CONTROL OF THE AIR EXCESS COEFFICIENT FOR THE NON-CONVENTIONAL ENGINE

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Abstract

One of the elements significant for the testing of combustion engines is the equipment for measurement of air consumed by the engine. The air excess coefficient, which depends on air consumption, is an important variable required for classification of combustion processes and evaluation for engine gas emissions.

The paper deals with the solution of a flow field of a designed non-standardized measuring element with the objective of measurements and control of the air excess coefficient of the non-conventional combustion engine.

In particular test stand (combustion engine – absorptive cooling equipmen)t, measuring element of the suction section of the combustion engine, modeling of the boundary layer, distribution of velocities and pressure field, distribution of density and temperatures in the flow field, course of static pressure and velocity in the measuring element axis for the engine torque, velocity profiles in cross sections, regulation of y+ parameter, comparison of velocities in dependence on torque, comparison of mass flow and pressure difference, contour of kinetic turbulent energy m2.s-2 for standardized and non-standardized measuring element, search dependence are presented in the paper.

Keywords: *non-conventional ICE, control, absorptive cooling equipment, air excess coefficient*

1. Introduction

In solving the non-conventional cooling engine [1], constructional and physical assumptions of cooperation of the combustion engine with basic elements of the absorptive cooling equipment were confirmed. A better energetic assessment of the engine as a stationary energetic unit can be achieved by the mentioned cooperation. At present the reconstruction of the test stand is carried out in order to provide a full-value cooperation of the engine with the complex absorptive equipment – Fig. 1. During the reconstruction it is necessary to solve the question of air consumption measurement. The reason for this is that it is necessary to determine the air excess coefficient in order to control it when rebuilding the engine for gas drive.

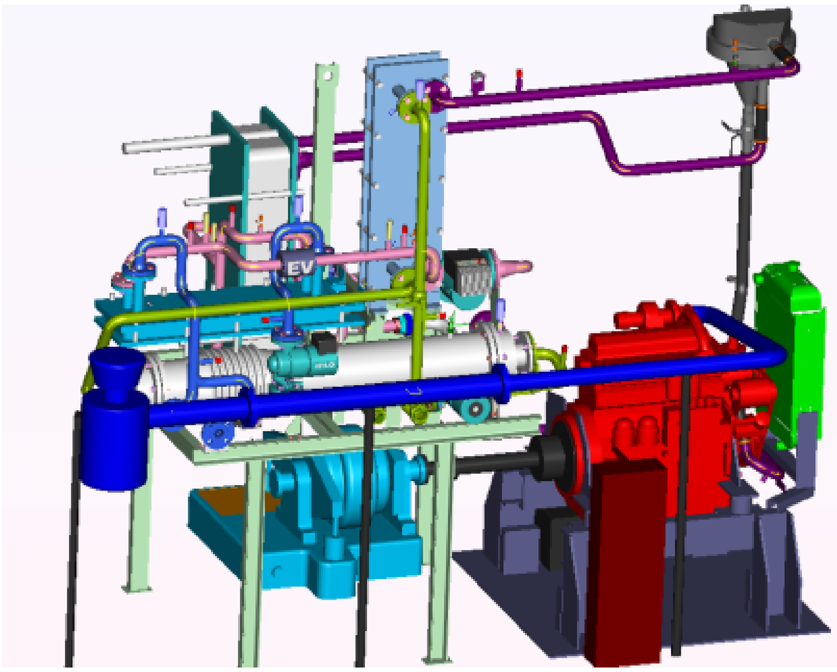

Fig.1 Test stand: combustion engine – absorptive cooling equipment [1]

Objectives of solution

The objectives of the solution are as follows:

- ⇒ to find the characteristic $\Delta p = f(M_{vz})$ for the designed measuring element,
- ⇒ to carry out – on the basis of the processed signal – the change of other variable for the control of the air excess coefficient,
- ⇒ to obtain the velocity profile and other data in the chosen places of the measuring chain.

Fuel consumption is measured by means of a mass method and also continually by a volume flow meter. A new measuring element has been designed for determination of consumption. The element uses a feasible sensor of pressure difference.

2. A design of the measuring element

The verification calculation of the unidimensional flow field in the designed measuring element was done in FLUENT. In Table 1 there are values of the observed parameters for the chosen engine torques and in Table 2 there are parameters calculated in FLUENT.

