Appendix B

Small and Micro Gas Turbine Combustor Fuel Injection Study

The P500 combustor features vaporizer tubes as the mode of fuel introduction. In full-sized engines, pressure atomizers are more popular. The reasons why pressure atomizers are not common in engines with lower thrust ratings (< 2000 N as expected for small and micro GTs) include the following.

- Large pump size relative to the combustor size: The pump required to supply fuel at the required pressures to enable atomization is usually large relative to the size of the combustor. In full-sized engines, this is not a problem since they have larger combustors. Schreckling [11] states that a pump capable of supplying up to 10 atmospheres would be required if a pressure atomizer were to be used in micro-gas turbine combustors.
- Blockage and erosion: A smaller combustor results in a lower required fuel mass flow rate. This generally results in a smaller injector. Small openings are prone to blockage and erosion. The most likely causes in this application would be soot and quenched combustion products.

Trends can be noticed when compiling a database of small and micro gas turbines so that the threshold thrust/mass/volume where implementing pressure atomizers instead on vaporizer tubes can be identified.

Table B.1: Small GT Data

Engines	$\dot{m}$ [kg/s]	PR	Max Thrust [N]	D [mm]	Mass [kg]	Fuel Introduction
P500-PRO (Jetcat)	0.9		500	175	4.9	
P550-PRO (Jetcat)	0.93	3.8	550	178.6	4.9	Vaporizer
P400-PRO (Jetcat)	0.7	3.8	397	148.4	4.01	Vaporizer
P300-PRO (Jetcat)	0.5	3.55	300	132	2.87	Vaporizer
P300-RX (JetCat)	0.5	3.55	300	132	2.63	Vaporizer
SPT15-RX (Jetcat)	0.37	3.5		112	4.39	Vaporizer

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Engines	ṁ [kg/s]	PR	Max Thrust [N]	D [mm]	Mass [kg]	Fuel Introduction
TRS 18 (Microturbo SA)			1100	325	37	
TRI 60-30 (Microturbo)	8.14	6.3	5500	343	61	Atomizer
F107-WR-101 (Williams Int.)	6.2	13.8	2830	305	66	Atomizer
J402-CA-400 (Teledyne CAE)	4.4	5.6	2937	318	46	Atomizer
TJ80 (PBS Aerospace)	1.47	4.7	800	235	12.5	Vaporizer
TJ100P (PBS Aerospace)	1.7		1249.95	272.0	17.60	Vaporizer
F112-WR-100 (Williams/RR)		30	3256.1	300	73	Atomizer
MW54 (Wren Turbines Ltd)	0.18	2.65	64	89	0.78	Vaporizer
KJ-66	0.22	2.2	75	110	0.93	Vaporizer
X45 (Xicoy)			45	60	0.47	Vaporizer
SW120B (Swiwin)			120	99.4	1.25	Vaporizer
SW190B (Swiwin)			190	109	1.45	Vaporizer
J85 (General Electric)		8.3	1380	1300	191	Atomizer
Arriel 1D1 (Turbomeca)		8.1		600	111	Atom
Arbizion IIIB2 (Turbomeca)	5.98	5.85	4020	421	115	Atomizer
Arbizon IIID (Turbomeca)	5.98	5.85	4160	432	115	Atomizer
Arbizon III (Turbomeca)	6	5.5	3700		115	Unknown
F107-WR-400 (Williams Int.)	6.17	13.8	2670	304	65.3	Unknown
TRI 60-1 (Microturbo)	5.84	3.7	3500	330	49	Atomizer
TRI 60-2 (Microturbo)	6.18	3.8	3700	330	49	Atomizer
TRI 60-5 (Microturbo)	6.5	4.1	4200	330	53	Atomizer
TRI 60-20 (Microturbo)		6.3	5400	343	64	Atomizer
J403-MT-400 (Teledyne CAE)		5.5	4000	330	53	Unknown
J402-CA-700 (Teledyne CAE)	4.3	5.5	2800		51	Unknown
J402-CA-701 (Teledyne CAE)		6.2	3200	317	51	Unknown
J402-CA-702 (Teledyne CAE)	6.21	8.5	4200		62.5	Unknown
MS 400 (Motor Sich)			3920	320	85	Unknown
PTAE-7 (HAL)	6.65	4.65	3720	330	65	Unknown
TJM4 (Mitsubishi)		6.7	2840	355	55.8	Unknown

Based on the trends observed in Figs. B.1 - B.4, the following conclusions can be drawn.

