution with a density function given by:

$f(x) = \left(\frac{1}{2b}\right) * exp(|x - a|), -\infty \leq x < \infty \& a, b > 0$ 10

This is the distribution of the differences between two independent variables with identical exponential distribution. The variance of this function is controlled by changing the position parameter 'a' and the scale parameter 'b'. Random numbers are generated from the absolute value of the exponential distribution in this way:

1. Generate uniform random number r_1 & r_2 by rand (0,1)
2. Check if$r_1 > 0.5$ the

$E(a, b) = a + b \times log(r_2)$ 11

$else\ E(a, b) = a - b \times log(r_2)$ 12

end

Y=abs (E(a, b)) where a=0.30 and b=1 13

Generating random numbers using abs (E (a, b)) for the stochastic coefficients of PSO can provide a batter understanding between the probability of small amplitudes around current points (fine adjustment) and a small probability of amplitudes more high, which can allow the particle to deflect from our current position. In DED_PSO, the speed is updated by eq. (14).

$$V_i^{k+1} = abs\big(E(a,b)\big) \times \left(P_{best(i)} - X_i^k\right) + abs\big(E(a,b)\big) \times \left(G_{best} - X_i^k\right) \qquad 14$$

B. Novel Self Adapting Inertia Weight PSO (NSAIW PSO):

In the simple PSO method, the inertial weight becomes constant for the particles in one generation, but the most important parameter that is responsible for moving the particle to the optimal position is the inertial weight w. The most regulated particle takes the rank first and, therefore, its weight will be smaller, while the lower regulated one takes the maximum range and movement of the particle with the maximum velocity given in equation 15

$$\omega = (3 - \exp(-PS/200) + (r/100)^2)^{-1} \qquad 15$$

Where PS is the population size and r is the rank of particle in whole population judged by fitness value.

C. Time-Varying Acceleration Coefficient PSO(TVAC_PSO)

In this variant of PSO, all inertial velocity weights w, $c1$ and $c2$, which are the best personal and global weights, vary over time. In this TVAC_PSO algorithm, the main goal is to achieve great diversity in initial iterations and high convergence to complete iterations.

$$v^{(i)}(n+1) = w(n)v^{(i)}(n) + c_1(n)r_1^{(i)}\left[u_p^{(i)}(n) - u^{(i)}(n)\right] + c_2(n)r_2^{(i)}\left[u_g(n) - u^{(i)}(n)\right] \qquad 16$$

N= 0, 1, 2….N-1, Personal best and global best weights are given as follows:

$$c_1(n) = c_{1f} - (c_{1f} - c_{1l})\frac{n}{N} \qquad 17$$

$$c_2(n) = c_{2f} - (c_{2f} - c_{2l})\frac{n}{N} \qquad 18$$

5. RESULTS AND ANALYSIS

Hydroelectric programming means to effectively use the reservoir's water resources in such a way that the river's water resources can be effectively used without landfill at the bottom. This programming problem becomes a more arduous optimization problem when the hydraulic system is interconnected with multiple tanks. In such systems due to the hydrological interdependence of plants, the operation of any plant influences the level of water and the storage in other plants of the same system. In this work, as dissert above, the programming problem of the NCHES generation was formulated and resolved by DED_PSO proposed for 24 hours per hour to satisfy the load demand. The identical problem has also been addressed by two other existing OSP variants, namely variable acceleration coefficients over time (TVAC_PSO) and a new self-adaptive inertia PSO (NSAIW_PSO).

Minimum value of objective function at different size for case 1

Population size	Minimum objective function E		
	DED_PSO	NSAIW_PSO	TVAC_PSO
5	1.30E+03	1.61E+03	1.83E+03
10	1.25E+03	1.74E+03	1.89E+03
15	1.39E+03	1.85E+03	1.96E+03
20	1.63E+03	1.42E+03	1.52E+03
25	1.82E+03	1.15E+03	1.26E+03
30	1.21E+03	1.09E+03	1.71E+03

Here the natural flows of different tributaries and evaporation losses between consecutive tanks have been considered. Hydroelectric projects are multi-purpose projects and in the present system studied, four projects belong to this category and meet the irrigation needs of their neighboring area. Therefore, irrigation needs are also considered for these plants. To exploit the potential energy of water released for irrigation, CHPHs are located at the outlets of the tank and the energy generated through them also contributes to meeting the load demand. The results are obtained for different population sizes of 5, 10, 15, 20, 25 and 30. The calculated values of the objective function are shown in the table. For this case, the population size of 10 also provides the best value of the objective function and its corresponding results, ie the minimum time value of Et and the optimal generation of energy through the power plants that use the three variants of PSO, ie DED_PSO, NSAIW_PSO and TVAC_PSO.

