Modelling and Simulation Aero Turbosupercharged Engine

Ing. Radoslav Makovník
doc. Ing. Ondrej Líška, CSc.

Technical University in Košice, Faculty of Mechanical Engineering
Department of Automation and Control
Park Komenského 8, 042 00 Košice
Radoslav.Makovnik@tuke.sk
Ondrej.Liska@tuke.sk

Abstract: The subject this work will be also the analysis of aero turbosupercharged engine as an object of regulation. Modelling and simulation are today progressive methods, which substitute projections and tests with real systems, which testing would be really expensive. Therefore, people are looking for other faster and cheaper manners of gaining necessary information about the system.

Keywords: Aero turbosupercharged engine, Mathematical model, PID controller, Simulation of chosen quantity, Closed system of adjustment, Electronical adjustment system

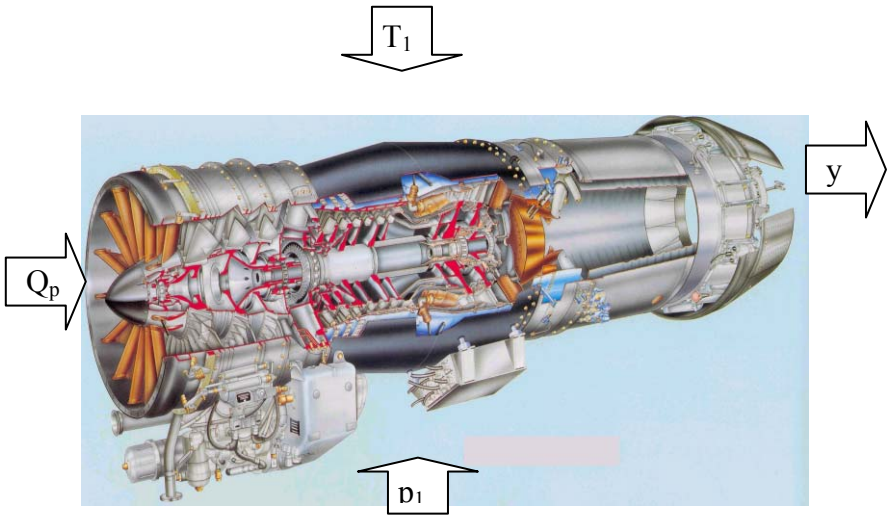
Introduction

Modelling and simulation are two relatively independent, contents different, but up to date connected processes. They are focus on recognition original through the medium model and on study his possible conduct in future. Modelling and succesive simulation on computer makes it possible to sample real system behind permanent raising of exigency, which are laying upon this systems. Most frequent exigency in the area aero-engines belong technical and economic terms. With development new technologies give out to fast development new type of engines as well as to fast development control systems. Most distinguished progress behind recent years registration aero turbosupercharged engines (ATSE). One block of this engines works only in atmosphere (oxygen necessary to burnings fuel is removal from air) and the second allowed be engaged in varios environs. They are the rocket engines (fuelling hold fuel and oxidant too) [5]. Claim to operative and control system turbosupercharged engines result above from facilities object control – ATSE. Between basic functions, which operative and control system must subserve belongs to engine control, adjustment and limiting quantity. From

listed functions is difficult to simulate adjustment of engine, near which are choices quantity of engine keep up on predetermine value, at sufferance execution of engine. Before simulation precede creation model.

1 Analysis Creation Model

Aero engine considers himself a regulated system which influence admission and failure quantity. Admissions and failures is abundance, therefore creation of model is only from general quantity. The most frequently as operative quantity be in at modelling application: fuel distribution in main burning store-room and plan angle rod linkage of motor control. Look like failure quantities are application: exterior temperature (ambient temperature), outer (atmospherics) tension, velocity of air and others atmospheric effect [2].



Picture 1
Turbosupercharged engine M88

Before lonely simulation be needed form mathematical model conduct of dynamic system. Mathematical model based on following analyses constructional set-up individual sections engine, analyses engine look like system convertor energy and identification inputs, outputs and failure de given dynamic system.

