Genetic Algorithms to Estimate the Pressure Deviations in Dynamic Transients of the Pressurizer Response in PWRs

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Abstract **- We propose the use of Genetic Algorithms, GAs, to optimize the transient dynamic pressure response of the pressurizer in Pressurized Water Reactor, PWR. The security and safety of the systems are crucial factors and are achieved by estimating the precise dimensions of the structure and pressure within the system to monitor the transitory behavior using GA techniques. In a light water pressurized reactor, the pressurizer with a steam to light-water interface is the key part to keep the prescribed pressure-temperature balance in the primary cooling circuit by using heaters to create more steam and increase pressure or cool water spray to condensate steam and reduce pressure. Two regions thermodynamic models of transitory performance of in-surge and out-surge boilers are presented. The thermodynamic theoretical model which produces a complete impact of each variation is analyzed and estimated by GAs as function of the operating parameters that affect the pressure transients such as: design pressure, design temperatures, diameter D, total height, level of water, spray flow rate Wsp and the electrical heat total power Qh. The results were compared with foreign data which showed close agreement.**

Keywords - genetic; pressurizer; transient; nuclear power plant; estimation

I. INTRODUCTION

More renewable and nuclear energy are currently used to meet electrical energy demands and deliver clean and friendly energy for the benefit of the environment by cutting the emissions of carbon dioxide. Nuclear energy still represents a significant share of the total energy provided now and in the future. From the earliest of 1950s, nuclear fission technology was exposed, a massive quantity of nuclear reactor plants was applied for, providing electrical power and still today progresses into new generation of nuclear reactor stations. Nuclear reactor stations deliver more than 11% of the global demand for electricity from about 450 power reactors, to provide continuous, reliable power to cover base-load range needed, without carbon dioxide releases as shown in fig.1. PWR represents the most types widely of the world's nuclear power plants and one of its three types is the light water reactor (LWR). Hence it is clear that the need for safety, nuclear power will be increased in the future, and then to emphasize the safety operation for the PWR, it is completely needed more work and researches in the pressurized reactor water systems especially that deals with the pressurizer. The importance of safety in nuclear accommodations requires the endless progress of the accurate models for examining the dynamic reaction of all components specifically those, which are decided the regulatory plant typical operation. The nuclear power plants share its output to 25% of the world total electricity production would have a very optimistic effect on air quality, minimizing CO2 releases, and refining energy safety without the worries of working about disseminating and discontinuous renewable energies. In (PWR), fig. 3. In an attempt to be the coolant water not to be boiled, the pressure must be over boiling to prevent water from boiling, and to remain this rising of pressure within limited access, the pressurizer is a basic apparatus of the nuclear reactor to prevent an uncontrolled nuclear reactor. Therefore, accurate inspection of this pressurizer performance is of the essence in the safety estimation of a PWR reactor. The reactor pressure is determined by the pressurizer by using two components play as a controller's equipment which are electrical heaters, pressurizer spray systems, and the valve operated power which is called safety and relief valves. The pressurizer is an essential tank in nuclear power plant and in all industrial applications because it is responsible for controlling the pressing of the reactor.

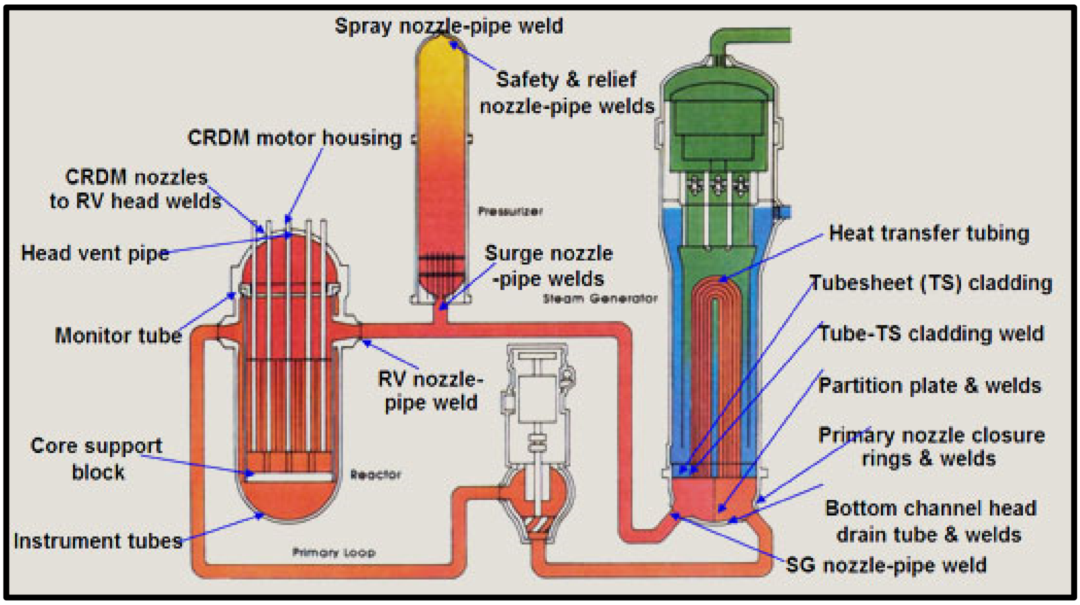

Fig.3. Pressurized water reactor plant

A. Pressurizer Function

In a pressurized water reactor plant, a typical pressurizer is shown in figure 4, which is a pressure container with a cylindrical form with curved tops, located vertically inside the reactor containment building elongated axis and straight connected by only one pipeline to the reactor coolant system. Even though the water is the same coolant in the all reactors as it in the pressurizer as in the rest of the reactor coolant system, it is principally stationary. Any pressurizer consists of:-

