Introduction to Problem, Basis and Measurement of Magnetic Aura of Turbojet Aircraft Engines

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Abstract: The control problem of turbojet aircraft engines for the purpose of lower fuel consumption as safety increase is one of the primary questions and concern research in many areas. This report is concentrated on one of them and that is magnetic aura of engine for the purpose of its utilization for errors diagnostic and so for situation control of turbojet aircraft engine (TAE). The assumption is that the operational diagnostics of critical states of turbojet aircraft engines is the primary part.

Keywords: magnetic field, engine, measurement, error diagnostic, control,part, results

1 Introduction

The airplane became important part of human lives as well as the device for transport, or the device for defense. Few people are aware of its command complication, control and errors diagnostic whereon as unit or by single parts. One of these parts of airplane is engine which is its main gear. The engines development went hand in hand with airplanes development.

The aircraft engines can be divided into several groups. There are several categories of engines from point of view of thrust produce. This report and so the problem solution are concerning on turbojet aircraft engines which together with by-pass turbojet engines found utilization in combat and transport planes.

The first turbojet engines were used on the plane Messerschmitt Me 262 already during the 2nd World War and after that on the plane Gloster Meteor. Really the first plane, which was powered by turbojet engine, was plane Heinekel He 178 which flied up in the first time on 27th August 1939.

Nowadays great emphasis is given on engine efficiency, safety, fuel consumption, greenness etc. To achieve the best results in this area it is important to know how to control the engine as unit and diagnose possible errors in time. This report concerns behavior of magnetic field (MF) in the surroundings of turbojet engines. The area of probing of magnetic field in the surroundings of turbojet engines further on called magnetic aura, which provides the aura diagnostic and its utilization for engine control and diagnostic of possible errors in time is not yet systematically explored. The knowledge from this area can be utilized for specification of control strategies which are composed of several situation classes [1,11]. Their utilization is possible also for creating anytime algorithms [6,12].

2 Magnetic Field

Physical field is specific form of mass existence which by its action of force joins elements into one system and creates cross action of force between them, so-called interaction. As its force affects all elements it is marked also as the force field. The physical fields are divided from mathematics and physical point of view. From physical point of view, they are divided into two main parts namely gravitation and electromagnetic field which has two main parts namely electric and magnetic part. Inter allia the physical fields are divided into for example sound, thermal and pressure fields. From mathematics point of view they are divided into scalar, vector, tensor, spin fields or from other mathematics point of view into static, steady and quasi-static fields.

This report is concerned with magnetic field which passed through ferromagnetic parts of turbojet engines. As was already mentioned, the magnetic field is kind of physical field. Each element in space is characterized by two force components namely electric and magnetic force. The orientation and size of magnetic force depends on orientation of element's movement in each point, or in arbitrary point of space the force is normal to the fixed orientation in space and its size is then proportional to velocity component which is normal to this marked orientation [5]. All mentioned properties include quantity called magnetic induction or the density of magnetic flow B which quantity is Tesla (T) in SI. The magnetic induction in given point to moving charge is represented by:

$$B = F/(Il\sin\alpha) \tag{1}$$

where

B – is density of magnetic flow (T),

F – created force in Newton (N),

l – effective cable length (m),

I – current (A),

α – angle between magnetic induction orientation and cable position.

The magnetic force is represented through magnetic induction like this:

$$F = qv \times B \tag{2}$$

where,

F – is created force in Newton (N),

q – electric charge in Coulomb (C),

v – velocity (m/s),

B – density of magnetic flow (T),

x – vector product.

This created force is called Lorentz force which in electromagnetic field is extended by electric force component and is defined by following expression:

$$F = q(E + v \times B) \tag{3}$$

where,

F – is created force in Newton (N),

q – electric charge in Coulomb (C),

E – magnetic field intensity (N/C),

v – velocity (m/s),

B – density of magnetic flow (T),

x – vector product.

