H06 AIR FILTER COMPARISON TEST

EVALUATION DIAGRAMS FOR LABORATORY REPORT

PRESSURE DROP CHARACTERISTIC CURVES

1) Filter pressure drop vs. flow rate $\Delta p_F = f(q_V)$

   Δp_F [Pa]; q_V [m^3/s]

   q_V [lit/sec]= 143,0365731722 · $e^{-0,9598010807 \cdot U[V]}$ (see on the next page, too!)

2) Filter pressure drop vs. filtration velocity $\Delta p_F = f(v_F)$

   where $v_F = q_V / A_F$, and A_F total surface of the filter

   Δp_F [Pa]; v_F [m/s]; A_F [m^2]

FORCE ACTING ON THE FILTER MATERIAL CHARACTERISTIC CURVES

3) Force vs. flow rate $F_F = f(q_V)$

   where $F_F = \Delta p_F \cdot A_F$

   F_F [N]

4) Force vs. filtration velocity $F_F = f(v_F)$

POWER LOSS CHARACTERISTIC CURVES

5) Power loss vs. flow rate $P_F = f(q_V)$

   where power loss: P_F [W] = $\Delta p_F \cdot q_V$

   (see on the 3rd page the engine's power curve P[kW]= f(n[rpm]) !)

6) Power loss vs. filtration velocity $P_F = f(v_F)$

Evaluation is to be performed for all diagrams, comparison of the filters with the help of the diagrams and in form of written summarising texts. (try to answer the question „Which filter to select for my car?")

PERMEABILITY (α) AND INERTIAL RESISTANCE FACTOR (C_2) CHARACTERISTIC CURVES

Moreover, based on the measured characteristic curves the following parameters are to be calculated. The ANSYS Fluent CFD (Computational Fluid Dynamics) software uses the following expression for pressure drop of flow through porous media.

$$\Delta p = -\left(\frac{\mu}{\alpha} v_f + C_2 \frac{1}{2} \rho v_f^{\,2}\right) \Delta m$$

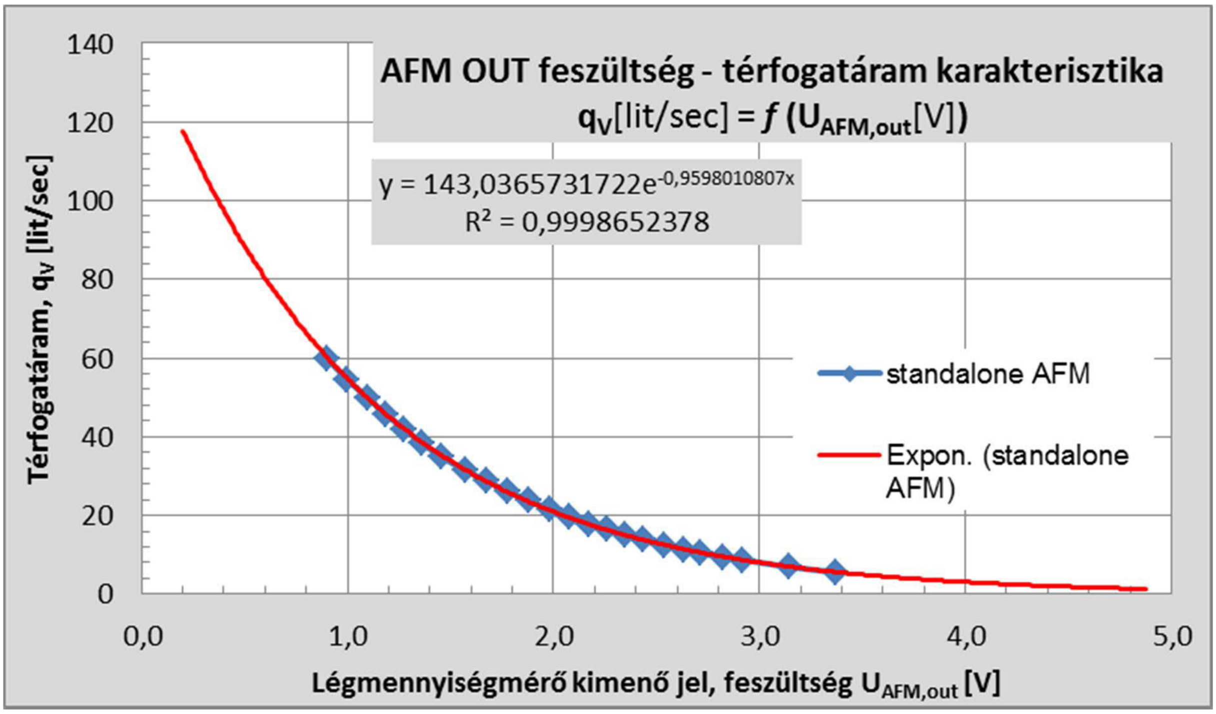
where

α (permeability) and

C_2 (inertial resistance factor)

