# MODELLING AND PARAMETRIC STUDY OF GAS TURBINE COMBUSTION CHAMBER

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***ABSTRACT***

*In order to find the amount of pollution created by combustion in a gas turbine, Conjugate CFD equations in turbulent mixing and combustion equations is done. Overall conservation equations for mass, momentum, energy and the combustion process, for large eddy simulation (LES) and the chemical reaction rate method is merged. For the numerical solution, solving the Structured Grid with the Staggered Grid and cylindrical coordinates is considered. Discretization equations used for grid capability and QUICK algorithm to solve the equations and the numerical algorithm is performed. To verify the numerical solution, the geometry of the boundary conditions of a gas turbine combustor controlled by analytical and experimental results, it turns out that the numerical solution has been considered. Compared with existing analytical models and experimental results with acceptable error has been approved. NO production output of combustion in a gas turbine based on variables such as changes in temperature and the amount of fuel and air entering the gas turbine power optimization has been found.*

***Keywords:*** *Combustion Chamber, Gas Turbine, Large Eddy Simulation, Chemical Reactions Rate, Discretization, Structured Grid, Staggered Grid*

## I. INTRODUCTION

Due to the worries about the biological peripheral are caused to exert the limit of the increasing of the propagation from the gas turbines systems. Briefly due to the investigation of the proliferation of pollution basically to the varieties of stable currents in the combustion chambers which is done by Rizk and Nandula another co-operations. [1,2,3] It is worthy to mention that Moin and Mahesh and Menzies work precisely on the analysis of in flammability in the combustion chambers of gas turbines. By some simulating ways and for finding the amount of No which is produced in the combustion chamber of gas turbine, this is analysed by the Fiechtner and Pekkan. [4,5,7] The first result of this article is insufficient studies and investigations on this course precisely, in order to produce a reliable current fluid for the gas combustion chamber. By the strategy which is set on this article most of the physical features of turbulent currents already maintained and of course complicated current of free dimensions which is followed by the deviation of those, most of those are predictable. The next step in the turbulent modelling is the production of the complete model of Reynolds stress. [6] Although this quantity of precise ended up to the complicated modelling, this matter needs more time of calculations which is a liberties task and it is absolutely vital for the analysis of combustion chambers of gas turbines. [8]

## II. CRUCIAL EQUATIONS IN COMBUSTION

For a combination of stable fuel and air (Ideal) all of the derived chemical and thermo dynamical equations are as follows:

- **Elements:**

$$\frac{\partial \rho y_i}{\partial t} + \nabla \cdot (\rho \boldsymbol{u} y_i) = -\nabla \cdot (\rho V_i y_i) + \rho w_i, \qquad i = 1, \dots, N_S \tag{1}$$

which ρ is density, u element mass ratio, $\boldsymbol{V_i}$ velocity vector, $\boldsymbol{w_i}$ the velocity of transportation of element mass, production ratio of chemical element ( Output of combustion) for the i element ( which i is From 1 to $N_s$).

- **Mass:**

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{u}) = 0 \tag{2}$$

- **Momentum:**

$$\frac{\partial \rho \boldsymbol{u}}{\partial t} + \nabla \cdot (\rho \boldsymbol{u}\boldsymbol{u}) = -\nabla \mathrm{p} + \nabla \cdot \tau + \rho \sum_i y_i f_i \tag{3}$$

Which **p** is pressure, $\boldsymbol{\tau}$ Tensor of viscous tension and $\boldsymbol{f_i}$ (Buoyancy force) is for the unit of mass elements.

- **Energy:**

$$\frac{\partial \rho (e+k)}{\partial t} + \nabla \cdot [\rho \boldsymbol{u}(e+k)] = -\nabla \cdot (p\boldsymbol{u}) + \nabla \cdot (\tau \cdot \boldsymbol{u}) - \nabla \cdot q + \rho \sum_i y_i f_i \cdot (\boldsymbol{u} + V_i) \tag{4}$$

Which **e** is the combination of internal energy and **k** is the vibration energy to the mass unit of $(k = \frac{1}{2}u^2)$.

- **Viscous Tension:**

$$\tau = 2\mu \left[ S - \frac{1}{3}(\nabla \cdot \boldsymbol{u}) I \right] + \mu_B (\nabla \cdot \boldsymbol{u}) I \tag{5}$$

Which is $\boldsymbol{\mu}$ is the molecule viscosity, $(\boldsymbol{\mu = \rho\nu})$, $\boldsymbol{\mu_B}$ is the Buoyancy viscosity and finally **S** is the intensity strain of tensor, and also **I** is the permanent tensor.

$$q = \underbrace{-\kappa \nabla T}_{\textbf{conduction}} + \underbrace{\sum_i \rho V_i y_i h_i}_{\textbf{Mass currency}} + \underbrace{\hat{R} T \sum_i \sum_j \frac{x_j D_{T,i}}{M_i D_{ij}} (V_i - V_j)}_{\textbf{Doffor Effects}} + \underbrace{q_R}_{\textbf{Radiation}} \tag{6}$$