For mathematical description and creation mathematical model turbosupercharged engine are used system of differential formulas, that are amplified edition algebraic formulas. By creation model engine are used a few reductions. There are

ignored inertia engine as accumulator tension and temperatures working matters. Next there are ignored temperature influence to change geometric measurement by transition actions. Then common fashion of differential formula is [6]:

$$\frac{dy}{dt} = k_1 n_1 + k_2 n_2 + k_3 Q_p \tag{1}$$

where y – output value

n_1 – operating speed law-pressure compressor

n_2 – operating speed high-pressure compressor

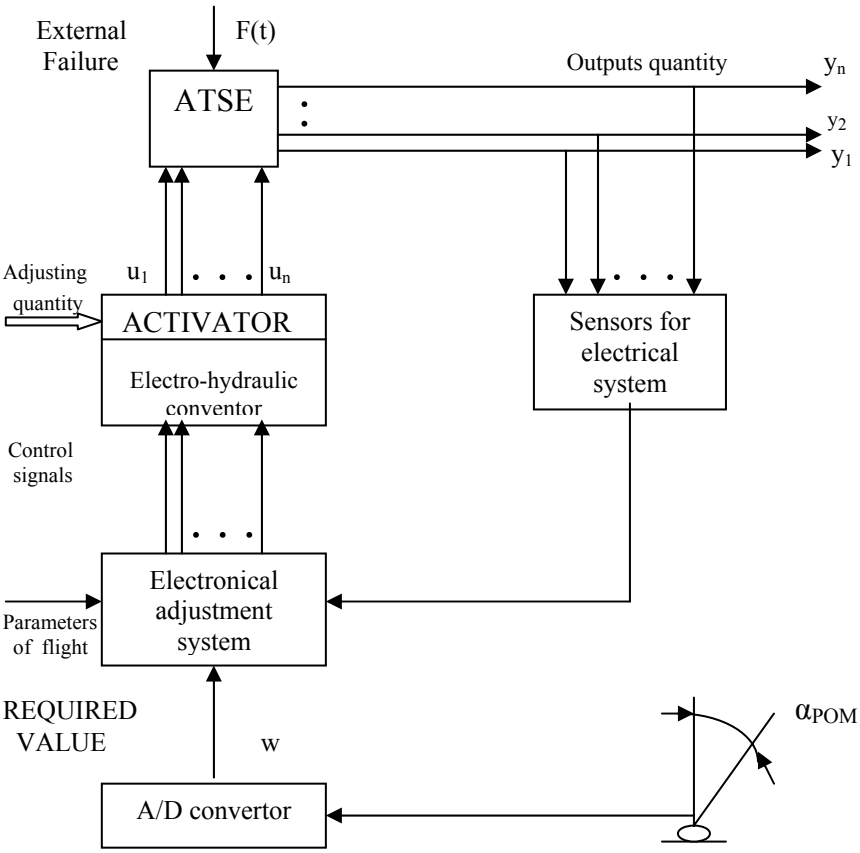
Q_p – fuel distribution

Mathematical model is designed for tangible type of aero engine DV 2. By application of model was used 9 outputs: operating speed law-pressure and high-pressure compressor, temperatures and tensions before turbine and behind turbine, temperature behind compressor, pull of engine and flow rating of air. Total number of index to exploitation by application of mathematical model is 27. [3] They are the index to linear differential formulas. These index are calculated following deflect from power cycle of engine by fixed mode in little change operative quantity (Qp – fuel distribution, A5 – cross-section ascension jet, etc.) and failure quantity (H - heigth, T1 – exterior temperature, p1 – atmospheric pressure). For account is used nodal model of engine alternatively single indexes of engine are detected experimental. Conclusion from application of mathematical model is common equation describing condition of dynamic system:

$$\begin{bmatrix} \dot{n}_1 \\ \dot{n}_2 \end{bmatrix} = \begin{bmatrix} k_1 & k_2 \\ k_4 & k_5 \end{bmatrix} . \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} + \begin{bmatrix} k_3 \\ k_6 \end{bmatrix} . Q_p \tag{2}$$

1.1 Base Design of Model Turbosupercharged Engine

Point of departure to assemble the basic schematics turbosupercharged engine is mathematical model. Mathematical model and from he establishing model for simulation start from tenet aero-engine with steadfast ascension jet. Base design describes switch-over interim lever motor control, PID controller (his pivotal member) and lonely aero turbosupercharged engine. It is concerned closed regulation circuit of operating speed. It is based on tenet disturbance variable compensation. [4]