As each vector field, also magnetic field is represented by lines of force which are also called magnetic induction lines. The tangents of these lines have the vector field orientation in each point and their density depends on size of field vector [5].

Deeper insight into molecular physic problem indicates that the heat and magnetic field closely relate together and therefore this problem area is often called also thermal magnetic aura. Because of the problem area size this report is concerned only with magnetic field.

3 Small Turbojet Engine (MPM 20) and Magnetic Field

For investigation of magnetic aura of ATE as object of investigation was selected small turbojet engine which is situated in area of Faculty of Aeronautics Technical University in Košice more precisely in Laboratory of Intelligent control systems of aircraft engines (LIRSLM) of Faculty of Aeronautics Technical University Košice.

MPM 20 was originally created from starter TS 20 and it is basically a single turbojet, single shaft engine with radial compressor. These engines were originally used as back up sources of electric and moving energy for ATE. The MPM 20 construction scheme which is situated at the stand is shown on Figure 1. Detailed description of MPM 20 structure and functionality is possible to find e.g. in publication [1].

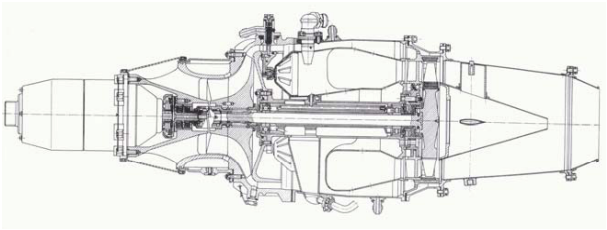

Figure 1
MPM 20 construction scheme

Nowadays measurements are performed on MPM 20, and research program is concentrated on modeling application and situation control including anytime algorithms in control. Corroborative goal of this research is determination and follow-up utilization of magnetic aura in research of modification of behavior dynamics, based on two measured parts of magnetic aura in surroundings of MPM 20 namely static and dynamic part.

Static part of magnetic field serves primarily for exploring the influence of different fuels for engine function and work efficiency and possible MPM 20 errors diagnostic and dynamic part could be used for improving MPM 20 control.

4 Measuring System for MPM 20 Magnetic Aura

For measurement of introduced parts suitable magnetometer is needed whereby primary measurements were conducted by single-base magnetometer VEMA -030 which was possible to measure magnetic field only in one selected axis. More detailed description of this magnetometer VEMA -030 is in publication [7].

Nowadays the measurements are conducted by four-base magnetometer, where this one is able to measure magnetic field in selected axis together at four places. The measuring network consists of wood construction which is overhung in close propinquity over engine and it is also adjustable.

Nowadays only horizontal part of magnetic filed was measured during the whole day whereby the results which are mentioned here were processed in the horizon of time from 8.00 PM to 9.00 AM. In advance, data are processed for this time range because of creating and finding specific reference value of magnetic field which can be used to determine the change of magnetic field caused by engine activity. Of course, for measurements to have some meaning during the engine activity it is important to concentrate on vertical part of magnetic field as well, which will be compared with horizontal part. On the basis of their comparison will be determined which part is stronger (more determining) or which has more important parameters of magnetic field.

After these primary measurements will follow measurements of horizontal and vertical parts, but now during the engine activity namely at first – engine cold overspeed and next production engine run. Also for each measurement are kept approximately the same surrounding conditions for necessary objects layout in laboratory. Besides these conditions, meteorological conditions must be known [14,15]. In the following table are primary meteorological data for realized measurement.

Table 1
Meteorological conditions for measurement in the days 19th -20th August 2008

Meteorological conditions					
Date of measurement	**Dew point [^{0}C]**	**Atmospheric preassure [hPa]**	**Outside average temperature [^{0}C]**	**Inside average temperature [^{0}C]**	**Ozone layer [Dobson unit]**
19th August	13	1016	29	26	279 (-13%)
20th August	14	1015	28	25	279 (-13%)

5 Measurement Results

At the following figures are represented selected results of performed measurement, more precisely mean value and dispersion (variance) by help of four-base magnetometer.