Which **K** is the thermal conductive indicator $\boldsymbol{\kappa = \rho c_p \alpha_T}$ and $\boldsymbol{\alpha_T}$ are the thermal currency indicator and $\boldsymbol{h_i}$ is the **i** th element enthalpy, and also **R** is the constant global gas. Hence $\boldsymbol{x_i}$ is the molly element ratio, $\boldsymbol{D_{T,i}}$ is the mass currency indicator of thermal element, $\boldsymbol{Dij}$ is the matrix currency indicator of element mass, $\boldsymbol{M_i}$ is the molecule element mass and $\boldsymbol{q_R}$ is the vector of the radiation currency. It is worthy to mention that defers influence is the effect of the thermal penetration.

$$\nabla x_i = \underbrace{\sum_j \frac{x_i x_j}{D_{ij}} (V_j - V_i)}_{\textbf{Stefan-Maxwe}} + \underbrace{(y_i - x_j) \frac{\nabla p}{p}}_{\textbf{Pressure Gradient}} + \underbrace{\frac{\rho}{p} \sum_j y_i y_j (f_i - f_j)}_{\textbf{Boyancy Force}} + \underbrace{\sum_j \frac{x_i x_j}{\rho D_{ij}} \left( \frac{D_{T,j}}{y_j} - \frac{D_{T,i}}{y_i} \right) \frac{\nabla T}{T}}_{\textbf{Soret}} \tag{7}$$

- **Equation of thermo dynamical mood:**

$$p = \rho \sum_i \frac{y_i}{M_i} \hat{R} T \tag{8}$$

By the omitting terms of the effect of the compressibility and acoustic, thermal released which is wasted in the time of viscosity, buoyancy viscosity, buoyancy fore, the effects of currency of pressure gradient and the radiation are simplified in the combustion chamber which is over simplified by the following equations:

- **Continuity Equation:**

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{u}) = 0 \tag{9}$$

- **Momentum Equation:**

$$\frac{\partial \rho \boldsymbol{u}}{\partial t} + \nabla \cdot (\rho \boldsymbol{u}\boldsymbol{u}) = -\nabla p + \nabla \cdot [2\mu \left(S - \tfrac{1}{3} I \nabla \cdot \boldsymbol{u}\right)] \tag{10}$$

- **Scalar Mass Transport:**

$$\frac{\partial \rho \phi_k}{\partial t} + \nabla \cdot (\rho \boldsymbol{u} \phi_k) = \nabla \cdot (\rho \alpha_k \nabla \phi_k) + \rho w_k, \qquad k = 1, 2, \ldots \tag{11}$$

- **Mood relation:**

$$\rho = f(\phi_1, \phi_2, \ldots) \tag{12}$$

## III. Circulated Current and Effect of Those on the Chemical Model

Choosing the scale by the LES strategy is basically due to the separation of small and big scale. For the definition of these two groups we have to identify a good resource of length separation.
Continuity equation after filtering is remained with no difference but the momentum equation after filtering leads us to an extra matter of scale in the main equation. We need to model this matter in the way to have less small scale circulator effect. It is worthy to mention that one of the privileges of simulating model is to responding them at any times. Density is basically analyzed by the Reynolds as follows:

$$\rho = \bar{\rho} + \rho'$$

And according to the velocity of Favre [9] modeling which already filtered:

$$u = \tilde{u} + u''$$
$$\tilde{u} = \frac{\overline{\rho u}}{\bar{\rho}}$$

We reviewed all the mentioned strategies of 9 to 12 equations in the LES:

- **Continuity Equation:**

$$\bar{\rho}_{,t} + (\bar{\rho}\tilde{u}_j)_{,j} = 0 \tag{13}$$

- **Momentum Equation:**

$$\begin{gathered} (\bar{\rho}\tilde{u}_i)_{,t} + (\bar{\rho}\tilde{u}_i\tilde{u}_j)_{,j} = -\bar{p}_{,i} + (2\bar{\mu}\tilde{S}_{ij})_{,j} + t_{ij,j} \\ \tilde{S}_{ij} = \tfrac{1}{2}\left(\tilde{u}_{i,j} + \tilde{u}_{j,i}\right) - \tfrac{1}{3}\delta_{ij}\tilde{u}_{k,k} \end{gathered} \tag{14}$$

- **Scalar Mass of Equation:**

$$(\bar{\rho}\tilde{\phi}_i)_{,t} + (\bar{\rho}\tilde{u}_j\tilde{\phi}_i)_{,j} = (\bar{\rho}\tilde{\alpha}_i\tilde{\phi}_{i,k})_{,k} + \bar{\rho}\widetilde{w}_i + q_{ik,k} \tag{15}$$