1. Especially the surge tank
2. Water spray system
3. Relief & safety steam system
4. Electrical heating elements

Under steady state operation circumstances, around 2/3 percent of the pressurizer volume is filled with water and the rest of it by steam. To maintain the water at saturation temperature and maintain a constant system operating pressure, an electric immersion heater, which are located in the bottom sector of the pressurizer. When the electrical load decreased, resulting in a transitory increase in the average temperature of the reactor coolant with an associated increase in coolant volume. The reactor coolant expansion when the level of the water rushed in the pressurizer caused compression in the steam, raising the pressure and activating the valves in the spray lines. To overcome this compression of pressure in the pressurizer by condensing, apportion of the steam by injecting a spray water of reactor coolant into the stem region this is called posits surge and condenses a ratio of the steam. And then the pressure reduced by this procedure and limits the pressure increases. Vice versa when the electrical load increased, resulting in a momentary decrease in the mean temperature of the coolant and making a coolant volume contraction. In brief coolant then surge out of the pressurizer into the branches to the reactor, this is called negative surge, therefore reducing the pressurizer level and force per unit area. Showing off more or less of the saturated water in the pressurizer to steam to boundary the pressure reduction. And then, as a consequence of this decreasing in the loudness of the steam, the heaters which are blanked out in the bottom portion of the pressurizer in the liquid phase also turned on to heat and raise water pressure in the pressurizer by transforming some of the water into steam to extra boundary over pressure decreasing. Falls in plant electrical load with resulting pressure increases more than the design pressure capacity of the spray systems of the pressurizer causes the steam relief valves to be worked upon. These valves are automatically opened or manually from the control room at a pressure below system design pressure. If the force per unit area (pressure) of the system remains to rise, self-actuating ASME-code safety valves will open. The vapor can flow through connected pipes from the guard and/or relief valves to the pressurizer relief tank which encloses the necessary water for condensing the steam. Cold water can be sprayed into the relief tank pressurizer to grow the heated bowl exchanging capacity. A rupture disc vents the tank to the containment if design pressure is exceeded. [1], [2].

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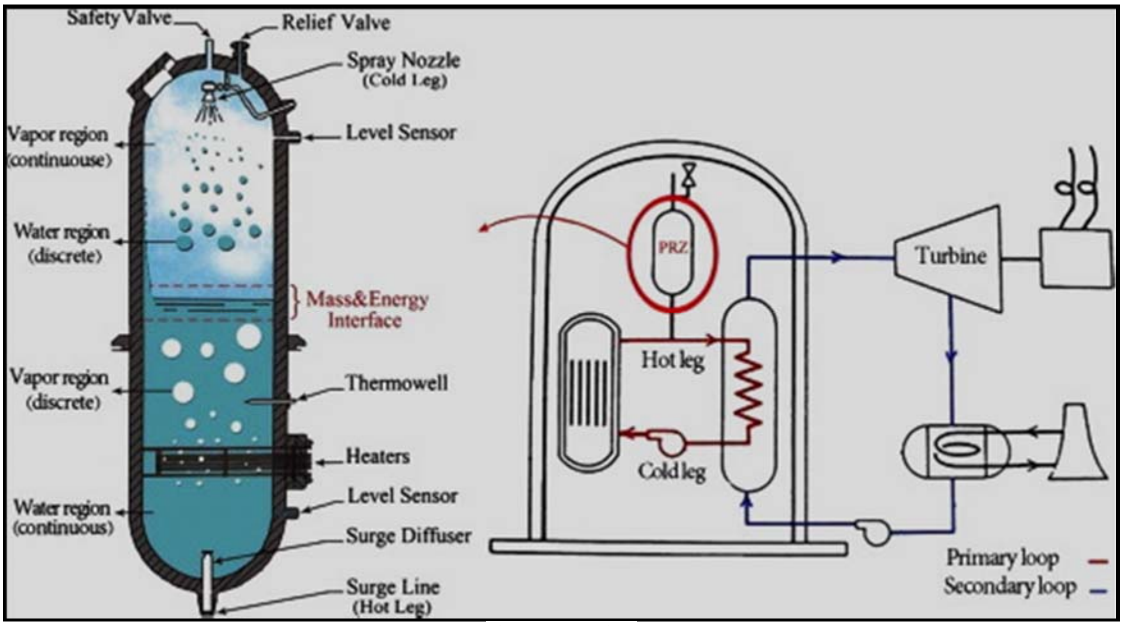

Fig. 4. Pressurizer

II. LITRETURE REVIEW

With the coming of nuclear reactor power plants and the increased with continuous needing the nuclear power as a part of power propagation in the world, the expansion of a rigorous theoretical model for anticipating the surge tank pressure transients during prescribed changes in liquid level history has been a subject of great interest to ensure the safety performance of nuclear power plant and decreases the accident's hazardous. The continually increasing demand related to the development of safer and more effective nuclear power plant needs either the improvement or all over re-conception of different apparatuses. In this regard, dynamic simulation is an essential tool for the development of detailed dynamic models aids the study of a system in order to make or better it. Modeling leads to deeper, thoughtful of the behavior of a system, to the optimization of its technological specifications and to the discovery of its possible failings. The researchers study and lecture about the overall situation of pressurizer dynamics, experimental, analytical, and empirical and mathematically modeling by codes.

Since 1950's, many researchers working on the pressurizer operation within safety limits. Primary approaches of analyzing a pressurizer applied a simple construction in which the complete vessel was considered as a single region at equilibrium conditions in [3] presented a procedure for the analysis and evaluation of thermodynamic transients with illustrative applications to the boiling water reactor and the pressurizer of the pressurized water reactor. The generalized thermodynamic approach is applicable to regular stream and non-current positions as well as transients. In [4] introduced development of a reliable design code for pressurizers together with a program for anticipating the dynamic response of the pressurizer to arbitrary motivation in the reactor cooling circuit. In [5 and 6] utilized the theoretical models with computational methods for pressure transients predicting during prescribed rates of increase or decrease of tank level. The digital computer program which is initiated in the theoretical cases and can be used to calculate pressure transients for any steam surge tank enclosing light or heavy water.