Verification table: IDEAL VERIFICATION CALCULATION *Table 1*

n [min^{-1}]	M_{vz}[$kg.s^{-1}$]	v_1[$m.s^{-1}$]	v_2[$m.s^{-1}$]	v_3[$m.s^{-1}$]	delta p[kPa]
700	0,008462	4,462	12,393	3,614	0,0822
800	0,00967	5,099	14,164	4,13	0,1074
900	0,01088	5,736	15,934	4,6464	0,1359
1000	0,01209	6,374	17,704	5,163	0,1678
1200	0,0145	7,648	21,246	6,195	0,2416
1300	0,01571	8,286	23,016	6,711	0,2836
1400	0,01692	8,923	24,786	7,227	0,3288
1500	0,01813	9,56	26,557	7,744	0,3775

1600	0,01933	10,197	28,327	8,26	0,4295
1700	0,02054	10,835	30,098	8,777	0,4849
1800	0,02175	11,473	31,868	9,293	0,5436
1900	0,02295	12,109	33,639	9,809	0,6057
2000	0,02416	12,7473	35,409	10,325	0,6711
2100	0,02537	13,385	37,179	10,842	0,7399
2200	0,02657	14,022	38,95	11,358	0,8121
2300	0,02778	14,659	40,721	11,874	0,8876
2400	0,02898	15,297	42,491	12,39	0,9664

Fig. 2 presents one of the variants of the measuring element (as well as cross sections 1-1, 2-2, 3-3), which is designed for the measurement of the required pressure difference with regard to the construction of the suction tract.

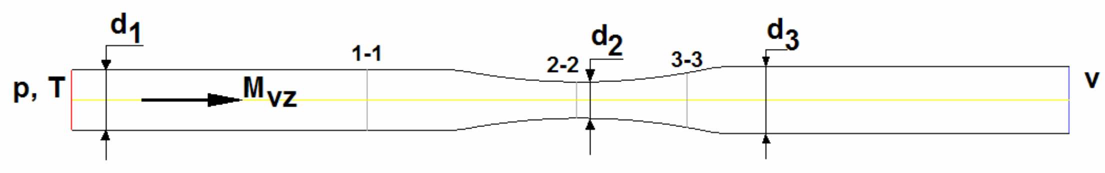

Fig.2 Measuring element of the suction section of the combustion engine

Values achieved by FLUENT. *Table 2*

n [min^{-1}]	Mvz [kg.s^{-1}]	v_1 [m.s^{-1}]	v_2 [m.s^{-1}]	v_3 [m.s^{-1}]	delta p [kPa]
700	0,008461	4,452	12,498	3,614	0,0903
800	0,009678	5,087	14,285	4,13	0,1174
900	0,01088	5,722	16,074	4,6464	0,1482
1000	0,01208	6,357	17,863	5,163	0,1824
1200	0,01449	7,626	21,446	6,195	0,2615
1300	0,0157	8,259	23,237	6,711	0,3062
1400	0,0169	8,894	25,033	7,227	0,3567
1500	0,01811	9,528	26,829	7,744	0,4068
1600	0,01932	10,162	28,626	8,26	0,4625
1700	0,02052	10,796	30,429	8,777	0,5219
1800	0,02173	11,429	32,228	9,293	0,5847
1900	0,02293	12,062	34,031	9,809	0,6533
2000	0,02413	12,694	35,835	10,325	0,7215
2100	0,02533	13,327	37,645	10,842	0,7956
2200	0,02653	13,959	39,454	11,358	0,8732
2300	0,02773	14,59	41,266	11,874	0,9545
2400	0,02893	15,221	43,079	12,39	1,0394

3. Modeling of flow in the designed element

The medium is defined as compressible air (even if Mach number is small). The calculation does not take into account air humidity. The $k-\varepsilon$ RNG model featuring a possibility of solving the area in the vicinity of the wall with regard to the changing pressure gradient along the length was used. It is in correspondence with the number of elements in the chosen area in the vicinity of the smooth wall. This fact is assessed with the parameter y^+ Fig. 3. From the figure it can be seen that if $y^+ < 5$, the calculation takes place as far as the laminar area and the influence of the wall on the flow field is taken into consideration. It is also possible to model changes in the flow field in the vicinity of the wall. The flowing is solved as stationary.