Picture 2
Base design of model ATSE

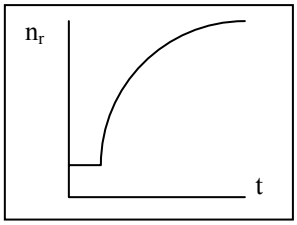
1.2 Closed System of Adjustment

Input in system is quantity φ, which introduce adaptation of lever motor control. This inspection introduce in simulation design block „step", which is setting in mini value displacement of lever (8°) and maximal value displacement, which is exploitationing by this simulation (90°). Another two bucket are entering as multiple of inputs signal with scalar constant factor. It is concerned external failure quantity: exterior temperature T_1 and outer (atmospherics) tension p_1. The changes value of failure quantity, which be the subject of simulation, induce different attributes of chosen quantity engine. Required value operating speed is limiting on mini and maximal level with saturation block. [3]

n_{min} = 5000ot/min

n_{max} = 13000ot/min

Required value isn't ideal step change but has following fashion:

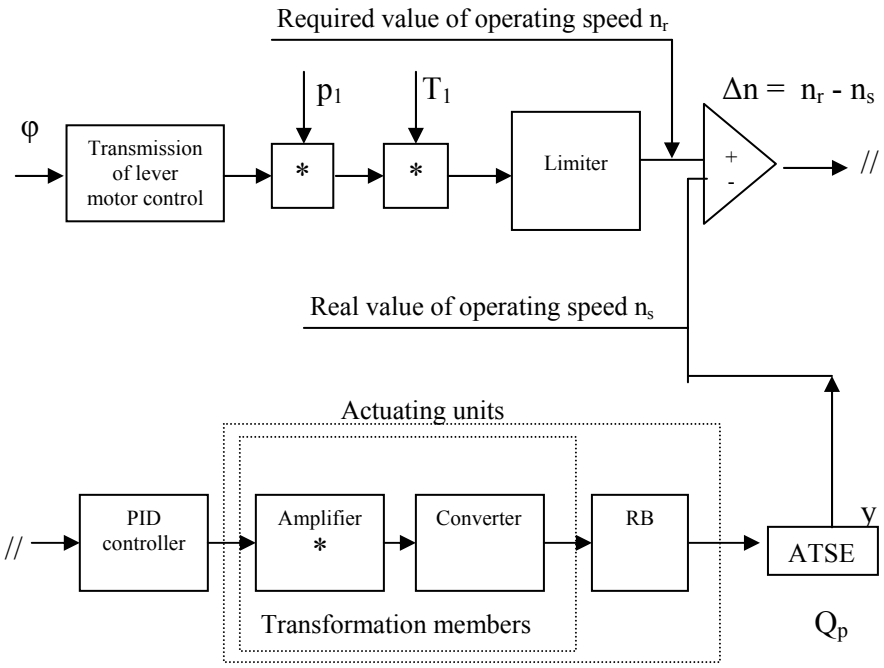


This step change of operating speed law-pressure compressor is entering to summing member. To summing member is also entering negative feedback as real value from operating speed law-pressure compressor. Regulation divergence is given from distinction of required value and real value.

Behind the summing member it is set PID controller, whose attributes of proportional gain, integration and derivative time constant are changing, what is one from a style of simulation chosen quantity. By the changes of constants PID controller it is simulation course of output quantity and time of control. Behind PID controller they are in serial connection: hydromechanical amplifier and electromechanical converter, which together to create electrohydraulic converter and they be ranked among the transformation members. Behind transformation members is regulatory body, whose transmission is F(s)=1. [3]

Responsibilities of regulatory body is put into practice regulation interference with controlled system, through changes of fuel distribution. [2]

Resultant signal direct on single constructional sections of aero-engine and it is designate as Qp - fuel distribution, which value on a large scale depend to displacement of lever motor control.



Picture 3
Scheme of closed control system

2 Simulation of Chosen Quantity ATSE

The simulation of chosen quantity ATSE was making in a program Matlab 6 Release 12. This program has standard high orientation of environs for scientific and technological calculations, modelling, simulation, presentation and data analysis. By the simulation was used subprogram Matlab – Simulink. In this program we can to simulate and to model dynamic system, create model in form block design based on differential formulas, create linear models, non-linear and in time discreet or linear systems. Simulink makes it possible to draft hierarchical structure model and too complex systems in digestedly scheme of subsystem without restrictions blocks count. [1] This property was applicated by creation of simulation model. Lonely simulation was oriented to adjustment value and to duration of control in connection with the option individual constant of PID controller. [3]

Conclusion

Modelling and simulation of aero-engines is based on analysis and right option of

steps by creation of mathematical model from beginning dot matrix fashion to lonely differential formulas, sequence by creation simulation scheme and in the end complex application of model turbosupercharged engine and his cosistent simulation.

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