In [7] fabricated a simply experimental apparatus for training and understanding the multiple surges pressure transients' of the pressurizer of nuclear reactors. The entry model, clarifying the related relation between the semi-empirical model and the experimental results.

In [8] a hybrid-computer simulation of reboiler dynamics was equipped, containing models of, heat conduction, tube steam condensation, steam appearing, a surge tank, the steam line carrying and stream-control valve. Then the experimental approach takes an important part in investigations such as in [9] performing a categorizations of experiments which helping for providing understanding the primal of the phenomena which are essential analyzing of a PWR pressurizer. Experiments contain the additional effects of noncondensable gases, and free surface heat transfer.

[10] Presented review of pressurizer modeling indicates that the neglecting of the' change in the internal energy of the so-called water during transients is an acceptable assumption. In [11] by using two phases simulating codes IDRIFF due to lack of understanding of non-thermodynamic equilibrium and other local two-phase phenomenon in the pressurizer, worked to prepare

necessary tools for a methodical study and investigate of the pressurizer phenomena under quasi-steady-states and to conclude the special effects of significant factors of pressurizer operation. In that respect are different commercial thermal-hydraulic codes such as RELAP5, RETRAN, RELAP4, SOPHT and FIREBIRD, and TRACE, which can be used to simulate the pressurizer performance. Yet, an accurate simulation model in these codes necessitates proficient and expert operators. After the TMI accident many designers understood the importance of simulating system transients with greater accuracy, [12] makes a detailed study of a case of normal transient phenomena resulting from a failure in the pressurizer controlling elements in a PWR system.

In [13] Presented derivation of a basic mathematical model from the first law of thermodynamics, which comprises all the significant thermal-hydraulic progressions that can occur in the pressurizer. For achieving satisfactory performances, the model is deteriorated and developed into three alternatives: comprehensive lumped parameter and pseudo one dimension representations, two-volumes and three-volume pressurizer models were obtained in order of increasing difficulty and correctness. Lastly, comparison of the three models with the experimental data taking from Shippingport pressurizer tests and with the RELAP5® simulations.

In [14, 20 and 21] performed an Analyzing of the transient behavior of the surge tank in a WWER pressurized water nuclear power works. By creating an analytical method for predicting the power per unit area and degree of water deviations in the surge tank resulting in or out surge processes. The pressurizer volume parted of three countries in holding with the phase situation and push. RELAP5/Mod3 and RELAP5/Mod2 were used to compare the event. In [15] Presented two separated volume steam-gas pressurizer model for measuring the precise system pressure for REX10, In [16, 26, and 18] developed a non-equilibrium models according to the two-part or three-region concept pressurizer model, and by using TRACE code type 5.0 to evaluate its pressure transients. The benchmark of the pressurizer model was done by comparing the simulation results with those from the tests at the Maanshan, MIT, PACTEL, by SPACE code. In [17] introduces the modeling of two-region model nonlinear state-space by taking the basic thermo-hydraulic processes into consideration in order to obtain a simple model structure for a pressurizer of a WWER-440/213-type PWR.

In [19]. An algorithm which is called a Particle Swarm Optimization (PSO) presented for gaining an optimized set of parameters for the pressurizer dynamics model. The parameter optimization algorithm was utilized to a simulation case in pressurizer of a 900 MW PWR. In [22] presented an imbalance dynamic model of two-phase mechanism of pressurizer in pressurized water reactor (PWR), the model of the pressurizer pressure control system is performed by MATLAB/Simulink.

At the current time, the using of, state space model, fuzzy system, genetic algorithms (GA) and artificial neural networks (ANNs); act as an important role to model the pressurizer such as in [24, 25]. [31,32,33and 34] which all try to use novel algorithms to examine the simulation and modeling of IRIS of either two or three volumes to simulate a typical out-surge transient by using the genetic algorithm (GA) search to scaled models of geometrical sizes, the surge mass flow rate, and the heater power needed to hold the press. They use similarity numbers to place a “fitness function” to assess the reference of the well-defined variant. It is suitable Using the GA optimization, and the numeric simulation of a surge transient, to design a sized experiments for demonstrating and restricted dimensions of the International Reactor Innovative and Secure (IRIS) pressurizer and try to design and built it in minimum dimension, the new application of the method of analyzing the pressurizer level transients according to surge operation was succeeded to find the scale sizing of the test prototype of more or less 1/100 volume scale. So for the new generation design of PWR which is IRIS is trying to downplay the volume of the reactor

III. THERMODYNAMIC MODEL of TWO-PHASE PRESSURIZER.

In this paper the mathematical analysis model of the pressurizer, two forms are presented into the modeling the steam phase (including the droplets), the water phase. All the forms are separately calculated by mass and energy conservation equations, and thermal non-equilibrium is possible between any two phases. The present model contains rainout, internal-region heat and mass transfer and bulk flashing. The boundary flow mostly contains the evaporation flow of urine, the steam condensate flow, and the spray condensing flow and the wall surface condensation flow. According to the pool boiling theory, the bubbles will progressively turn off down to vanish in sub cooled water, and then the bubble production flow should not be counted in. While water enthalpy is more than saturated one corresponding to the saturated pressure, the water will develop bubbles and the quantity of bubbles will rapidly increase compatibly. The phase diagram of a pressure system in the pressurizer mechanism model is shown in Fig. 5.

A. Analytical Analysis and Assumption

The pressurizer volume can be divided into two areas: the Steam zone and the liquid zone. Under the following premises, a two-phase dynamic non-equilibrium stabilizer model is set up.