- For engine mass $\leq$ 17.6 kg, vaporization is preferred. When the mass is $\geq$ 46.0 kg, atomization is preferred. More data is needed for engines between 17.6 and 46.0 kg.
- Vaporization is preferred for engine volumes ≤ 0.037 m^3, while atomization is common above 0.053 m^3.
- In line with the observed trends, most of the unknown engines can be assumed to use pressure

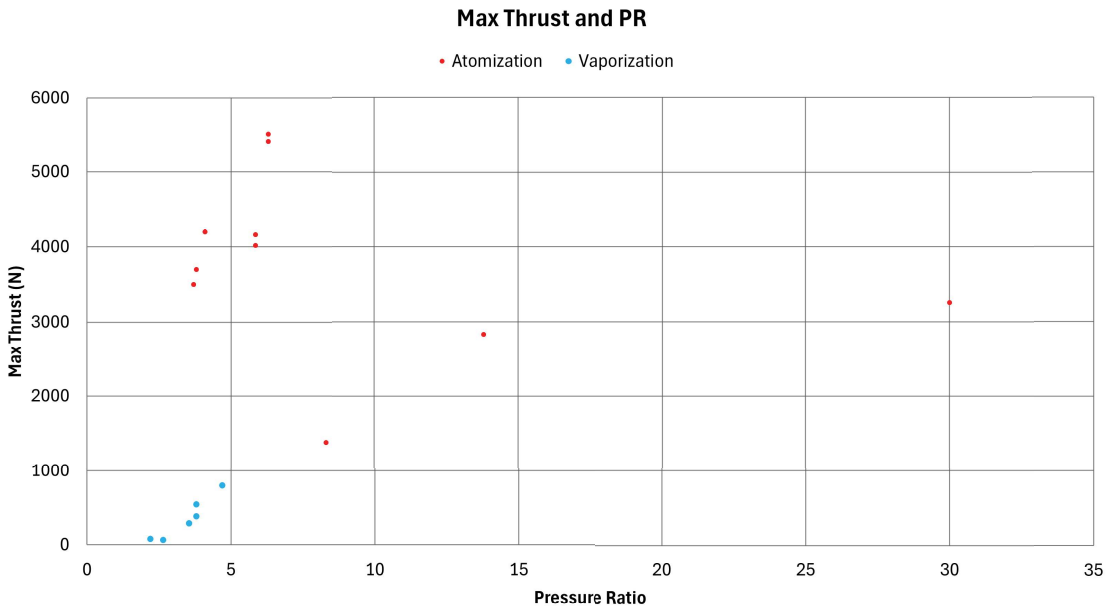

Figure B.1: Trend: thrust and PR

atomizers.

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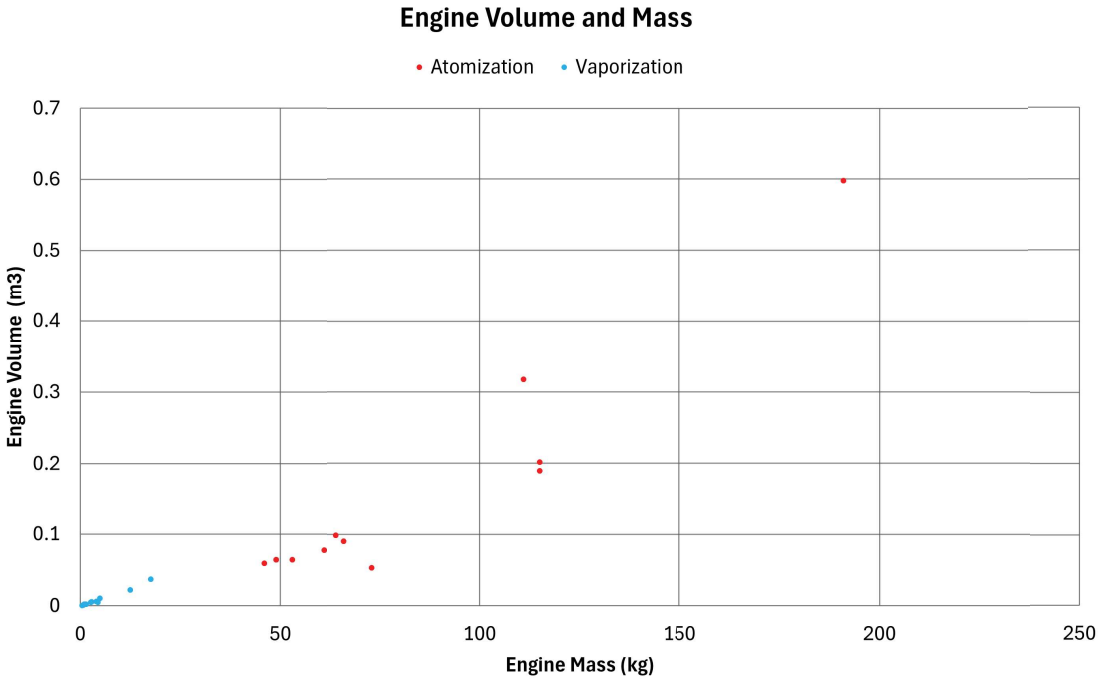

