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스마트 무인기용 터보축 엔진(PW206C)의 장착성능에 관한 연구

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Study on Installed Performance of Turbo Shaft Engine (PW206C) for the Smart UAV

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ABSTRACT

The purpose of this study is to analyze both the design and off design performance simulation of the PW206C turbo shaft engine used in the development of the smart UAV (Unmanned Ariel Vehicle) by KARI(Korean Aerospace Research Institute). Its mainly aims to investigate performance behavior at the un-installed and installed conditions.

The ways employed to be able to analyze the performance extensively were mainly carried out by comparison of performance simulation results from both the commercial program 'GASTURB 9' using compressor maps generated by Genetic algorithms (GAs) or Scaling Method, and the engine manufacturer's program 'EEPP'. Off-design performance analysis was performed through matching of both mass flow and work between engine components. The set of performance simulations of the developed analytical models was performed by a commercial program package (GASTURB 9) that provides great flexibility in the choice of independent variables of the overall system. The results from the simulations are used to compare turbo shaft engine (PW206C) performance data obtained by the EEPP.

At un-installed condition, it was found that the results with the compressor map generated by GAs were relatively agreed well than those with the compressor map generated by the Scaling Method.

The performance calculation results using the compressor map generated by GAs were compared at un-installed condition and installed conditions with ECS-off and ECS-Max in variation of altitude, gas generator speed and flight speed.

Key Words: Un-installed and Installed performance, Genetic Algorithms, Scaling Method, Turbo Shaft Engine.

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1. Introduction

Performance simulation is one of the most important activities not only to minimize risk and cost in development phase but also to monitor engine health in operation phase. When an engine is installed on an aircraft, the temperature rise, the pressure loss in inlet duct, the bleed air loss extracted for air conditioning, the power loss due to accessory power extraction, and exhaust duct pressure loss occur. [1]

As previously mentioned in the abstract, the study was conducted through simulation of the turbo shaft engine using special map generated by Genetic Algorithms and Scaling Method, and the results of the performance simulation were compared with the calculated results by the Estimated Engine Performance Program (EEPP) at un-installed condition[2]. Moreover, various operating conditions were considered while doing performance analysis at both installed and un-installed conditions at various gas generator RPM, altitude and flight Mach number.

The installed condition were evaluated at ECS -off and ECS-Max.

2. Engine Description

The PW206C is a free power turbine type turbo shaft engine consisting of two modules such as gas generator and power section including reduction gearbox. The single stage centrifugal compressor is driven by a single stage compressor turbine, and the out power shaft is driven by a single stage power turbine.

The Figure 1 shows the schematic layout of this engine. Table 1 shows the operating range of a PW 206C engine as used on the smart UAV. Table 2 shows two working parameters at maximum take-off sea level static condition and the 10000ft static condition for un-installed performance analysis which were provided by the engine manufacturer. [3] The set of performance simulations calculations were performed by a commercial program package (GASTURB 9) that provides great flexibility in the choice of independent variables of the overall system.[4]

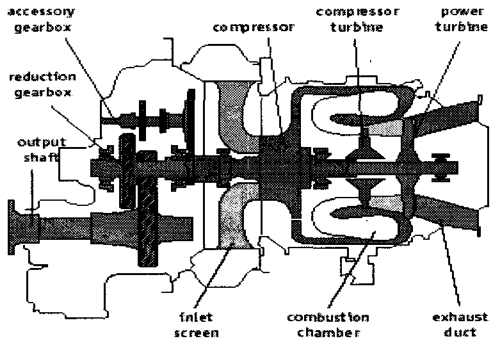

Fig. 1 Engine schematic diagram of PW206C turbo shaft engine

Table 1 Operating range of propulsion system

Gas Generator RPM	65% ~ 100%
Altitude (ft)	0 ~ 15000
Flight Mach No.	0 ~ 0.4

Table 2 working parameters at two reference points for scaling Compressor Map

Atmospheric condition	static sea level standard	Alt 10000ft Mach No 0 static
Mass flow rate(lbm/s)	4.418	3.307
Fuel flow rate (lbm/s	0.087	0.0724
Compressor pressure ratio	7.912	9.82
Turbine inlet temp	2258	2388
Shaft horse power(hp)	560.8	496.0
SFC (lbm/hp hr)	0.556	0.5260
Gas gen spool speed	58900	56221
Propeller rotational speed (100% RPM)	6120	6120