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1. Pressure is uniform throughout the pressurizer all the time;
2. The pressurizer is divided into two volumes, the lower one filled with liquid, the upper with vapor;
3. The spray reaches instantly the lower region, together with the steam, that condenses;
4. Phase changes due to pressure changes (flashing of liquid, rain out of vapor) are possible and are adopted to happen instantly;
5. Instantaneous evaporation by pressurizer heaters is considered.
6. The fluid form is either saturated or subcooled, and the steam phase could be either saturated or superheating.
7. It is light water pressurizer.
8. The pressurizer is good isolated system. Adiabatic system.
9. Rent to maintain saturated vapor to prevent subcooling.
10. Flashing to maintain saturated liquid to prevent superheating.
11. The mass exchanges in the interface between the two areas are finished in an instant;
12. When the two-phase separates completely, the thermodynamic parameters of each phase maintain the consistency in the meantime;
13. The spray water is saturated before leaving the steam zone, that means, the spay efficiency is 100%;
14. The surge entropy is constant and the surge flow is given.
15. The non-condensable gas should be negligible;
16. The spray water plus condensing mixture reaches saturation temperature before leaving the steam phase. The spray condensation processes at once;
17. The spray rate α pressure difference.
18. The mass and energy transfer from wall condensate and surface evaporation is assumed to contribute very little and may be neglected.
19. Condensate droplet velocity is considered as nominal.
20. The in-surge flow of coolant water mixes perfectly with the hot water in the bottom of pressurizer.
21. The state function of entropy is the same for the sprayed water into the pressurizer and the water coming from the cold leg in the reactor vessel
22. The heat transfer between fluids and the vessel materials and between the two phases (by conduction) is negligible, i.e. QW=QS=0, [37].
23. There is no steam discharged from the relief valve.
24. The heaters must always be completely liquid-covered, which for a fixed pressurizer geometry prescribes the minimum required liquid volume, approximately the water must be 60% of the pressurizer. [27]
25. Flashing and Condensation

Figure 6 and Table I, gives an illustration of spontaneous flashing and condensation. If a unit mass of liquid, at pressure P and saturation conditions 2 is depressurized by an amount ΔP, some of the liquid flashes into saturated steam. The horizontal interception on the temperature-entropy diagram is a measure of the amount of flashing. Similarly, a unit mass of vapor, at pressure ΔP and saturation conditions 3, will partially condense when depressurized by an amount ΔP. Again, the condensation drops amount is given by the horizontal intercept. Figure 6 also shows that, initially subcooled liquid at 1 or superheated vapor at 4, when depressurized, must first reach the saturation line before flushing or rent to liquid phase. In conclusion, a pressure increase from P to P+AP suppresses flashing and condensation, regardless of the initial state of the liquid (1 or 2) or vapor (3 or 4).

M_{SU}dt=mass of water surge line from hot leg.

M_{SUI}dt=mass of water entering surge line and mixing with the liquid phase from hot leg.

M_{SUO}dt=mass of water, leaving the liquid phase surge line to the reactor coolant hot leg.

M_{SP} dt=mass of spray injected into the pressurizer from cold leg.

M_{CS} dt=mass of steam condensing on spray droplets.

M_{RO} dt=mass of condensed falling into liquid from steam, or rainout

M_{CW} dt=mass of condensate on the pressurizer wall.

M_{re} dt=mass of steam leaving through the relief valve.

M_{sv} dt=mass of steam leaving through the safety valve.

M_{FL} dt=mass of water leaving from liquid entering steam from bubble rise.

Where m=dm/dt, the rate change of mass. Fig. 5. Clear the above statements.

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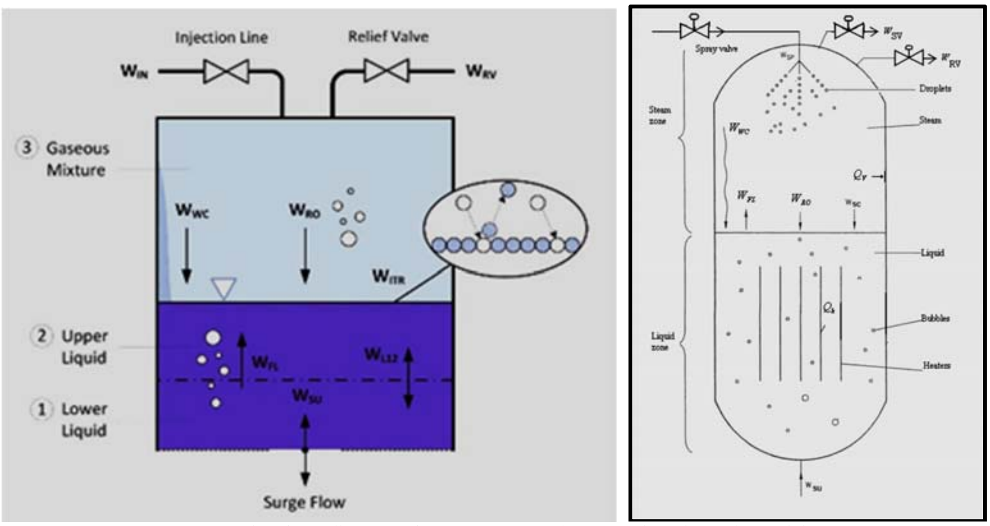