- **And the relationship mood:**

$$\bar{\rho} = \overline{f(\phi_1, \phi_2, \dots)} \tag{16}$$

Then $\boldsymbol{t_i}$ is the tensor tension residue and $\boldsymbol{q_{ik}}$ is the chemical thermal residue and $\tilde{\boldsymbol{w}}_{\boldsymbol{i}}$ which have to be modeled. [10] Amount of remained tension in the circular viscosity is as follows: [11]

$$t_{ij} = -\bar{\rho}\widetilde{u_i u_j} + \bar{\rho}\tilde{u}_i\tilde{u}_j = 2\mu_t\tilde{S}_{ij} - \frac{1}{3}\bar{\rho}q^2\delta_{ij} \tag{17}$$

And $\frac{1}{2}\bar{\boldsymbol{\rho}}\boldsymbol{q}^2$ is the basic kinetic energy; also $\boldsymbol{\mu_t}$ is the circular viscosity which is defined as following equations:

## IV. MODEL OF SMAGORINSKY

Hence, it is worthy to mention the equations are as following, which they called as the Smagorinsky model:

$$\begin{aligned} \tilde{S}_{ij} &= \frac{1}{2}(\tilde{u}_{i,j} + \tilde{u}_{j,i}) - \frac{1}{3}\delta_{ij}\tilde{u}_{k,k} \\ \mu_t &= C_\mu\bar{\rho}\Delta^2|\tilde{S}| \\ |\tilde{S}| &= \sqrt{\tilde{S}_{ij}\tilde{S}_{ij}} \end{aligned} \tag{18}$$

And for the description of basic kinetic energy it has to be the equation number 19:

$$\bar{\rho}q^2 = C_k\bar{\rho}\Delta^2|\tilde{S}|^2 \tag{19}$$

And also for the basic thermal basic currency: [12]

$$q_{ik} = -\bar{\rho}\widetilde{u_k\phi_i} + \bar{\rho}\tilde{u}_j\tilde{\phi}_i = \bar{\rho}\alpha_t\tilde{\phi}_{i,k} \tag{20}$$

$$\bar{\rho}\alpha_t = C_\alpha\bar{\rho}\Delta^2|\tilde{S}| \tag{21}$$

Indicators formulas of $\boldsymbol{C_\alpha}$ و $\boldsymbol{C_k}$ و $\boldsymbol{C_\mu}$ already solved in the dynamical solutions which are already mentioned above.

## V. NUMERICAL THEORY

Basic utilized pattern of this article is in the first figure. In this figure angles of the main control volume are $\boldsymbol{v}$ ,$\boldsymbol{u}$. The first and the most conclusion of this infrastructure is the mass current ratio from different angles of control volume without any mid calculations of velocity matters.

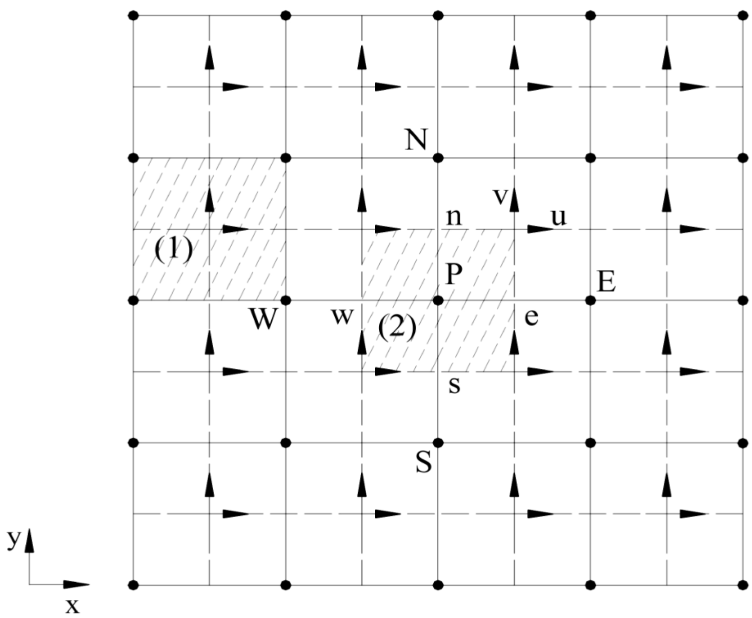


**Figure 1.** Transport network pattern

For the coordinate system in two directions of X and Y and for a permanent network with differences of X and Y which is separated by the matters of i and j. [13,14] Also the operations of mid calculations are defined as follows:

$$\overline{u}^{x}\Big|_{i,j} = \frac{u_{i+1/2,j} + u_{i-1/2,j}}{2}, \quad \overline{u}^{y}\Big|_{i,j} = \frac{u_{i,j+1/2} + u_{i,j-1/2}}{2} \tag{22}$$

Therefore differential operations are also:

$$\delta_x(u)|_{i,j} = \frac{u_{i+1/2,j} - u_{i-1/2,j}}{\Delta x}, \quad \delta_y(u)\Big|_{i,j} = \frac{u_{i,j+1/2} - u_{i,j-1/2}}{\Delta y} \tag{23}$$

## VI. DESCRITIZATION OF THE VITAL EQUATION

We assume a transport network that velocity and density are located at the border of the cells and other transport networks which are already mentioned are defined as space time [15], (Figure 2). We call every cell in this network as a continuous cell which is occupied by the velocity and density and the equations between them are simplified as the continuity equation.