3. Comparison of Un-installed Performance by Two Different Generated Compressor Maps

At the un-installed condition, the bleed air and the accessory power extraction were not considered. In addition, the pressure losses at inlet duct and at nozzle caused by engine installation to the aircraft were ignored. Table 3 shows the range of variation of gas generator speed, altitude and flight Mach number in un-installed performance analysis.

The Fig. 2, 3 and 4 shows comparison between performance analysis results using compressor maps generated by Genetic Algorithms and Scaling Method, and the engine performance deck data calculated by EEPP in variation of altitude, flight Mach number and gas generator speed, respectively. In case of using the scaled compressor maps,

Table 3 Un-installed Performance with Altitude, gas generators rpm flight Mach number Variation

Gas gen % rpm	60	70	80	90	100
Alt(ft)in thousand	5	10	15	20	25
Mach no	0	0.1	0.2	0.3	0.4

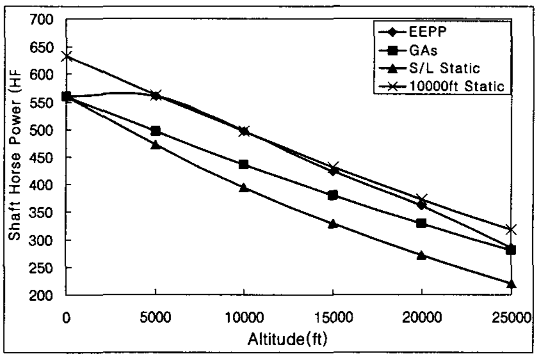

Fig. 2 Shaft Horse Power with Varying Altitude at Un-Installed Condition(S/L static, 100% Gas Generator Speed)

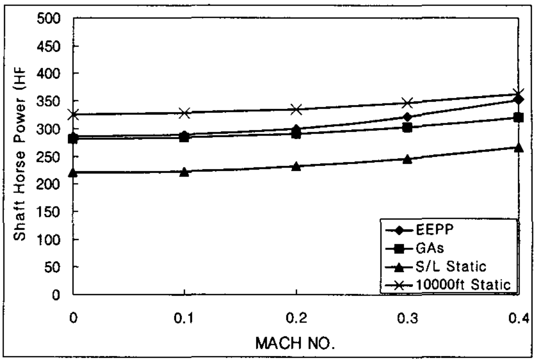

Fig. 3 Shaft Horse Power With Varying Mach No. at Un-Installed Condition (25000ft Altitude, 100% Gas Generator Speed)

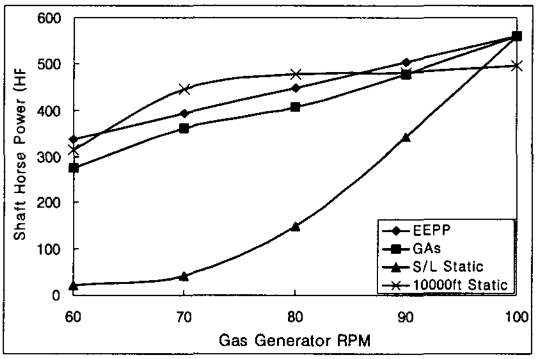

Fig. 4 Shaft Horse Power with Varying Gas Generator RPM at Un-Installed Condition (S/L Static)

two kinds of scaling factors based on the sea level static 100% gas generator speed and 10000ft altitude static 100% gas generator conditions were considered. As seen in the figures, the performance results using the compressor map generated by GAs are much closer to EEPP data than the other results.

Hence, the following installed performance was performed by the compressor map generated by GAs.