FIG. 5. The phase diagram of pressure system in pressurizer dynamic model

TABLE I. FLASHING AND CONDENSATION

The system has the same five prescribed input parameters: spray, msurge, h spray, surge, and Qh							
Cases	**Pressure**	**Condition of**		**Condensation**	**Flashing**	**Constraints**	**Unknown**
		Vapor	**Liquid**				
1	Rising	Saturated	Saturated	No	No	$h_l = h_f(p)$, $u_l = u_f(p)$ $h_V = h_g(p)$, $u_v = u_g(p)$ $W_{RO} = 0$, $W_{FL} = 0$	P, α_P,
2	Rising	Saturated	Subcooled	No	No	$h_V=h_g(p)$, $u_V=u_g(p)$ $W_{RO}=0$, $W_{FL}=0$	P, h_l, α_P
3	Rising	Superheated	Saturated	No	No	h_l,$=h_f(p)$, $u_l=u_f(p)$ $W_{RO}=0$, $W_{FL}=0$	P , h_V ,α_P
4	Rising	Superheated	Subcooled	No	No	$W_{RO}=0$, $W_{FL}=0$	P, h_l, h_V, ,α_P,
5	Falling	Saturated	Saturated	Yes	Yes	h_l,$=h_f(p)$, $u_l=u_f(p)$ $h_V=h_g(p)$, $u_V=u_g(p)$ $W_{RO}\neq0$, $W_{FL}\neq0$	P, α_P, W_{FL}, W_{RO}
6	Falling	Saturated	Subcooled	Yes	No	$h_V=h_g(p)$, $u_V=u_g(p)$ $W_{RO}\neq0$, $W_{FL}=0$,	P, , h_l,α_P, W_{RO}
7	Falling	Superheated	Saturated	No	Yes	h_l,$=h_f(p)$, $u_l=u_f(p)$ $W_{RO}=0$, $W_{FL} \neq 0$	P , h_V, α_P, W_{FL}
8	Falling	Superheated	Subcooled	No	No	$W_{RO}=0$, $W_{FL}=0$	P, h_l, h_V, ,α_P,

Refer to [37].

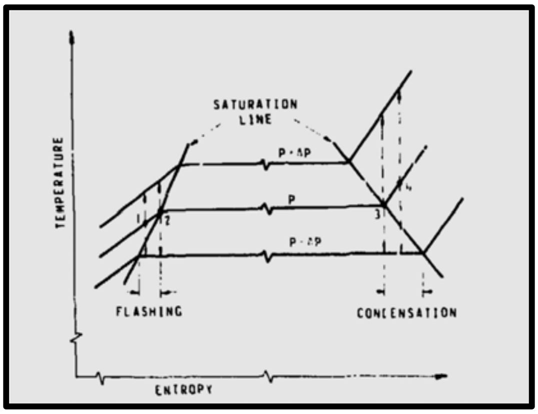

Fig. 6 temperature-entropy diagram showing spontaneous Flashing and condensation [36]

B. Abbreviations and Acronyms

D	Pressurizer diameter in m	msp	Spray mass flow rate Kg/sec
Vt	Pressurizer total volume m3	msuri	Surge in mass flow rate Kg/sec
VF	Volume of liquid phase m3	msuro	Surge out mass flow rate Kg/Sec
VG	Volume of steam phase m3	mspr(max)	Maximum spray mass rate Kg/Sec
MF	Mass of liquid phase in Kg	ΔU	Change in internal energy
MG	Mass of steam phase in Kg	Q	Heat added to the system
h_F	Subcooled water enthalpy in KJ	W	Work done by the system
h_G	Superheated steam enthalpy in KJ	P	Pressurizer pressure in Pascal
hf	Saturated water enthalpy in KJ	Qh	Hater input power in KJ
hg	Saturated steam enthalpy in KJ	q_F	Net heater rate added to the water phase in KJ
hfg	Latent heat =hg-hf in KJ	q_G	Net heater rate added to steam phase in KJ
hsp	Spray water enthalpy (cold leg) in KJ	Qh	Heater output power in KJ
hsu	Surge water enthalpy (hot leg) in KJ	t	Time in Sec
V_F	Subcooled water specific volume in m3/Kg	T	Temperature in degree
V_G	Superheated steam specific volume in m3/Kg	$\dot{U}_G$	Steam Internal energy rate dU/dt in KJ/sec
V_f	Saturated water specific volume in m3/Kg	U_G	Steam, Internal energy in KJ
Vg	Saturated steam specific volume in m3/Kg	U_F	Liquid internal energy in KJ
Z	Water level in the pressurizer in m	$\dot{U}_F$	Liquid Internal energy rate dU/dt in KJ/sec
m_F	dmF/dt Change of Mass rate of Water phase Kg/sec	T_{sat}	Is saturation temperature
m_G	dmG/dt Change of Mass rate of steam phase Kg/sec		

C. The General Mass and Energy Conservation Equation of Two –Fluid Pressurizer Model

Mass balance equation:

Steam mass

$M_G = M_{FL} - M_{re} - M_{sv} - M_{RO} - M_{CS} - M_{CW} + \cdots \ldots \ldots (1)$

Water mass

$M_F = M_{SU} + M_{SP} + M_{CS} + M_{RO} + M_{CW} - M_{FL} \ldots \ldots \ldots \ldots (2)$

Volume, balance equation

Steam: $V_G = M_G \vartheta_G \ldots \ldots \ldots \ldots \ldots \ldots (3)$

Water: $V_F = M_F \vartheta_F \ldots \ldots \ldots (4)$

$Pressurizer$: $V_T = V_G + V_F \ldots \ldots \ldots (5)$

$h_G = \frac{U_G}{M_G} + P\frac{V_G}{M_G} \ldots \ldots (6)$

$h_F = \frac{U_F}{M_F} + P\frac{V_F}{M_F} \ldots \ldots (7)$

Energy balance equation of:-

Steam

$h_G = \frac{U_G}{M_G} + P\frac{V_G}{M_G}$

$h_G M_G = U_G + PV_G$

$\frac{\partial(M_G h_G)}{dt} = q_G + V_G\frac{dP}{dt} \ldots \ldots \ldots \ldots (8)$

$q_G = (m_{FL} - m_{re} - m_{sv} - m_{CS} - m_{CW})h_G - m_{RO}h_F \ldots (8a)$

Water

$h_F = \frac{U_F}{M_F} + P\frac{V_F}{M_F}$

$M_F h_F = U_F + PV_F$

$\frac{\partial(M_F h_F)}{dt} = q_F + V_F\frac{dP}{dt} \ldots \ldots (9)$

$q_F = m_{SU}h_{SU} + m_{SP}h_{SP} + (m_{CS} + m_{CW} - m_{FL})h_F + m_{RO}h_F + Q_h \ldots (9a)$