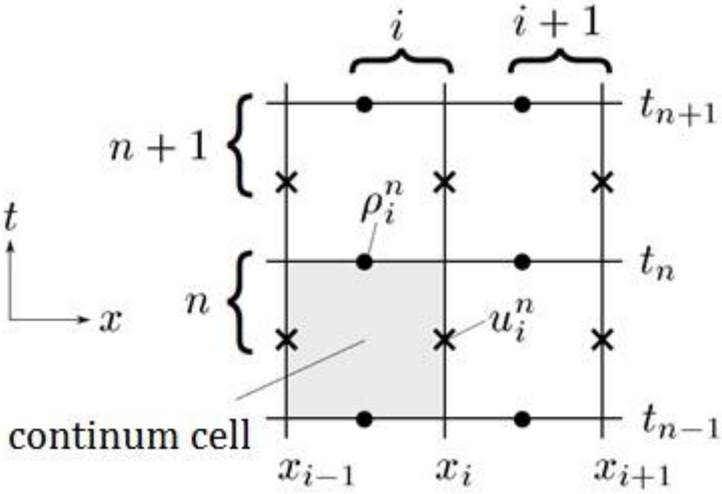


**Figure 2.** Separated Network in the Space-Time

With the definition of:

$$g_i = \overline{\overline{\rho}^{x_i}}^{t} u_i\,, \qquad u_i = g_i / \overline{\overline{\rho}^{x_i}}^{t} \tag{24}$$

Separated vital equations over simplified are then:

- **Continuity**:

$$\delta_t(\rho) + \delta_{x_j}(g_j) = 0 \tag{25}$$

- **Momentum**:

$$\delta_t(g_i) + \delta_{x_j}\left(\overline{\overline{g_j}^{x_i}}^{t}\, \overline{\overline{u_i}^{x_j}}^{t}\right) = -\delta_{x_i}(p) + \delta_{x_j}(\tau_{ij})$$

$$\tau_{ij} = \begin{cases} \overline{\overline{\mu}^{x_i}}^{x_j}\left[\delta_{x_j}(\overline{u_i}^{t}) + \delta_{x_i}(\overline{u_j}^{t})\right] & i \neq j \\ 2\mu\left[\delta_{x_j}(\overline{u_i}^{t}) - \frac{1}{3}\delta_{x_k}(\overline{u_k}^{t})\delta_{ij}\right] & i = j \end{cases} \tag{26}$$

- **Scalar Mass Transport:**

$$\delta_t(\rho\phi) + \delta_{x_j}\left(g_j\overline{\overline{\phi}^{x_j}}^t\right) = \delta_{x_j}\left[\overline{\overline{\rho\alpha}^{x_j}}^t \delta_{x_j}(\overline{\phi}^t)\right] + \overline{\rho}^t w(\overline{\phi}^t) \tag{27}$$

For a better definition of the above equations we are going to review the continuity equation 25 as follow:

$$\begin{aligned}\frac{\rho_{i,j}^{n+1} - \rho_{i,j}^{n}}{\Delta t} + \frac{1}{4\Delta x}&\left[\left(\rho_{i+1,j}^{n+1} + \rho_{i,j}^{n+1} + \rho_{i+1,j}^{n} + \rho_{i,j}^{n}\right)u_{i,j}^{n+1}\right.\\ &\left.- \left(\rho_{i,j}^{n+1} + \rho_{i-1,j}^{n+1} + \rho_{i,j}^{n} + \rho_{i-1,j}^{n}\right)u_{i-1,j}^{n+1}\right]\\ &+ \frac{1}{4\Delta y}\left[\left(\rho_{i,j+1}^{n+1} + \rho_{i,j}^{n+1} + \rho_{i,j+1}^{n} + \rho_{i,j}^{n}\right)v_{i,j}^{n+1}\right.\\ &\left.- \left(\rho_{i,j}^{n+1} + \rho_{i,j-1}^{n+1} + \rho_{i,j}^{n} + \rho_{i,j-1}^{n}\right)v_{i,j-1}^{n+1}\right] = 0\end{aligned} \tag{28}$$

**Figure 3** is the indication of a transport network and figure number 4 with coordinates of **x و r و θ are** for the preliminaries of solving problems:

