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AMESim MODELING AND ANALYSINGPRESSURE BUILD UP INGAS GENERATOR

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ABSTRACT
Gas generator is a key element in the rocket engine working on the gas generator cycle. It is pre burner which is responsible for the supply of working fluid to the prime mover of pumps. Which is located prior to the turbine inlet. Some part of the fuel and oxidizer is directed to the GG for developing the enthalpy of at the inlet of turbine. This study is mainly focus on AIMSim modeling and analysis of the pressure build up in the GG during the flight condition. The model in analyzed in three conditions up-rated, nominal and de-rated. Parameter study using the AIMSim simulation of hydrogen-oxygen gas generator gives temperature and pressure rise in the range of 840-960K and 36-56 bar respectively. The result obtained from the software is similar to the sample flight result of the working gas generator.

KEYWORDS: AMESim, Gas generator (GG), LH_2,LOX, Chamber pressure

1. INTRODUCTION
One of the first power cycles developed for rocket propulsion. Propellants can be supplied from separate propellant tanks or can be bled off the main propellant feed system. Where liquid hydrogen and liquid oxygen is used as the propellant in most cases, both at cryogenic temperature. Combustion product produced during this power cycle is used for the working of turbo-pump system. Inlet to the turbine comes from the combustion product produced from gas generator. Gas generator cycle is relatively simple; the pressures in the liquid pipes and pumps are relatively low It has less engine-specific impulse compared to expander cycle or a staged combustion cycle. The pressure ratio across the turbine is relatively high. Uses either dedicated or common propellants in gas generator (GG) to produce turbine drive gas. Turbine exhaust dumped which is used to run the pumps, resulting in degraded Isp performance, it has, Good reliability, Robust start/shutdown, Lower operating pressures mitigate the need for boost pumps. Can utilize almost any viable bipropellant combination.GG Cycle Variations (i) Monopropellant GG (ii) Bipropellant GG. as we know hydrogen is the future fuel, renewable resource [1]. The Power-to-Gas technology is well-known [2-3].combustion in the gas generator is localized, the temperature may vary according to the geometry of the gas generator, combustion pressure and oxidant excess factor are significant factors [4-7]. “Quenching” effect, during the cooling of combustion product which results in the increase of residual hydrogen amount after the combustion chamber[8].combustion product obtained during this process is steam which results in the way for complete avoidance of hazardous emissions[9-11]. In this present study a gas generator is modelled and analyzed in AMESim, where the gas generator.

2. MODELLING AND ANALYZING IN AMEsim

AMESim
Advanced **M**odelling **E**nvironment for performing **Sim**ulation of engineering system. AMESim is a commercial simulation software for modelling and analysis of mutli-domain systems .AMESim is one dimensional lumped parameter time domain simulation platform system. AMESim uses symbols to represent AMESim uses symbols to represent individual components within the system which are either: based on the standard symbols used in the engineering field such as ISO symbols for hydraulic components or block diagram symbols for control

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systems or when no such standard symbols exist: symbols which give an easily recognizable pictorial representation of the system.

Simcenter AMESim is a multi-domain software. It allows to link between different physics domains (hydraulic, pneumatic, mechanic, electrical, thermal, and electromechanical). The modelling of a system is done in four steps:
1. Sketch mode: in which the different components are linked,
2. Sub model mode: in which the physical sub model associated to each component is chosen,
3. Parameter mode: in which the parameters for each sub model are set,
4. Run mode: in which the simulation is started and results analyzed.

Gas generator comprises of combustion chamber, injectors, injection valves, cooling channels. Inlet conditions are taken from the parameters listed in the table 1 for the gas generator combustion chamber. Thrust chamber is taken from the liquid propulsion library while injection valves and injectors orifices are taken from two phase propulsion library sensors and adiabatic chambers are taken from thermal library. The outlet atmospheric condition is provided with the aeronautics and space library. While the inlet condition is provided in terms of pressure and temperature, there by a constant mass flow rate is generated in this system. The mixture ratio in this system is constant it is 0.9 .The cryogenic fluid is initialed in the system by dedicated fluid library , product obtained is water vapor.