Equation of state of the two regional model with surge transient and the upper region is superheated and the lower region is so-called:-

$\vartheta_G = \vartheta_G(p, h_G)$…… ……………..…. (10)
$\vartheta_F = \vartheta_F(p, h_F)$……………………... (10a),

After some steps in mathematics the overall equations which are describing the model of the pressurizer will be found in ref [37] if researcher would understand the all derivation operation. These six equations are: the rates of pressure changes, the level of water, steam mass, water mass, steam enthalpy, water mass and enthalpy:-

$$\frac{dp}{dt}\left[\!\left[M_G\left(\frac{\partial\vartheta_G}{\partial p}\right)_{h_G} + M_F\left(\frac{\partial\vartheta_F}{\partial p}\right)_{h_F} + V_G\left(\frac{\partial\vartheta_G}{\partial h_G}\right)_P + V_F\left(\frac{\partial\vartheta_F}{\partial h_F}\right)_P\right]\!\right] = -\left[m_G\vartheta_G + m_F\vartheta_F + \left(\frac{\partial\vartheta_G}{\partial h_G}\right)_P[-m_{re}h_G - m_{sv}h_G - m_{CS}h_G - m_{CW}h_G - m_{RO}h_G + m_{FL}h_G - m_G h_G] + \left(\frac{\partial\vartheta_F}{\partial h_F}\right)_P * [m_{SU}h_{SU} + m_{SP}h_{SP} + (m_{CS} + m_{CW} + m_{RO} - m_{FL})h_F + Qh - m_F h_F\right] \text{….} (11)$$

$$\frac{dz}{dt} = \frac{4}{\pi D^2}\left[m_F\left((\vartheta_F - \left(\frac{\partial\vartheta_F}{\partial h}\right)_p h_F\right) + \left(\frac{\partial\vartheta_F}{\partial h}\right)_p m_{SU}h_{SU} + \left(\frac{\partial\vartheta_F}{\partial h}\right)_p m_{SP}h_{SP} + \left(\frac{\partial\vartheta_F}{\partial h}\right)_p m_{CS}h_F + \left(\frac{\partial\vartheta_F}{\partial h}\right)_p m_{CW}h_F + \left(\frac{\partial\vartheta_F}{\partial h}\right)_p m_{RO}h_F - \left(\frac{\partial\vartheta_F}{\partial h}\right)_p m_{FL}h_F + \left(\frac{\partial\vartheta_F}{\partial h}\right)_p Qh + \frac{dp}{dt}\left\{V_F\left(\frac{\partial\vartheta_F}{\partial h}\right)_p + M_F\left(\frac{\partial\vartheta_F}{\partial h}\right)_p\right\}\right] \text{…………………… ..} (12)$$

$$\frac{dM_G}{dt} = +\frac{dM_{FL}}{dt} - \frac{dMre}{dt} - \frac{dM_{sv}}{dt} - \frac{dM_{CS}}{dt} - \frac{dM_{CW}}{dt} - \frac{dM_{RO}}{dt} \text{……………………………………………} (13)$$

$$\frac{dM_F}{dt} = \frac{dM_{SU}}{dt} + \frac{dM_{SP}}{dt} + \frac{dM_{CS}}{dt} + \frac{dM_{CW}}{dt} + \frac{dM_{RO}}{dt} - \frac{dM_{FL}}{dt} \text{………} (14)$$

$$\frac{dh_F}{dt} = \left[\frac{h_{SU}}{M_F}\frac{dM_{SU}}{dt} + \frac{h_{SP}}{M_F}\frac{dM_{SP}}{dt} + \frac{h_F}{M_F}\left(\frac{dM_{CS}}{dt} + \frac{dM_{CW}}{dt} + \frac{dM_{RO}}{dt} - \frac{dM_{FL}}{dt} - \frac{dM_F}{dt}\right) + \frac{V_F}{M_F}\frac{dP}{dt} + \frac{dQ_h}{M_F dt}\right] \text{…….} (15)$$

$$\frac{dh_G}{dt} = \frac{h_G}{M_G}\left(-\frac{dM_{CS}}{dt} - \frac{dM_{CW}}{dt} - \frac{dM_{RO}}{dt} + \frac{dM_{FL}}{dt} - \frac{dM_G}{dt}\right) + \frac{V_G}{M_G}\frac{dp}{dt} \text{……………………………………} (16)$$

Finally, in Table. II. The design parameters of the pressurizer taken in genetic optimization program were from ref [23].

TABLE. II. THE DESIGN PARAMETERS OF THE PRESSURIZER TAKEN IN GENETIC OPTIMIZATI

No.	Parameters	Unit	Minimum value	Maximum value
1	Design Pressure P	Mpa	15.	16
2	Design Temperature T	°C	350	360
3	Diameter d	cm	1	3
4	Total Height	m	12	13
5	Spray Flow	m^3	0	0.04
6	Electrical Total Heat Power	kW	1500	1650
7	Water Volume VF	m^3	23	24
8	Saturated Temperature T_{sat}	°C	340	345
9	Water Level Z	m	5	9