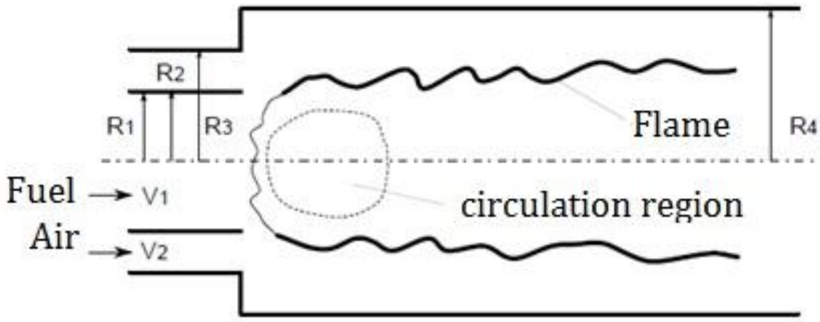


**Figure 3.** Suggested combustion chamber for numerical exported equation

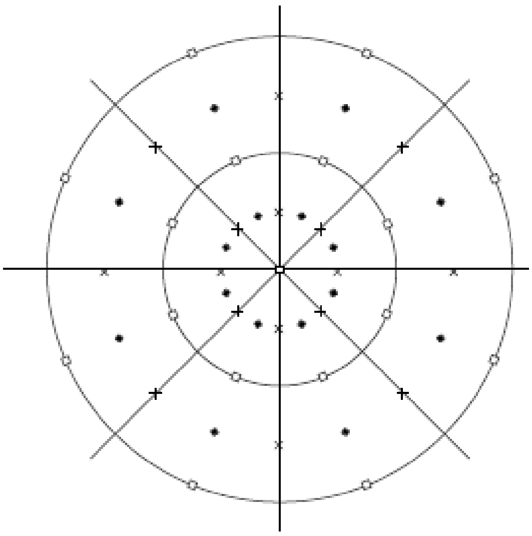

**Figure 4.** Cylindrical transport network which *p*, u, φ and p are in the centre of cellules (Fully black points), and also $u_\theta$ is in the boundary of cellules

In cylindrical coordinates system, derived equations are also proposed as:

- **Mass currency:**

$$g_x = \overline{\overline{\rho}^x}^t u_x, \quad g_r = \overline{\overline{\rho}^r}^t u_r, \quad g_\theta = \overline{\overline{\rho}^\theta}^t u_\theta \tag{29}$$

- **Velocity divergence:**

$$\Theta = \delta_x(u_x) + \frac{1}{r}\delta_r(ru_r) + \frac{1}{r}\delta_\theta(u_\theta) \tag{30}$$

- **Continuity:**

$$\delta_t(\rho) + \delta_x(g_x) + \frac{1}{r}\delta_r(rg_r) + \frac{1}{r}\delta_\theta(g_\theta) = 0 \tag{31}$$

- **Momentum:**

$$\delta_t(g_x) = \delta_x(f_{xx}) + \frac{1}{r}\delta_r(rf_{xr}) + \frac{1}{r}\delta_\theta(f_{x\theta}) \tag{32}$$

$$\delta_t(g_r) = \delta_x(f_{rx}) + \frac{1}{r}\delta_r(rf_{rr}) + \frac{1}{r}\delta_\theta(f_{r\theta}) - \frac{\overline{f_{\theta\theta}}^r}{r} \tag{33}$$

$$\delta_t(g_\theta) = \delta_x(f_{\theta x}) + \frac{1}{r}\delta_r(rf_{\theta r}) + \frac{1}{r}\delta_\theta(f_{\theta\theta}) - \frac{\overline{f_{\theta r}}^r}{r} \tag{34}$$

- **Scalar Transport:**

$$\delta_t(\rho\phi) = \delta_x(q_x) + \frac{1}{r}\delta_r(rq_r) + \frac{1}{r}\delta_\theta(q_\theta) + \rho w \tag{35}$$

- **Outputs of f are as the follows:**

$$f_{xx} = 2\mu\left[\delta_x\left(\overline{u_x}^t\right) - \tfrac{1}{3}\overline{\Theta}^t\right] - \overline{\overline{g_x}^x}^t\,\overline{\overline{u_x}^x}^t - p \tag{36}$$

$$f_{rr} = 2\mu\left[\delta_r\left(\overline{u_r}^t\right) - \tfrac{1}{3}\overline{\Theta}^t\right] - \overline{\overline{g_r}^r}^t\,\overline{\overline{u_r}^r}^t - p \tag{37}$$

$$f_{\theta\theta} = 2\mu\left[\frac{1}{r}\delta_\theta\left(\overline{u_\theta}^t\right) + \frac{\overline{\overline{u_r}^r}^t}{r} - \tfrac{1}{3}\overline{\Theta}^t\right] - \overline{\overline{g_\theta}^\theta}^t\,\overline{\overline{u_\theta}^\theta}^t - p \tag{38}$$

$$f_{xr} = \overline{\overline{\mu}^x}^r\left[\delta_x\left(\overline{u_r}^t\right) + \delta_r\left(\overline{u_x}^t\right)\right] - \overline{\overline{g_r}^x}^t\,\overline{\overline{u_x}^r}^t \tag{39}$$