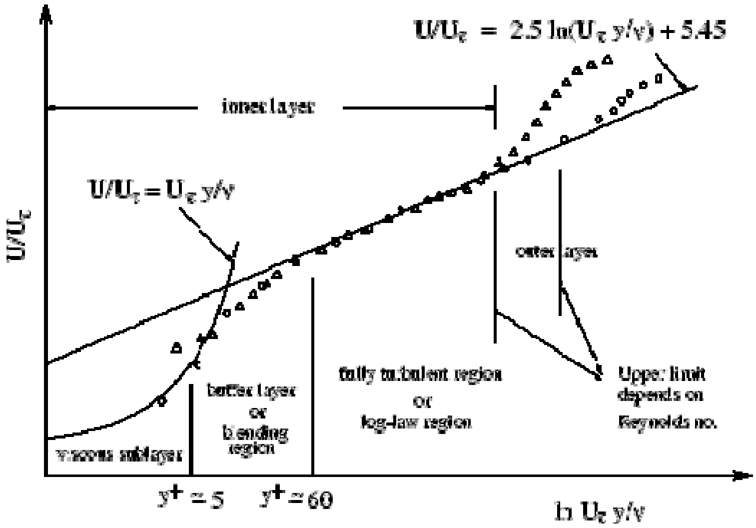

Fig.3 Modeling of the boundary layer

Figs. 4 and 8 illustrate some parameters of the flow field for the engine torque of 2 400 min^{-1}.