D. Genetic Algorithms

A genetic algorithm is an exploratory search method used in artificial intelligence and computing. It is applied for finding optimized solutions to such problems based on the theory of natural selection and evolutionary biology. Genetic algorithms are brilliant for searching through large and complex data sets. They are considered skillful of discovery sensible resolutions to complex problems as they are extremely talented of resolving unconstrained and constrained optimization issues. (GAs) are optimization methods stimulated in the development theory, in which artificial chromosomes make up of binary numbers (genes) encode solution runners. In this work, the chromosome encodes the list of search variables. In the GA, primarily chromosomes to get together in a population which is generated randomly. And so, guided by a fitness function (the objective part of the optimization problem), the development happened by the selection of simulated natural, crossovers and mutations. The solution candidates by these operations, then the (chromosomes) will be improved from one generation to another. [34]. Genetic Algorithms (GAs) pictured an intelligent exploitation of an indiscriminately looking out accustomed solve improvement issues. The simple practices of the GAs square measure designating to simulated processes in standard systems required for evolution, particularly those keep an eye fixed on the Charles Robert Darwin of "survival of the fittest "styles of awareness start set around since in nature, rivalry among individuals for inadequate assets prompts the fittest individuals ruling over the weaker one. GAs faux the survival of the rightest amongst people over succeeding generation for resolution a haul. The search house pictured by every individual truth of a doable answer. The population consists of character strings that square measure analogous to the body that may be seen in creature polymer. A gAs square measure supported an analogy with the genetic structure and behavior of chromosomes inside a population of individuals' by means of the subsequent foundations:

- The population of Individuals in competing for incomes and mates.
- Those individuals' best in every 'opposition' will deliver more posterity than those individuals that perform ineffectively.
- Genes from `good' individuals proliferate all through the populace with the goal that two great guardians will in some cases deliver posterity that are superior to either parent.
- Therefore, each succeeding generation will become more suitable to their surroundings. [35].

IV. RESULTS AND DISCUSSIONS

The Pressurizer surge tank's physical characteristic and equipment's pressure set-points are listed in (table II ref) [23]. The pressurizer pressure fluctuate range was 15.4MPa<P<15.6 Mpa after the first appearance of the steam turbine load -10%. Water and vapor's parameters were regarded unchanged and the rate of change was constant in such a small pressure fluctuate range.

A state space model of the pressurizer is solved by using genetic algorithm. A Matlab programming is constructed by using data obtained from [23]. Input data source values for favored value are appearing in Table III. The yields initiate for pressurizer can be defined as a straight mix of informational factors. Based on Figure 7 and 8, the pattern on graph for levels of water and pressure in a pressurized water reactor are in agreement with the assumptions that have mentioned before. Fig. 9. Confirmed that when the pressure spreads to the saturation pressure parallel to the initial temperature, the heat transfer to the cold wall shrinks the influence of flashing, and because of that, the pressure drop for this case is more rapid than a simple outside case. Fig. 10. Shows the optimization agreement with the above results which stated that when the pressure rise the spray system must be on to overcome the excess pressure by condensing some amount of steam to retain back the pressure to setting value and this is clear from the peaks appear in fig 10. Of design diameter. As mentioned in the abstract the optimization of some design parameters will be done, so fig. 11. And 12.Shows the optimum design parameters for the diameter and height of the pressurizer which compatible with the source taking from it ref [23].

TABLE III. GENETIC SEARCH NUMBER

DAIMETER m	Total Height m	Water Volume m^3	Spray Flow Wsp Kg/s	Electrical heat total power Qh kW	Saturated Water Temperature ºC	Water Level m	Design Pressure Mpa
2.8	12.9	23.5	0.02	1650	340	5.3	15
2.7	12.8	23.5	0.02	1650	340	5.5	15.5
2.4	12.8	23.3	0.02	1650	340.2	5.4	15.1
2.2	12.7	23.4	0.02	1650	340.1	5.3	15.7
2.3	12.8	23.5	0.02	1650	340	5.1	15.5
1.6	12.7	23.4	0.03	1650	340	5	15.4
1.4	12.7	234	0.03	1650	340	5.6	15.9
2.8	12.8	23.9	0.02	1650	340	5.3	15.5
1.6	12.9	23.6	0.01	1650	340	5.2	15.6
1.8	12.9	23.4	0.02	1650	340	5.3	15.8
2.1	13	23.3	0.03	1650	340.2	5	15.3
1.2	12.9	23	0.03	1650	340.4	5	15.3
1.9	12.8	236	0.02	1650	340	5.1	15.5
2.4	12.7	231	0.02	1650	340.1	5.3	15.7
1.9	12.8	23.3	0.01	1650	340.4	5	15.5
1.7	12.8	23.4	0.03	1650	340	5	15.5
1.6	12.7	23.5	0.03	1650	340	5	15.1
2.2	13	23.4	0.02	1650	340	5.4	15.2
2.5	12.9	23.6	0.02	1650	340	5.2	15.4
2.2	12.6	23.4	0.02	1650	340	5.3	15.2
2.2	12.6	23.5	0.02	1650	340	5	15.3