4. Installed Performance

Table 4 indicates two installed loss conditions ECS-off and ECS-Max, respectively.

Fig. 5, 6 and 7 shows comparison results of shaft power between ECS-off and ECS-max installed loss conditions and un-installed conditions, respectively. According to comparison, the shaft power with ECS-Max is less than the shaft power with ECS-off due to power extraction by ECS, inlet temp rise, bleed air loss and so on.

Table 4 installed loss

Loss Coefficient	ECS OFF	ECS MAX	Uninstalled condition
Inlet efficiency	1	0.9922	1
Inlet temp. rise	5R	5R	0
Bleed air loss	0	5%	0
Power extraction	5hp	7hp	0

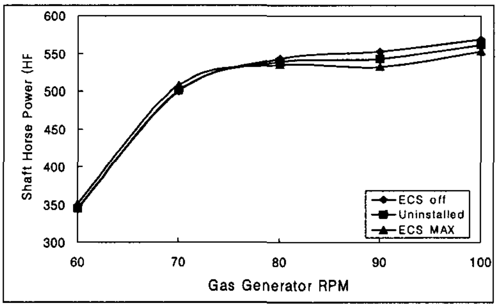

Fig. 5 Shaft Horse Power With Varying Gas Generator at Installed Condition(S/L Static)

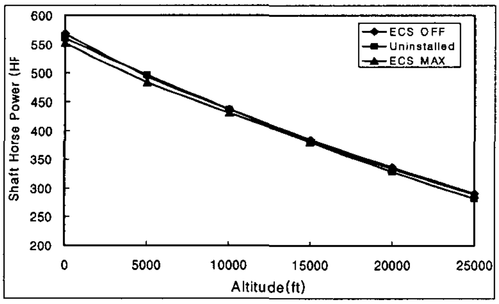

Fig. 6 Shaft Horse Power With Varying Altitude at Installed Condition (Static, 100% Gas Generator Speed)

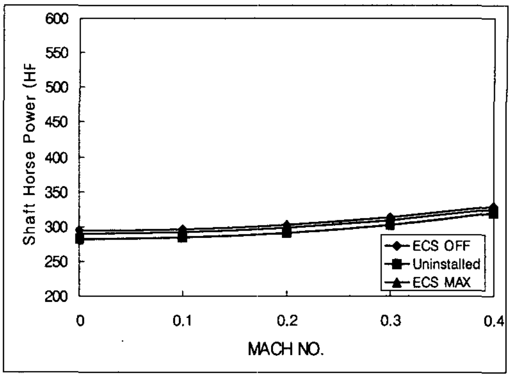

Fig. 7 Shaft Horse Power With Varying Mach No. at Installed Condition (25000ft Altitude, 100% Gas Generator Speed)

However, In the case of high altitude, the ECS power extraction is not influenced greatly relative to part load and altitude variation.

5. Conclusion

Through this study, both the design and off design performance simulation of the PW206C turbo shaft engine, used in the development of the smart UAV (Unmanned Ariel Vehicle) by KARI(Korean Aerospace Research Institute) were performed.

According to analysis results, it was found that the results with the compressor map generated by GAs are much closer to those of EEPP than those with the compressor map generated Map by the traditional Scaling Method at un-installed condition.

Secondly, shaft power with ECS-max was mostly less than the shaft power with ECS-off due to power extraction by ECS, inlet temp rise, bleed air loss and son on. However in case of high altitude, the ECS power extraction is not influenced greatly relatively to part load and altitude variation.

Reference

1. Kong, C. and Ki, J., 2003, "A New Scaling Method for Component Maps of Gas Turbine Using System Identification ", J. of Engineering for Gas Turbines and Power, Vol. 125, Number.
2. C. D. Kong et al., 2006, Component Map Generation of a Gas Turbine Using Genetic Algorithms, J. of Engineering for Gas Turbines and Power, vol.128 no.128.
3. P&WC, , "EEPP(Estimated Engine Performance Program)
4. GASTURB 9,2001 ,"Operation Manual"