Figure B.2: Trend: engine volume and mass

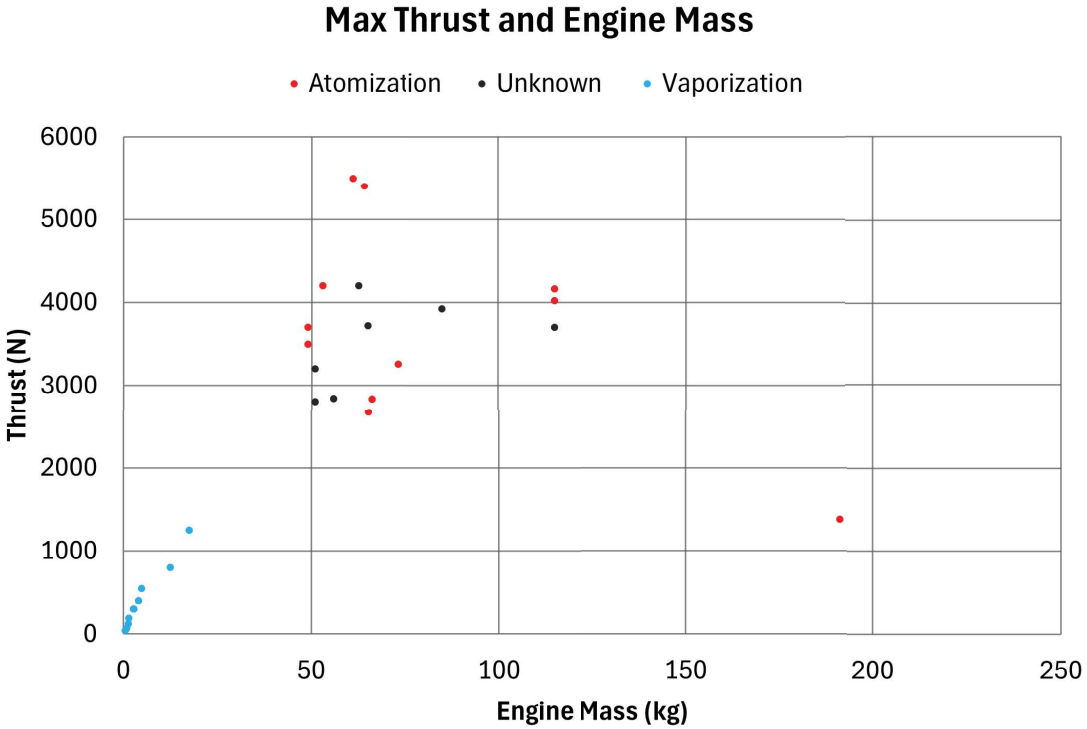

Figure B.3: Trend: thrust and engine mass

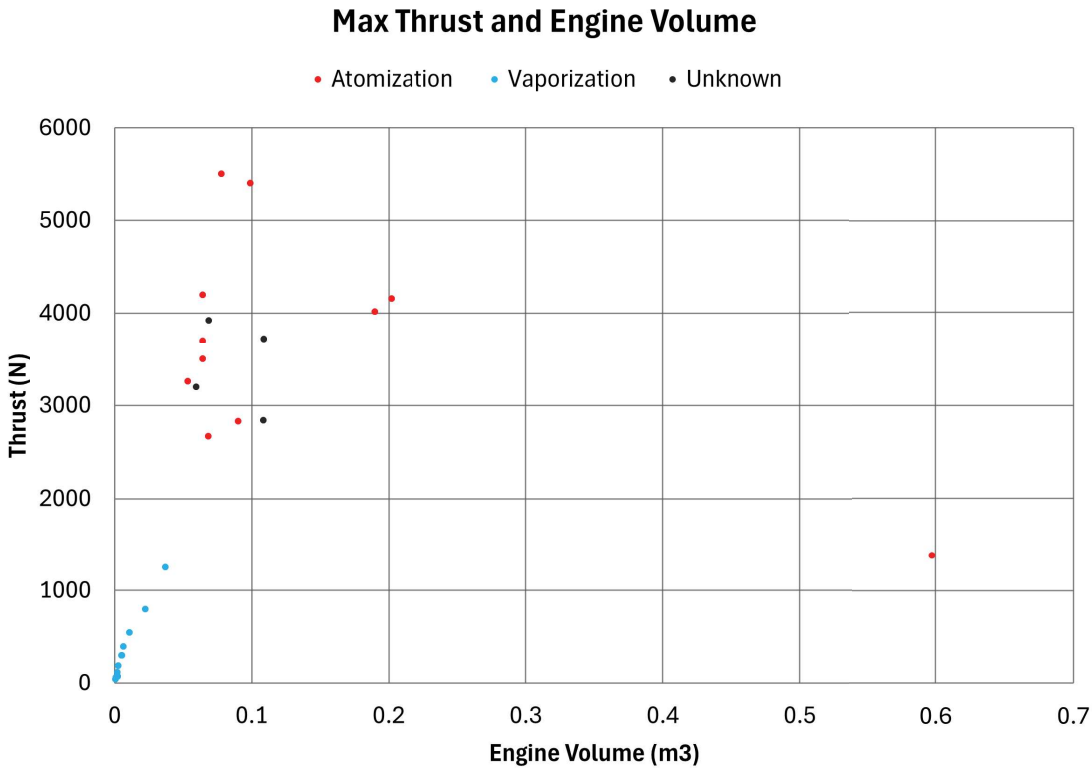

Figure B.4: Trend: thrust and engine volume