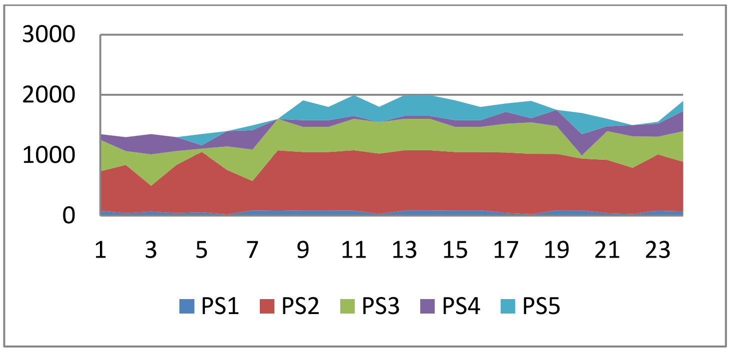


Fig 3: Optimal generation through river bed power houses of NCHES energy plants using DED_PSO for case 1

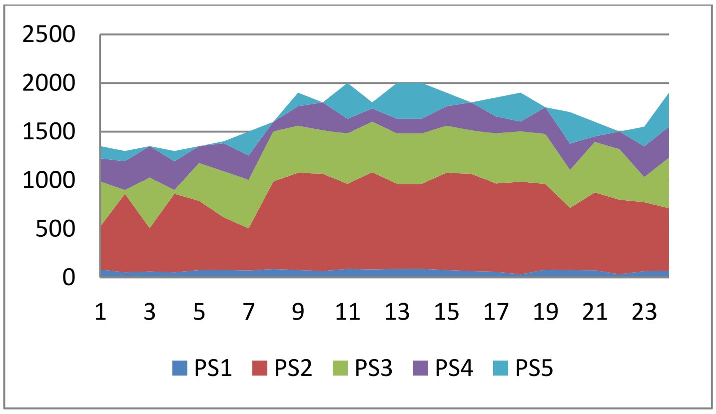


Fig 4: Optimal generation through river bed power houses of NCHES energy plants using NSAIW_PSO for case 1

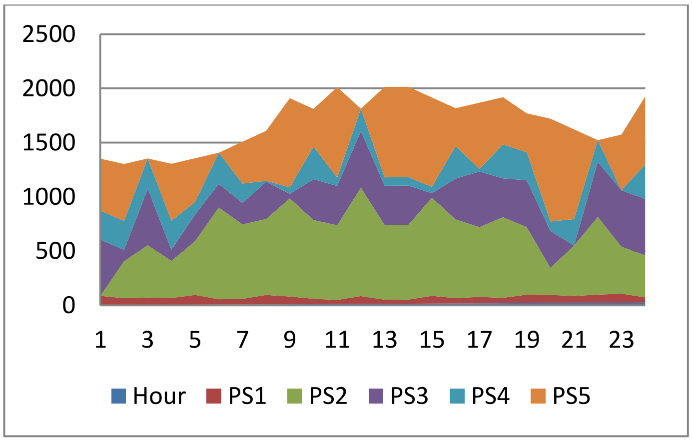


Fig 5: Optimal generation through river bed power houses of NCHES energy plants using TVAC_PSO for case 1

The results showed that for an optimal operation of NCHES, the average value of the power generated through each RBPH and the percentage of energy generated by its installed nominal capacity, that is, the system factor or the capacity factor, table in The clear clear OSP mention has the maximum plant factor followed by RABS, ISP, MSP and SSP. It means that for optimal NCHES operation, the small reserve capacity RBPH generates more power than its installed capacity compared to large reservoirs.

Table Average electricity generated and plant factor of RBPH,s of NCHES

PSO Variants	RABS		ISP		OSP		MSP		SSP	
	Average power (MW)	Plant factor	Average power (MW)	Plant factor	Average power (MW)	Plant factor	Average power (MW)	Plant factor	Average power (MW)	Plant factor
DED_PSO	67.2426	74.71	872.65	87.26	417.89	80.36	159.08	39.77	155.59	12.96
TVAC_PSO	63.107	70.11	603.34	60.334	328.36	63.14	178.25	44.56	479.77	39.98
NSAIW_PSO	69.475	77.19	791.97	79.197	443.41	85.27	217.03	54.25	148.95	12.41

The results showed that, for the optimal functioning of NCHES, the average value of the electric field generated by each RBPH and the percentage of energy generated by its nominal capacity, that is, the plant or the capacity factor, in the Table. In this case the RABS system component is the maximum chase by OSP, ISP, MSP and SSP. The implantation factor of RBPH is reflected on the basis of the reservoir storage capacity.

Average reservoir storage of RBPH in MCM

Name of RBPH	Average reservoir storage for schedule horizon		
	DED_PSO	TVAC_PSO	NSAIW_PSO
RABS	3919.96	3919.58	3919.85
ISP	12219.86	12219.71	12219.58
OSP	986.9988	986.87	987.6305
MSP	482.99	428.81	482.9982
SSP	9461.99	9461.29	9462

The results showed that, for the optimal functioning of NCHES, the average discharge value of the power generated through each RBPH and the percentage of energy generated by its nominal capacity, ie the plant or capacity factor, were mentioned in Table . In this case the RABS system cause is the maximum chase by OSP, ISP, MSP and SSP. The implantation factor of RBPH is reflected on the footing of the reservoir storage capacity.

Average discharge for RBPHs in NCHES

Name of RBPH	Average Discharge for schedule horizon		
	DED_PSO	TVAC_PSO	NSAIW_PSO
RABS	0.000146	0.000130209	0.000149
ISP	0.001479	0.001092	0.001358
OSP	0.001176	0.000943	0.001188
MSP	0.001002	0.001076	0.001239
SSP	0.007	0.000632	0.00705

6. CONCLUSION

The problem of short-term planning of hydroelectric power production for the cascaded hydroelectric system can find water discharges, storage of water in the tank and the energy generated through each hydroelectric plant and all scheduling periods, and operational constraints. The problems of hydraulic programming require the formulation of optimization problems. During the formulation, the time to move water from the system upstream to the immediate downstream plant is considered constant in spite of the various drains. In this destination function, the main objective of the model is expressed to curtail the deviation between load demand and generation through hydropower plants.

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