$$f_{rx} = \overline{\overline{\mu}^x}^r\left[\delta_x\left(\overline{u_r}^t\right) + \delta_r\left(\overline{u_x}^t\right)\right] - \overline{\overline{g_x}^r}^t\,\overline{\overline{u_r}^x}^t \tag{40}$$

$$f_{r\theta} = \overline{\overline{\mu}^r}^\theta\left[\delta_r\left(\overline{u_\theta}^t\right) + \frac{1}{r}\delta_\theta\left(\overline{u_r}^t\right) - \frac{\overline{\overline{u_\theta}^r}^t}{r}\right] - \overline{\overline{g_\theta}^r}^t\,\overline{\overline{u_r}^\theta}^t \tag{41}$$

$$f_{\theta r} = \overline{\overline{\mu}^r}^\theta\left[\delta_r\left(\overline{u_\theta}^t\right) + \frac{1}{r}\delta_\theta\left(\overline{u_r}^t\right) - \frac{\overline{\overline{u_\theta}^r}^t}{r}\right] - \overline{\overline{g_r}^\theta}^t\,\overline{\overline{u_\theta}^r}^t \tag{42}$$

$$f_{x\theta} = \overline{\overline{\mu}^x}^\theta\left[\delta_x\left(\overline{u_\theta}^t\right) + \frac{1}{r}\delta_\theta\left(\overline{u_x}^t\right)\right] - \overline{\overline{g_\theta}^x}^t\,\overline{\overline{u_x}^\theta}^t \tag{43}$$

$$f_{\theta x} = \overline{\overline{\mu}^x}^\theta\left[\delta_x\left(\overline{u_\theta}^t\right) + \frac{1}{r}\delta_\theta\left(\overline{u_x}^t\right)\right] - \overline{\overline{g_x}^\theta}^t\,\overline{\overline{u_\theta}^x}^t \tag{44}$$

- **Outputs of q are as follows:**

$$q_x = \overline{\rho\alpha}^x\delta_x\left(\overline{\phi}^t\right) - g_x\overline{\overline{\phi}^x}^t \tag{45}$$

$$q_r = \overline{\rho\alpha}^r\delta_r\left(\overline{\phi}^t\right) - g_r\overline{\overline{\phi}^r}^t \tag{46}$$

$$q_\theta = \overline{\rho\alpha}^\theta \delta_\theta \left(\overline{\phi}^t\right) - g_\theta \overline{\overline{\phi}^\theta}^t \quad (47)$$

- **Border Circumstances:**

According to the Akselvoll and Moin [16], also Mohseni and Colonius [17] Proposals, measurement of $\mathbf{u_r}$ in all degrees calculated from the average calculation across to the **r** coordinate:

$$u_r(r = 0, \theta) = \frac{1}{2}[u_r(\Delta r, \theta) + u_r(\Delta r, \theta + \pi)] \quad (48)$$

- **Wall border circumstance:**

We consider the wall without any vibrations and the amounts of velocity to the wall are zero.

$$\frac{\partial \phi}{\partial t} + c\frac{\partial \phi}{\partial n} = 0 \quad (49)$$

In above equation fee parameter of scalar and or velocity and of course sees as the transport velocity, and is the perpendicular direction to the coordinate vector.

$$\frac{\partial u_r}{\partial t} + c\frac{1}{r}\frac{\partial (r u_r)}{\partial r} = 0 \quad (50)$$

## VII. FIXING A CREDIT OF COMPUTER CODE

For this purpose the scientifically model of combustion chamber as shown in figure 3 which is done by Owen and his assistants, these scientists analyzed their conclusions in different procedure. [18] In the first model the temperature and velocity and production of combustion are precisely under the control of defined circumstances. The input air temperature increased to 750K as a preheat and the pressure of 3.8atm. For making a constant current of air and fuel from a combination of metal disks which is utilized in the injection spot of air and fuel. We are making the walls of combustion chamber cooler by cold water which we can fix it at the constant temperature of 500K. We assume the natural gas and the normal air in this process; all the figures are shown in Table 1.

**Table1.** The dimensional quantity and other elements of combustion chamber

| | |
|---|---|
| Central Pipe Radius (R1) | 3.157 cm |
| Annular Inner Radius (R2) | 3.175 cm |
| Annular Wall Thickness (R2 - R1) | 0.018 cm |
| Annular Outer Radius (R3) | 4.685 cm |
| Combustor Radius (R4) | 6.115 cm |
| Combustor Length | 100.0 cm |
| Mass Flow Rate of Fuel | 0.00720 kg/s |
| Mass Flow Rate of Air | 0.137 kg/s |
| Bulk Velocity of Fuel (V1) | 0.9287 m/s |
| Bulk Velocity of Air (V2) | 20.63 m/s |
| Overall Equivalence Ratio | 0.9 |
| Temperature of Fuel | 300 K |
| Combustor Pressure | 3.8 atm |