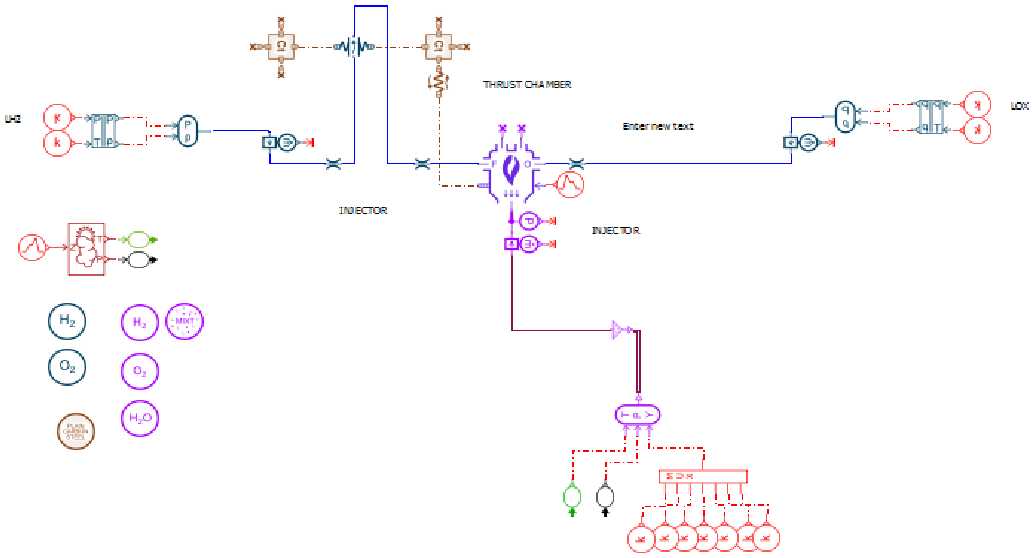

Figure 1.AMESim thrust chamber model

Cooling method used in gas generator is regenerative cooling, where liquid hydrogen is used to pass through the cooling jacket to protect the gas generator from excess heating and to extension life of GG can be possible through this method. Heat augmentation occur there by it increase the combustion performances.

Table 1.Gas generator boundary condition

Inlet condition of Chamber	parameters
volume (L)	1
temperature (K)	293.15
pressure (bar)	1
Fuel	hydrogen
Oxidiser	oxygen

Gas generator is modelled for three condition, uprated, nominal and de-rated condition

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3. RESULTS AND DISCUSSION

As per the inlet condition provided in terms of pressure and temperature for the three conditions different flow rates are obtained where the uprated condition produce more flow rates while the mixture ratio in the system remains constant throughout .for higher flow rate produce higher pressure build up in the chamber figure2(a) resulting in 56, 43, 34.80 bar is developed in the chamber for the condition up-rated, nominal and de-rated respectively. Graph shows the same trend in pressure buildup. The temperature developed in the system is shown in figure 2 (b) depend up on the pressure as it also follows the same trend .the temperature produced in the system cannot be more than a certain limit because the combustion product is induced into the turbine it should be limited. in the numerical modelling developed a temperature of 835,890and 960K respectively for the up-rated, nominal and de-rated condition.