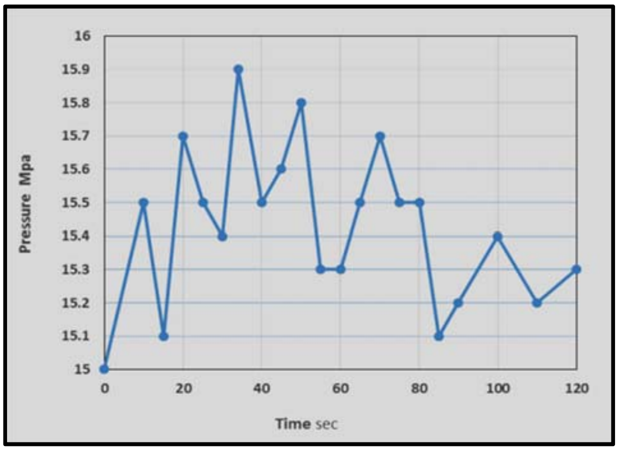

Fig.7 .pressure Changes during Surge Transient

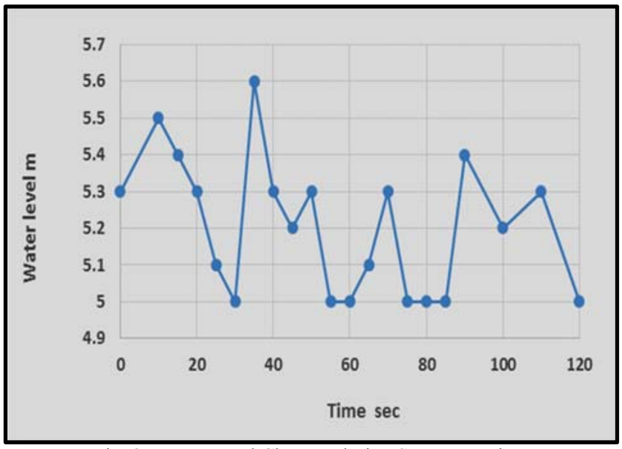

Fig. 8 .Water Level Changes during Surge Transient

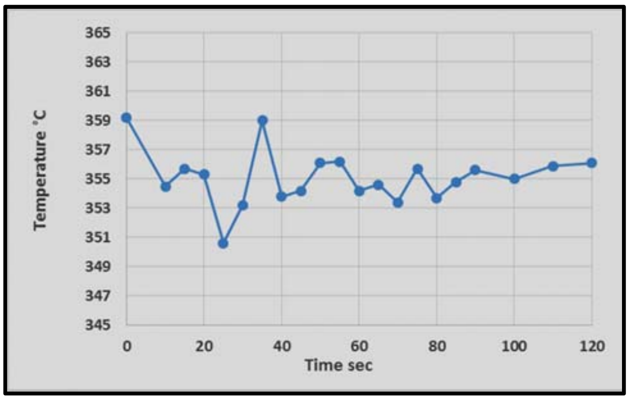

Fig. 9 .Temperature Changes during Surge Transient

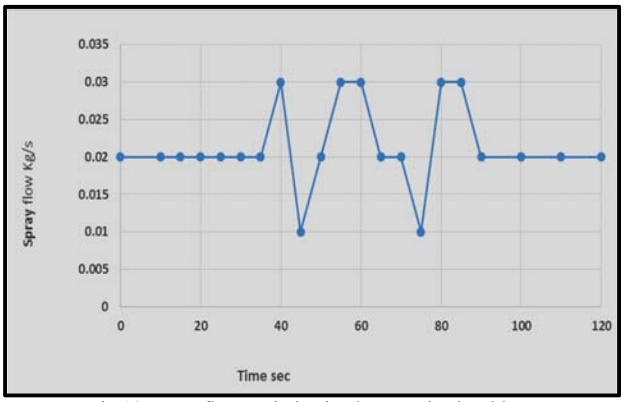

Fig.10 .spray flow optimization by genetic algorithms

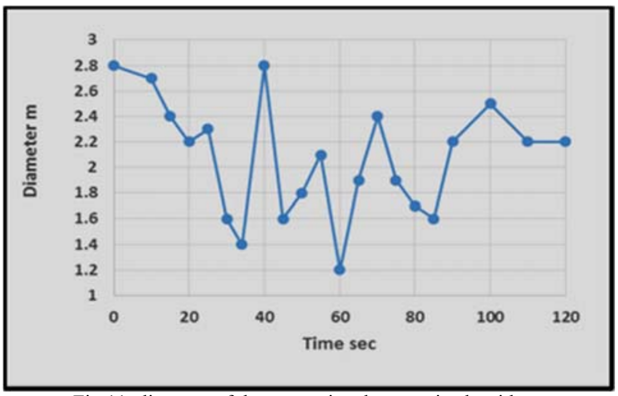

Fig.11 .diameter of the pressurizer by genetic algorithms

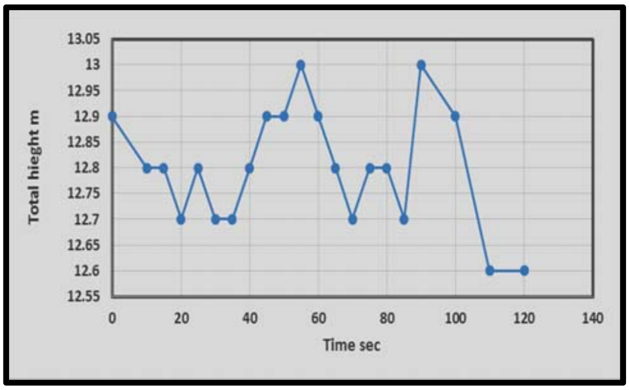

Fig.12 .total high tot the pressurizer optimization by genetic algorithms

V. CONCLUSION

Using Genetic Algorithm (GA) optimization, we effectively determined the search variables of scale models, which are: the design pressure and temperature, geometrical sizes (total height, diameter of pressurizer), the spray mass flow rate, and the heater power needed to control the pressure in the pressurizer in a nuclear power reactor. The results show that the percentage error in the input and output is small. The simulation shows that if the water level increased the pressure increased. Vice versa, if the water levels decrease, then the pressure is decreased.

The operation of the systems was verified using a two-volume transient model to simulate a typical surge transient. The GA optimization and the numeric simulation of a surge transient, to design scaled experiments for modeling the pressurizer. As shown, are almost identical, using either a separate solver or a simultaneous solver. The initial confirmation is the agreement reached by all the developed software with the data of pressurizer from a foreign country experimentally data, and the close.

The derivation of the present constitutive models is of great relevance to scale the local phenomena of remote, flashing and wall condensation in a scaled model. The GA described the selected parameters (spray flow rate, heat, power, pressure and temperature and size). This GA optimization is a considerably valued tool to acquire the parameters for the model.

The individual designer would face much difficulty to define the best parameters for safety design of the nuclear facilities without the GA or other good optimization algorithm. The GA optimization, and the numeric simulation of a surge transient, of pressure increases, can be used to design scaled experiments for modeling the pressurizer. Since there is no access to an experimental facility to compare experimental results with the model output, the results obtained are compared with reference [23], this comparison shows that the results are in agreement with the above complex and valid optimization.

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