The production of combustion in the scietifical model which is gained (based on the mollies' quantity) NO, CO, $CH_4$, $O_2$ and for the productions of $H_2O$ and $H_2$ and the steichiometry equations are as follows:

$$x_{H_2} = 2x_{CO} \quad \text{و} \quad x_{H_2O} = 2x_{CO_2}$$

And for the calculation of mollies' quantity of nitrogen we assumed:

$$x_{N_2} = 1.88(2x_{O_2} + 2x_{CO_2} + x_{H_2O} + x_{CO})$$

Figures number 5 to 6 shows the average of combustion's production of the combustion chamber. Every figure consists of the average combustion production's and these results are scientifically proven and the laboratory and of course already analyzed numerically. For numerical comparison of the research with the scientifical outputs in the laboratory the distance from the combustion chamber to its center of radius is shown as $R_4$ for more oversimplification and eradicating the dimensions like are $R_r$ and x/R. It is readily distinguishable in these figures as we are getting backward from the combustion chamber; the result of numerical outputs alters to the analyzed solutions and of course as we are getting forward to the combustion chambers the numerical mistakes are getting less and less and the average of these mistakes to the analyzed solution is 7.3 percent, which they are almost acceptable. Figures 5 to 6 are the average combustion production mass in the radius locations of the spontaneous combustion.

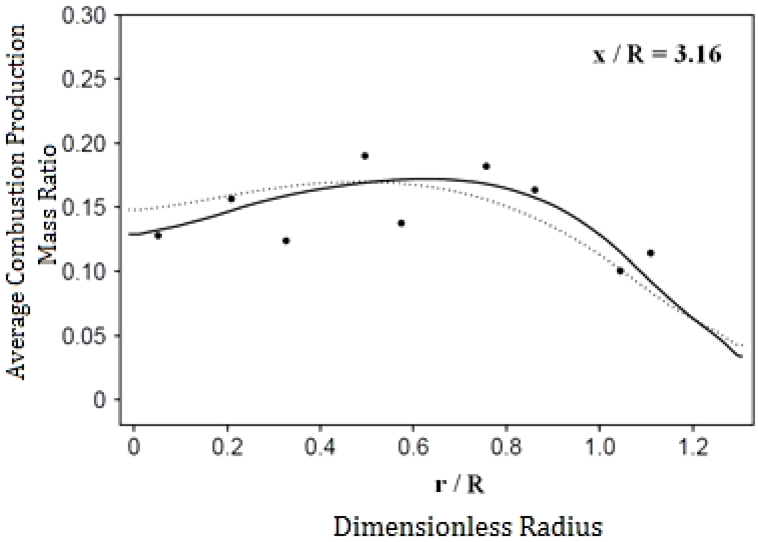


**Figure 5.** Dimensionless radius

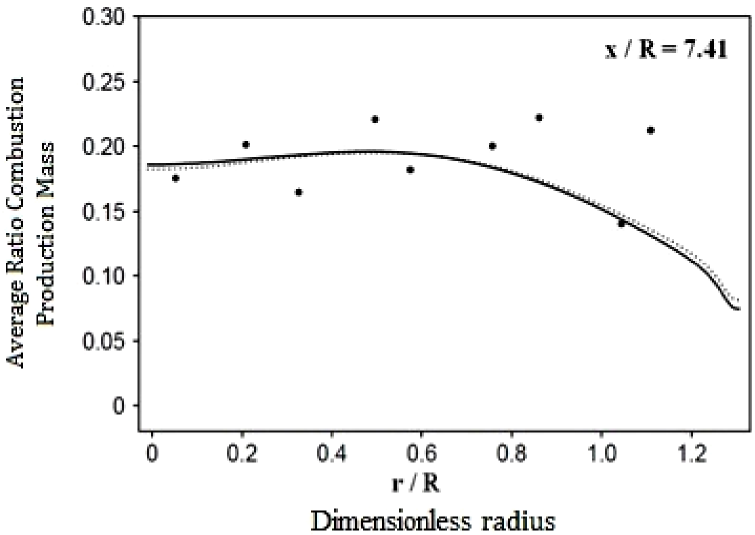


**Figure 6.** Average combustion production mass in the radius locations of **x/R=7.41**

## VIII. RESULT OF NUMERICAL SOLUTION

**Figure 7** shows the influences of incoming thermal alterations for the amount of production of NO in different air temperatures which is the indication of reduction of NO by increasing the incoming temperature.