parameters are to be set. These parameters can be calculated based on the measured data. (We can calculate and use the μ dynamic viscosity, ρ air's density based on the measured laboratory ambient data, and using of Δm=1mm (=10^{-3}m) filter thickness.) In the expression Δp is the pressure loss of the filter (Δp_F). The $\Delta p/\Delta m$ [Pa/m] pressure gradient characterises the pressure loss of the fluid flow through the filter material having thickness of Δm. A pressure is decreasing in streamwise direction, that is why there is a „-„ sign in the expression. The expression can be rewritten in the form of $\Delta p = A \cdot v_F + B \cdot v_F^2$, where v_F is the filtration velocity. Plot also results: the characteristic curves for:

7) Permeability vs. filtration velocity $\alpha = f(v_F)$
8) Inertial resistance factor vs. flow rate $C_2 = f(v_F)$

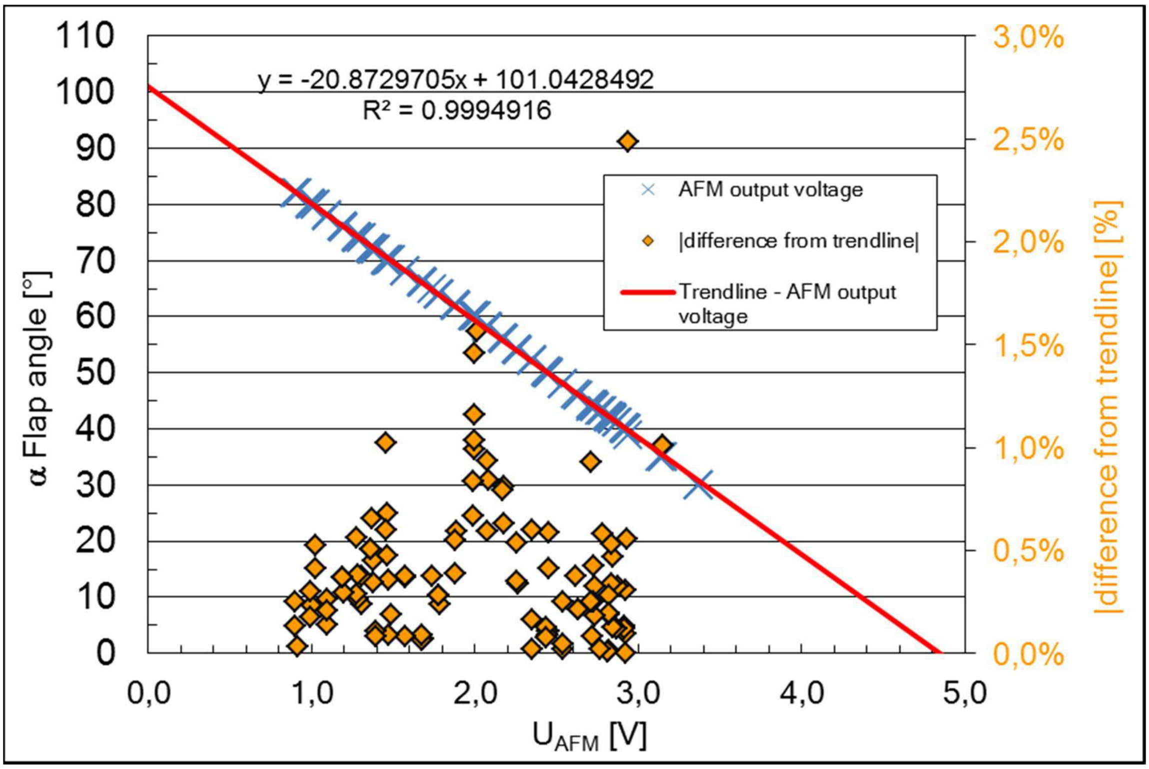


The AFM (air flow meter) was calibrated previously to a standard orifice plate. The trendline fitted to the data points can be seen above in the diagram.

Flow rate q_V [lit/sec] can be recalculated using the $U_{AFM,out}$[V] output voltage signal of the AFM using the trendline's equation:

$$q_V \text{ [lit/sec]} = 143{,}0365731722 \cdot e^{-0{,}9598010807 \cdot U[V]}$$

We can plot also the α[°] flap angle vs. $U_{AFM,out}$[V] output voltage signal of the AFM. α[°] = f ($U_{AFM,out}$). In the set-up α=0° corresponds to the fully closed flap position. It was measured also previously, your own data can be compared to the previously measured linear trendline, see figure below.



