'r' in above equations is a capricious vector in [0,1] and 'a' is shrunk linearly from 2 to 0 respectively in subsequent repetitions. It means that with the the help of capricious vector 'r' any position or location can be reached while searching for prey. For mathematical modelling of the approach used by humpback whales i.e. bubble net feeding methods two methods are discussed and are presented as follow.

3.1. Shrinking Surrounding:

This approach is achieved by reducing 'a' in equation 7. The decrease in 'a' also effects the value of A causing it to reduce its range. Fresh locality can be established anyplace among the prevailing finest agent locality and original locality of the search agent by describing capricious values of A in [-1, 1].

3.2. Spiral Updating:

In this approach amid the locality of target and whale a spiral equation is created to reproduce the helix formed motion of whales.

$$X(t+1) = \overrightarrow{F'}.e^{cl}.\cos 2\pi l + \overrightarrow{X^*}(t) \tag{9}$$

$\vec{F}' = |\overrightarrow{X^*}(t) - \vec{X}(t)|$ postulates the distance amid ith whale and the prey, the profile of logarithmic spiral is defined by 'c' which is a constant, 'l' is a capricious figure in [-1, 1].

Humpback whales updates their localities towards the prey in spiral fashioned path and in shrinking approach at the same time. So we take chance that there is fifty percent possibility of either approach and is shown below in mathematical form.

$$\vec{X}(t=1) = \begin{cases} \overrightarrow{X*}(t) - A.D & if\ h < 0.5 \\ \overrightarrow{F'}.e^{cl}.\cos 2\pi l + \overrightarrow{X^*}(t), & if\ \ h \geq 0.5 \end{cases} \tag{10}$$

'h' designates a capricious figure in [0, 1].

Humpback whales also hunt haphazardly. Consequently, by varying value of $\vec{A}$ chase for target is completed. In order to make humpback whales move away from a whale capricious values greater than one or less than '-1' are to be used.

$$\vec{D} = |\vec{C}.\overrightarrow{X_{arb}} - \vec{X}| \tag{11}$$

$$\vec{X}(t+1) = \overrightarrow{X_{arb}} - \vec{A}.\vec{D} \tag{12}$$

WOA starts with a set of capricious results. In each repetition humpback whales update their localities w.r.t either a capricious whale or the prevailing finest result depending upon the value of $abs\vec{A} > 1$ or $abs\vec{A} < 1$. Similarly, reliant upon the value of 'h' WOA change between spiral or circular approach. Lastly, WOA is ended after meeting a termination criteria.

4. Model Results

4.1. Three Generators System

In this test system for the power requirement of 850 MW the required coefficients for fuel cost and the minimum and maximum generation limits of generators are obtained from [6]. The losses associated with power transmission are overlooked for the three generators test system situation. The test system is analysed for the effects of VPL as well as without the effects of VPLE. The WOA is executed for 500 iterations in each independent run. The number of independent were kept 20. While executing the algorithm for without the effects of valve point loading the search agents were kept 7500 while for including the effects of valve point loading the search agents were kept 15000 respectively. The results obtained using WOA for the aforesaid parameters are presented in Table 1 in the form as superlative, middling and poorest and fuel charge. The superlative results of WOA for the above stated parameters defined for three generators system are also shown with convergence characteristics curve shown in Fig. 1 for both with the effects of valve point loading and without the effects of loading.