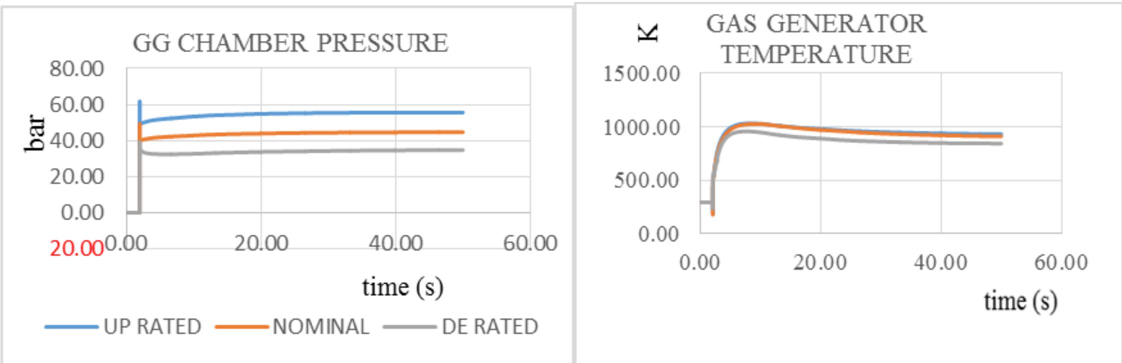

Figure 2 (a) Gas generator chamber pressure build up (b) Gas generator temperature

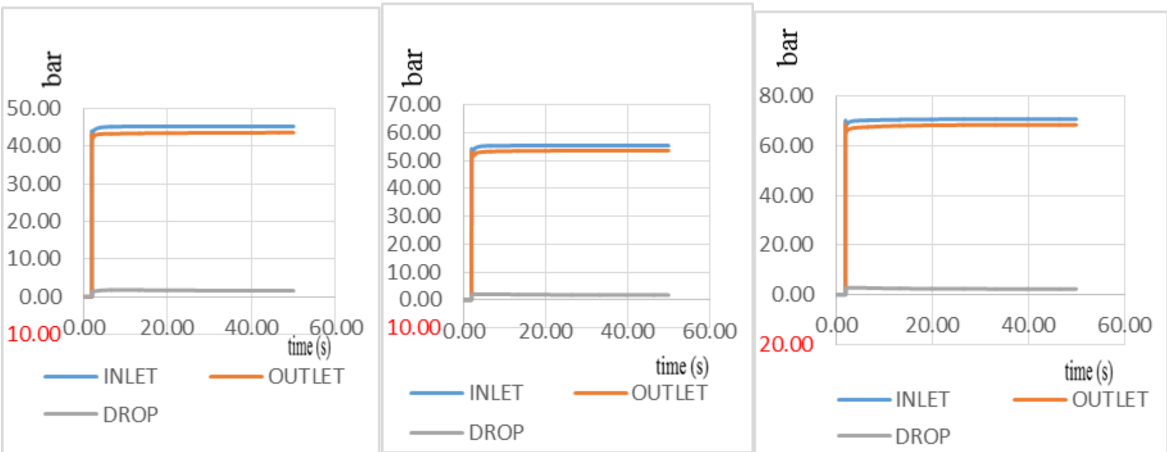

Figure 3(a) up-rated injector condition (b) nominal injector condition(c) de-rated injector condition

Table 2 Injector inlet, outlet and pressure drop

pressure, bar	Up-rated	Nominal	De-rated
inlet	68.49	53.64	43.57
outlet	56.01	43.14	34.80
drop	12.49	10.50	8.77

The chamber pressure and temperature depend upon the injector pressure which leads in the chamber pressure build up so the inlet outlet and pressure drop across the liquid hydrogen is given above figure 3 for up-rated, nominal and de-rated condition values are listed in table 2.

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4. CONCLUSION

Gas generator used to power the system to supply the liquid propellant to the combustion chamber. In gas generator chamber pressure developed during the simulation is in the range of 34-56 bar and temperature ranges from 840-960 K. Results obtained from the AMESim is compared with the sample flight results. Temperature of the combustion product is observed in the safe limit, thus it doesn't affect the structural rigidity of turbine blades. AMESim simulation satisfies the same physical phenomenon during the actual flight conditions. Resemblances of the AMESim model with the actual flight conditions ensure the customization of engine elements by changing the parameter.

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