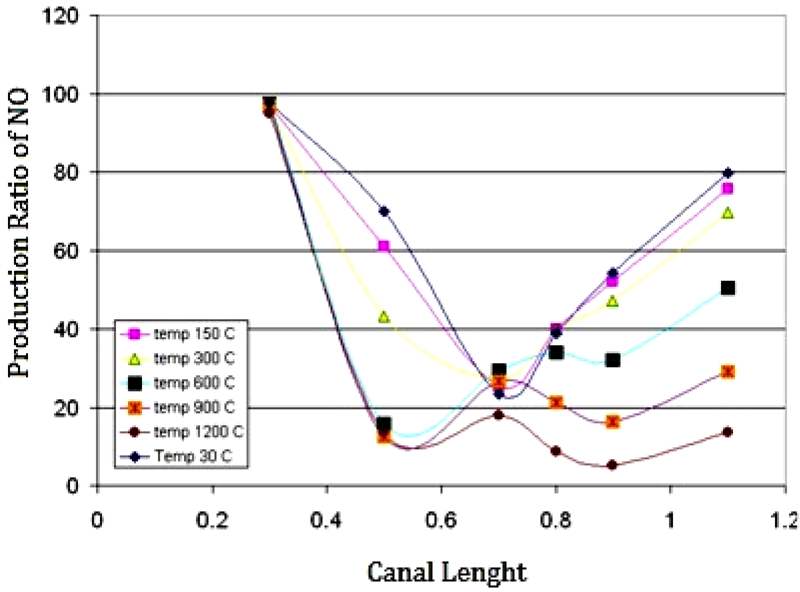


**Figure 7.** Effect of incoming air thermal degree for the production of NO

**Figure 8** illustrate the amount of produced NO of the first effect of the temperature.

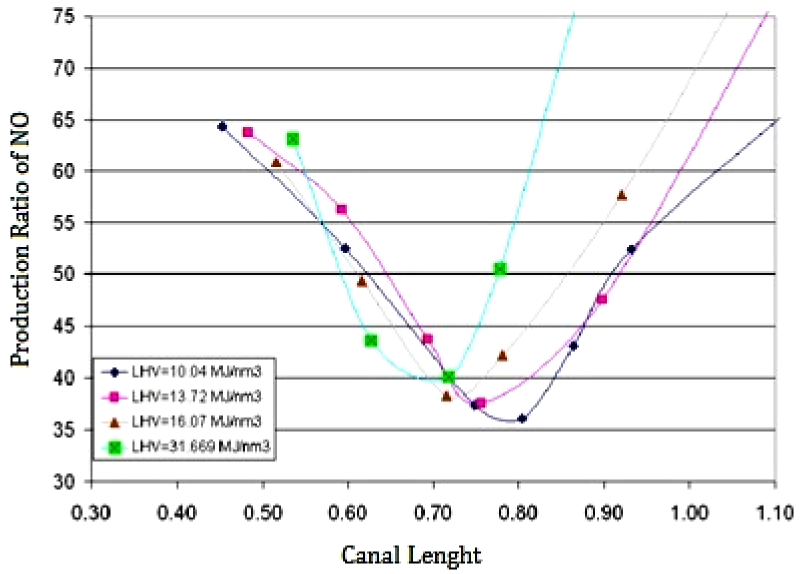


**Figure 8.** Effect of incoming air thermal degree for the production of NO

And in **Figure 9** the effect of the out coming power of the produced NO are readily distinguishable.

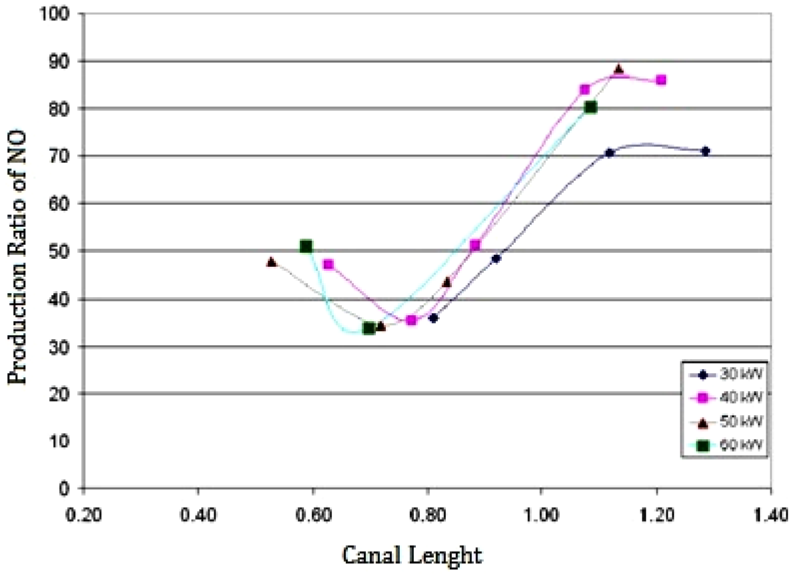


**Figure 9.** The effect of outcoming power of the quantity of produced NO

# IX. CONCLUSIONS AND RECOMMENDATIONS

Different strategies of NO currency control for temperature reduction and the combustion chamber by different relative ideal stoichiometry equations which they are enriched of consumptions for limiting the amount of available oxygen.

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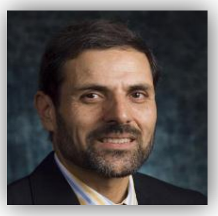

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