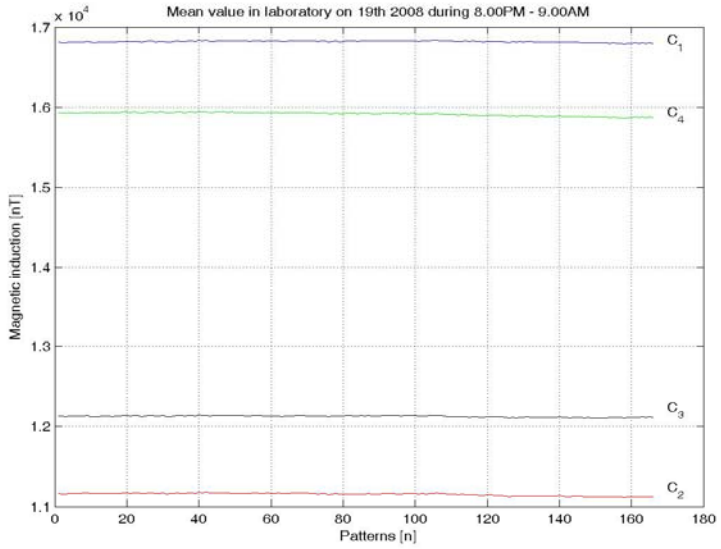

Figure 2
Mean value of measurement from date 19th August 2008

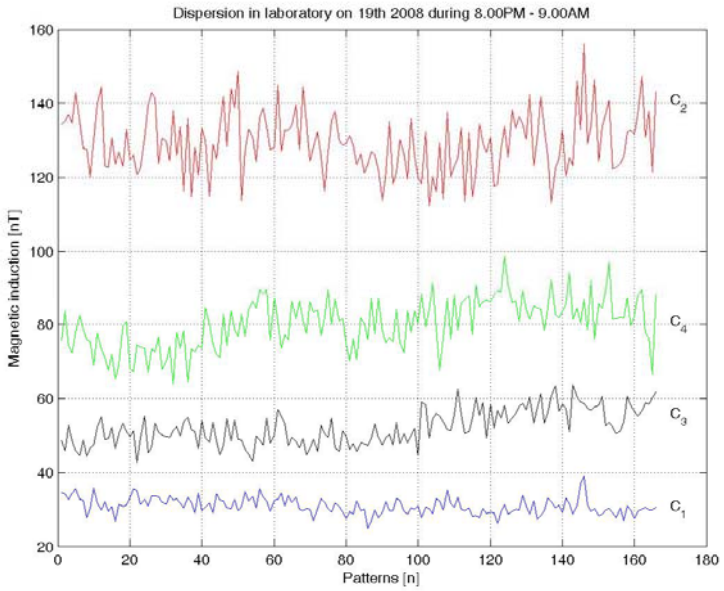

Figure 3
Dispersion of measurement from date 19th August 2008

Legend for figures no. 2, 3:

C_1 – Canal 1,

C_2 – Canal 2,

C_3 – Canal 3,

C_4 – Canal 4.

Conclusions

Measured data were evaluated for long time range and from previous figures is evident, that the magnetic aura which is situated around MPM 20 is variable and influenced by surroundings and also engine's presence. For finding and demonstration of other MPM 20 effects during different modes will be measured data evaluated in shorter time range. Assumption is, that from these measured data will be possible to determine waveform (shape) of MPM 20 magnetic aura.

All following measurements will be performed in horizontal and vertical part of magnetic field during engine cold overspeed and its production run. After doing all important measurements based on which will be evident the variability of magnetic aura, the research will be concentrated on exploring the static and dynamic part of magnetic field from the errors diagnostic point of view and improving MPM 20 control.

Acknowledgement

The work was supported by projects: VEGA no. 1/0394/08 – Situational control algorithms and large scale systems modeling.

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