It is useful to know what n[rpm] engine's main shaft' rotational speed range corresponds to the measured air flow rate range.

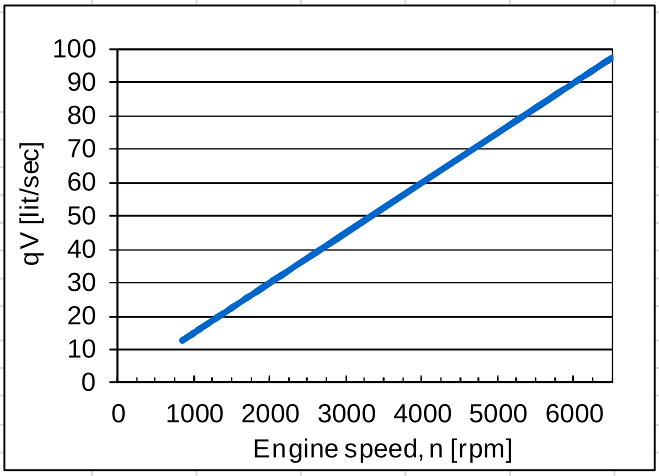
$$q_V[\text{lit/sec}] = f\,(V[\text{lit}], n[\text{ford/min}]).$$

Assuming volumetric efficiency 100% , we can calculate the flow rate based on the engine's data (DOHC, 4–stroke, 4cylinder, V=1796 cm3 =1,796lit) :

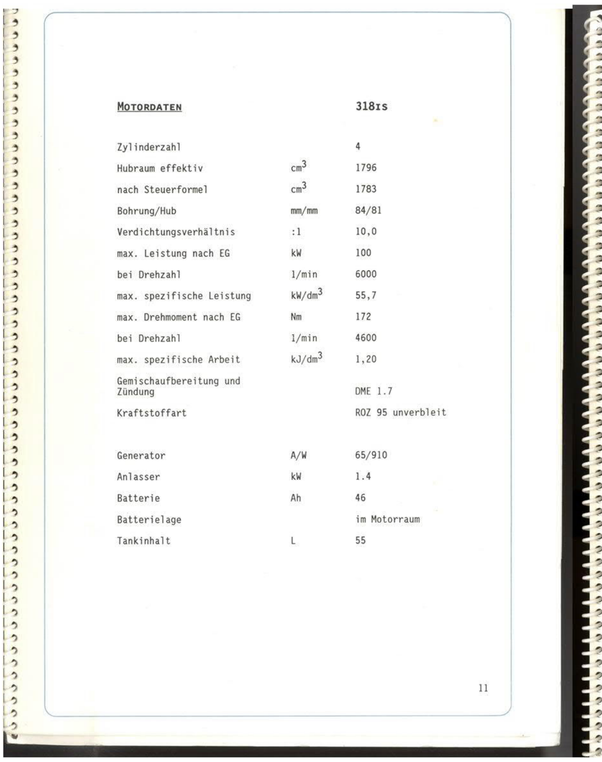
$$q_V\,[\text{lit/sec}] = 0{,}5 \cdot V[\text{lit}] \cdot (1/60) \cdot n\,[\text{ford/min}]$$

displacement	1796	ccm	1,796	litre

Engine speed n [rpm]	q_V [lit/sec]	
850	12,7	
900	13,5	
1000	15,0	
1250	18,7	
1500	22,5	
2000	29,9	
3000	44,9	
4000	59,9	
5000	74,8	
6000	89,8	
6500	97,3	



What is power loss of the air filter compared to the engine's power at a given rpm ? The engine's power curve P[kW]=*f*(n[rpm]) is known only in a form of a photocopy (see below). We can read the P[kW] engine's power at given n[rpm], and we can calculate the air filter's power loss relative to the actual power of the engine in %. (The max. power is known: P_{max}=100kW(136hp) @ 6000rpm, but the radial fan of the experimental set-up cannot flow through such high air flow rate that corresponds to the max. rpm!)



MOTORDATEN 318IS

Zylinderzahl		4
Hubraum effektiv	cm^3	1796
nach Steuerformel	cm^3	1783
Bohrung/Hub	mm/mm	84/81
Verdichtungsverhältnis	:1	10,0
max. Leistung nach EG	kW	100
bei Drehzahl	1/min	6000
max. spezifische Leistung	kW/dm^3	55,7
max. Drehmoment nach EG	Nm	172
bei Drehzahl	1/min	4600
max. spezifische Arbeit	kJ/dm^3	1,20
Gemischaufbereitung und Zündung		DME 1.7
Kraftstoffart		ROZ 95 unverbleit
Generator	A/W	65/910
Anlasser	kW	1.4
Batterie	Ah	46
Batterielage		im Motorraum
Tankinhalt	L	55

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