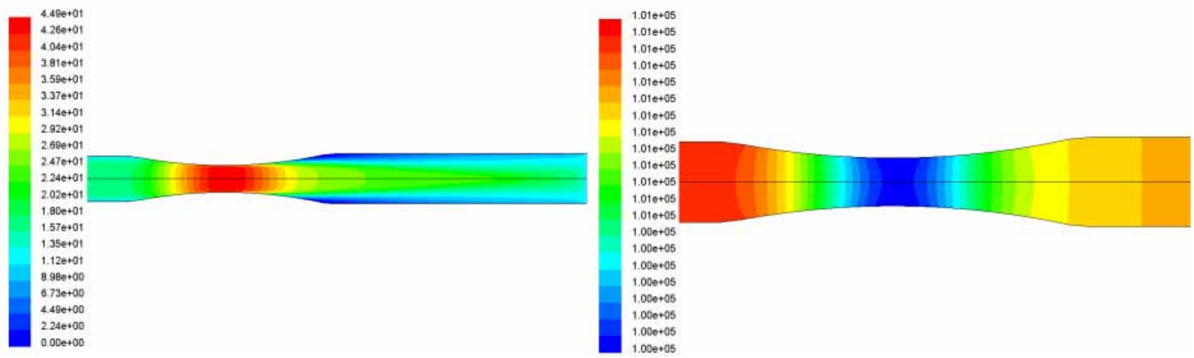

Fig.4 Distribution of velocities and pressure field

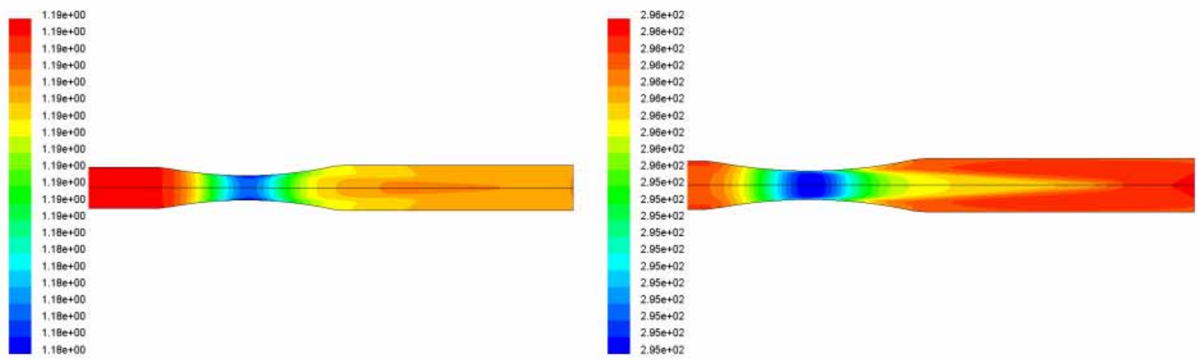

Fig.5 Distribution of density and temperatures in the flow field

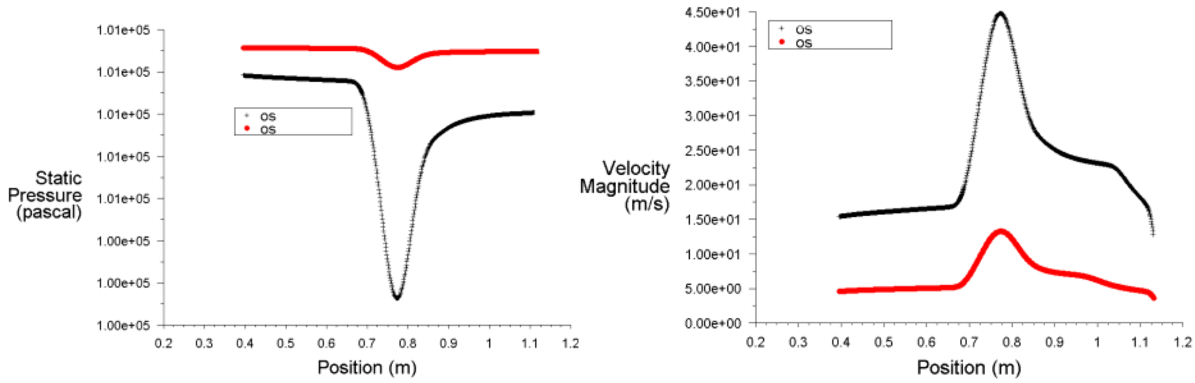

Fig. 6 Course of static pressure and velocity in the measuring element axis for the engine torque of 2400 min^{-1} and 700 min^{-1}

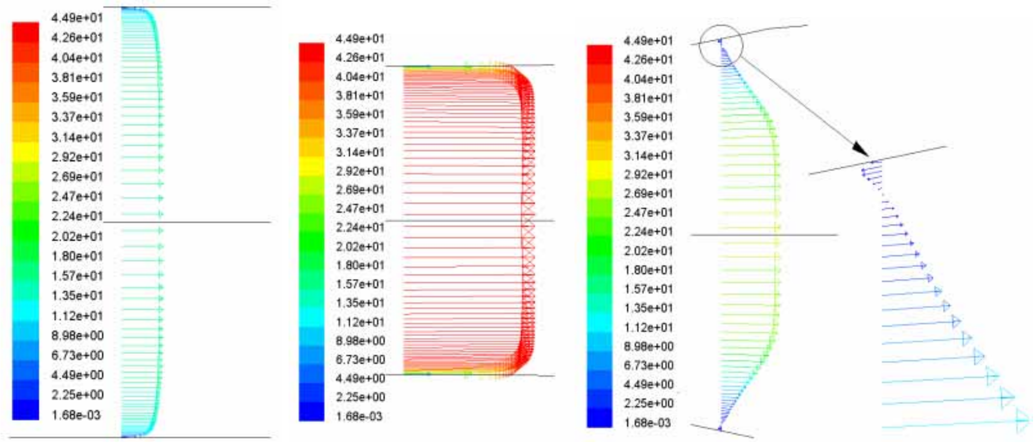

Fig.7 Velocity profiles in cross sections 1-1, 2-2, 3-3

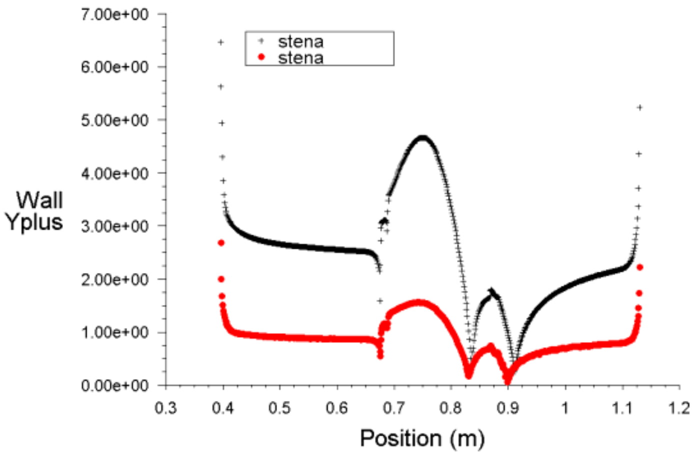

Fig.8 Regulation of y^+ parameter

The comparison of the results gathered from both calculations can be seen in Figs. 9 and 10.

