Review: Future Scope of Mathematical Modelling of Pulse Combustor Suggested by Ahrens Et Al.

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Abstract**—**various types of mathematical modeling give us different parameters in which model or technique is exclusive of some of one. In Kilicarslan model it reduces larger quantity of noise with unwavering output but at same time mean noise and self noise quantity having disturbances [2]. This paper is discussing about how Ahrens et al model is different and useful in combustor accept Kilicarslan. What are the unique parameters in Ahrens which is useful in pulse combustor?

Keywords**—***Kilicarslan Model, Ahrens et al Model*

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I. Introduction

As Author mentioned in his paper [2] Kilicarslan model is suitable for pulse combustor. But Ahrens model is more comfortable while assume the reaction zone is to be independent with cool zone that is covered by the reactants and a hot zone that is covered by the process of pulse combustor. Combustion having a thin flame sheet that separating the both cool zone and hot zone for producing more accuracy. Now, the heat releases in model only by the movement of an equivalent plane flame sheet in combustion chamber, where moving pressure has independent 'flame speed. With this assumption, Combustor increase the level of density in combustor chamber and it can also increase reactants mass, its burning level and at the end it increases the pressure level. Pressure level increases means it can satisfy the condition of Rayleigh criteria.

Rayleigh criteria and assumptions leads to 2nd order differential equation as same as Kilicarslan. But the only difference is its damping process and efficiency.

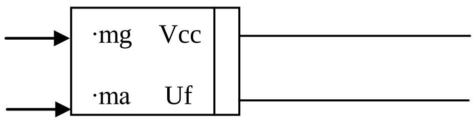
II. Mathematical way of Ahrens Model

A. Derivation and Equation

Kilicarslan Model and Ahrens Model's mathematical equations are almost same i.e. in this paper author focus more in change in equations.

B. Control Volume

Ahrens et al. presume that the blazing procedure within the combustion chamber takes place in a skinny zone (front moving flame) reactant mixture under the freeze known as cold zone, completely varied, from combustion under in hot zone. But one assumption to be filled in both zones that is uni-formality in variables performs under zones. Due to this process of mixup liquidity having same volume as of the combustion chamber. Kilicarslan's appearance in this process is separate zone and sequentially performance while in this model performance is parallel and similar and simultaneous in both the zones without separation. Below figure shows a schematic diagram of pulse combustor, with model parameters and sign conventions.



III. Energy Conseervation

Some of the assumptions we have taken from our previous paper which describes for the derivation of Kilicarslan's model equations for gases behaving in ideal condition, of the ratio of specific heats v/s its reactants which will being constant and the answer of ratio being equal for larger period of time that will apply here [2]. In this model, performance is parallel and having equal and constant ratio in combustion chamber with equi amount of volume of mixture in both (hot and cold) zones apply superposition theorem that leads equilibrium equation with same energy.

$$\frac{dE_{cc}}{dt} = \dot{Q} + h_r\dot{m}_r - h_e\dot{m}_e$$

where Ecc is the total energy produce under in combustion chamber, Q is equals rate of heat release by combustion, mr and me are the mass fluxes in & out of the combustion chamber, hr and he are the specific enthalpies of the reactants and products, respectively. So, the Ecc can be written as a Total energy in pulse combustor :

$$E_{cc} = \frac{PV_{cc}}{\gamma - 1}$$

where γ= cp/cv is the ratio of specific heat for constant pressure, cp, and for constant volume, cv, P is the pressure and Vcc is the volume of the combustion chamber.

$$\dot{Q} = \dot{m}_b \frac{\Delta H_f}{r+1} = \dot{m}_b (h_e - h_r) \ldots [1]$$

where mb is the mass burning rate of the reactant mixture, Hf is the heat of combustion per unit mass of fuel, r is the air-fuel ratio on mass basis and he and hr are the enthalpies leaving the combustion chamber to the tailpipe and entering the combustion chamber, respectively. Note that Kilicarslan assumed the mass burning rate to be equal to the mass rate of reactants entering the combustion chamber, i.e., mb = mr, and thus assumed burning the exact amount of mass entering the chamber at the exact moment of entrance. The burning occurs at an inconvenient moment of rarefaction of the gases in the combustion chamber.

IV. Need Of Stable Oscilation

Ahrens et al. mentioned they have identify the problem of Kilicarslan's assumption in its pulse combustion model and try to modify with their mathematical equations for stable oscillation with larger period of time. They have identified the model parameter Uf and the maximum peak point amplitude of the oscillation pmax must having a specific value and also having upper and lower boundaries for less fluctuation in [0, countable finite T). With the help of assumption and mathematical formulation they analyze their stability criteria. The analysis yields two expressions relating Uf and pmax, with which the unique values for these parameters can be estimated.

After stabilized Uf and Pmax one of the requirement for stability criteria is there no accumulation or depletion of reactants in the combustion chamber while performing under a cycle. And the other requirement for stability criterion is, there is no time dependency in the pressure amplitude of the oscillations, and the mean pressure. Due to above assumptions the mean pressure should be zero, as a consequence of the assumption that there is no friction in the tailpipe.

A. Stability Critearea

The unique pressure for forward substitution and its parameters:

$$P_{\max} = \left(\frac{2I}{\pi}\right)^{-1} \frac{P_0(1+r)h_r}{\Delta H_f}$$

And, Back substitution and it parameters:

$$U_f = \sqrt{\frac{I}{2\pi} \frac{RT_0(1+r)^{\frac{3}{2}}}{A_b\sqrt{P_0}}} \sqrt{\frac{h_r}{\Delta H_f}}$$

Let's check if Uf and Pmax are unstable then heat loss becomes increases and based on that there is continuously increasing fluctuations occurred. This is the proof of assumption for stabilizing Uf and Pmax for longer duration. And these expressions for the model parameters Uf and pmax are also used as estimates for the values that are necessary for a stable oscillation of the pressure in the combustion chamber. More accurate values can be obtained by solving the model equations numerically and requiring the fulfillment of the two stability criteria.

Conclusion

For stable operation of a pulse combustor the model presented by Ahrens et al. requires stability in Uf and Pmax for constant damping ratio with independency in time.

But still Ahrens model cannot be described about overall performance of pulse combustor and is there any opposite effect while stabilized Uf and Pmax? This is the future scope of Ahrens Model for its more accurate performance.

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