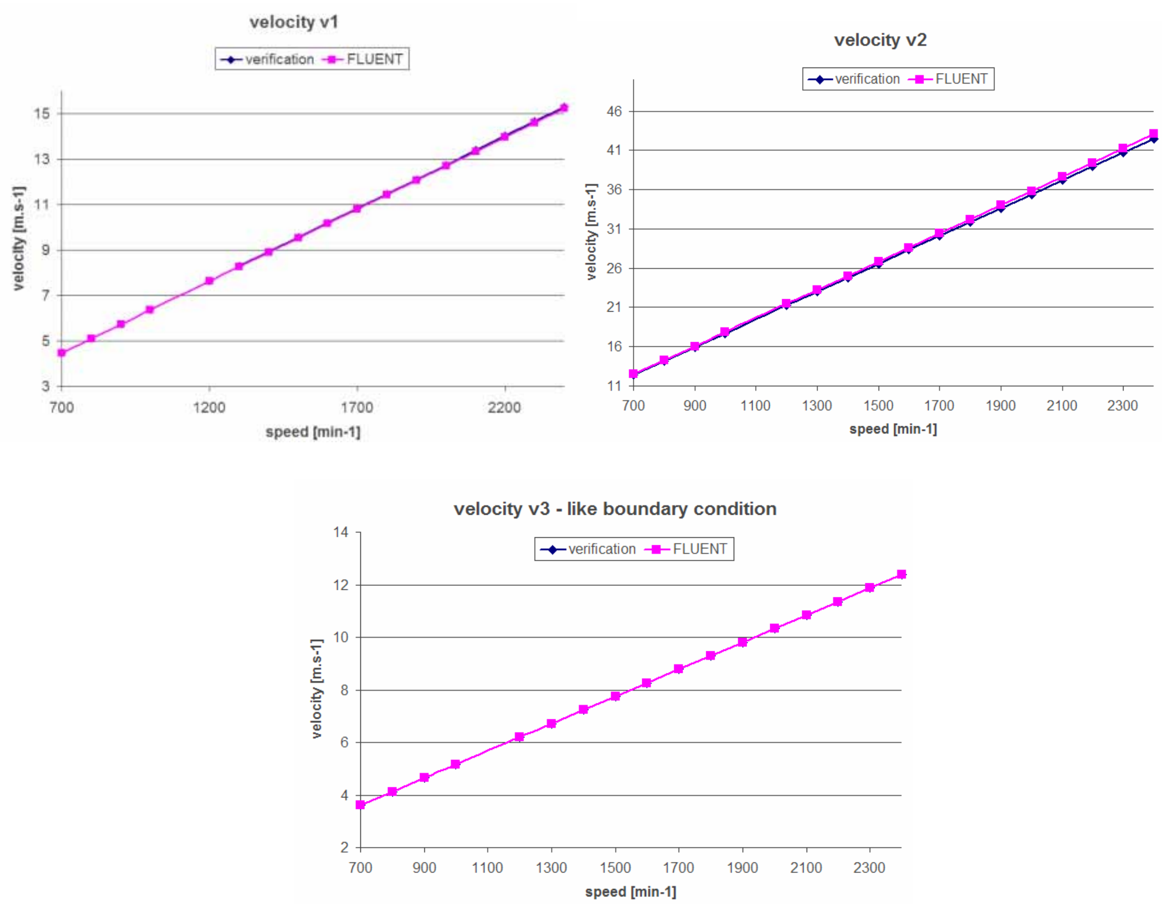

Fig.9 Comparison of velocities in dependence on torque

In the figures it can be clearly seen that there is agreement of parameters gathered by means of the verification calculation and FLUENT calculation. The difference is though in the pressure difference – Fig. 10. The FLUENT calculation takes into consideration the influence of the wall and the influence of the turbulent flow.

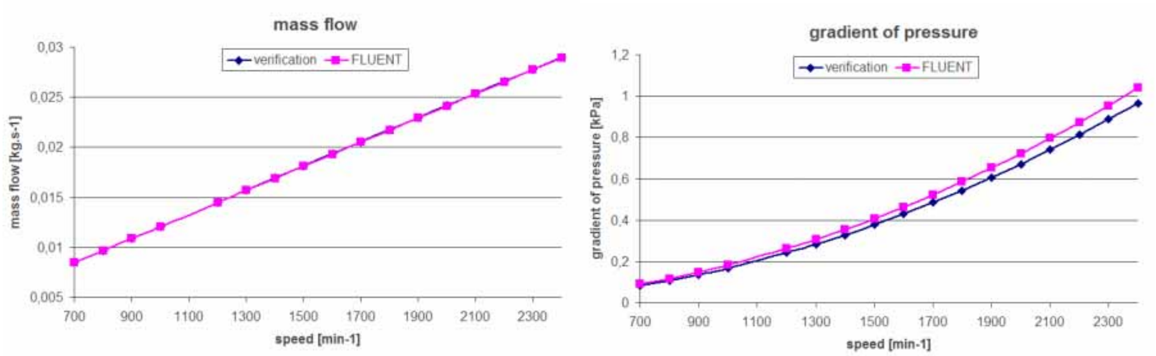

Fig.10 Comparison of mass flow and pressure difference

Fig. 11 presents the results of the observed parameters and turbulent kinetic energy in the torque of 2400 min^{-1} for the measuring element:

- constructed in compliance with required dimensions and standard,
- non-standardized.

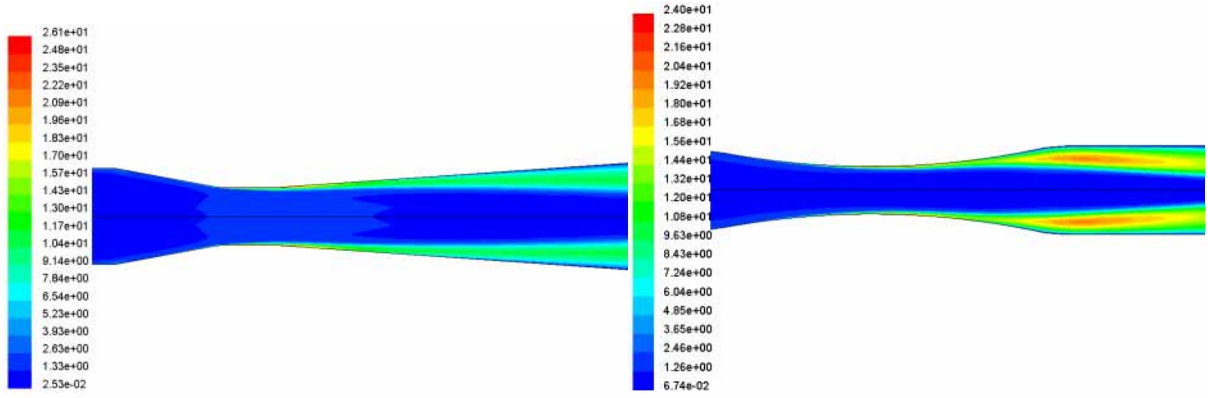

Fig.11 Contour of kinetic turbulent energy $m^2.s^{-2}$ for standardized and non-standardized measuring element

The result of measurement is the graphical dependence shown in Fig. 12. After being experimentally verified it can be plotted into the measurement program to control the air excess coefficient.

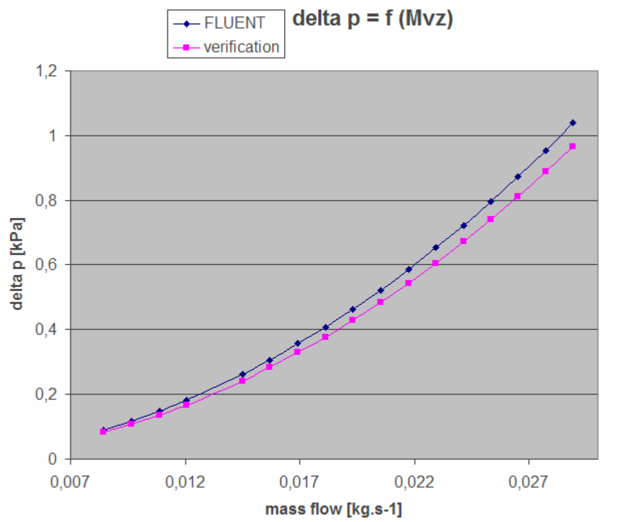

Fig.12 Search dependence

4. Conclusion

The paper deals with the solution of the flow field of the non-standardized measuring element designed for measurement and control of the air excess coefficient. The element – Fig. 3 – was designed for the required parameters. The objective was to examine the flow field and to determine the dependence $\Delta p = f(M_{vz})$.

For the obtained dependence to be plotted in the measurement program it is necessary to verify it experimentally. The verification enables then to confirm the accuracy of the search dependence.

5. References

[1] Hlavňa V., Sojčák D., An analysis of heat flows in the combustion engine of a ship non – conventional energetic system, Communications – scientific letters of the university of Žilina, EDIS 1/2005 ISSN 1335 - 4205

[2] Hlavňa V., Research report, Žilina 2005

[3] Sojčák D., Hlavňa V., Barta D., A structure of the cooling system, 6- th European Conference of Young Research and Science Workers in Trasport and Telecommunications, Žilina 2005, ISBN 80 – 8070 – 419 – 8

The contribution was created within the framework of the project APVT – 20 – 018404, which is supported by the Agency for Support of Science and Technology of the SK