Flow capacity coefficient of strainers

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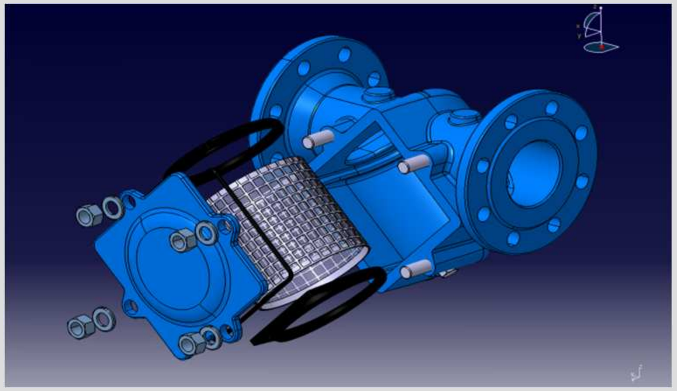

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Plan of presentation:

- New filter structure development
- DN 80 and DN 200 filter body test results
- DN 80 and DN 200 strainers test results
- Dimension analysis and similitude
- Test results of the entire strainers series
- Conclusion

The relevant feedback received from the users has inspired the Hawle (Hawle Armaturenwerke) to develop a new filter structure with improved hydraulic parameters and a more easily accessible screen insert.

The entire prototype development process lasted for approximately 1 year.

In the first place, prototypes of new strainers were created, featuring the DN 80 and DN 200 diameters. On this basis, still before starting the production of the entire series (DN 50, DN 80, DN 100, DN 150, DN 200), the hydraulic parameters of prototypes were assessed in order to establish the suitability of the new device for the operating conditions of a water network.

Hydraulics research of stainers was conducted in the Water Laboratory of the Department of Hydraulic and Sanitary Engineering of the Poznan University of Life Sciences

K_v flow coefficients*:

$$K_V = Q \cdot \sqrt{\frac{\rho}{H \cdot \rho_0}} \qquad [m^3 \cdot h^{-1}] \qquad (1)$$

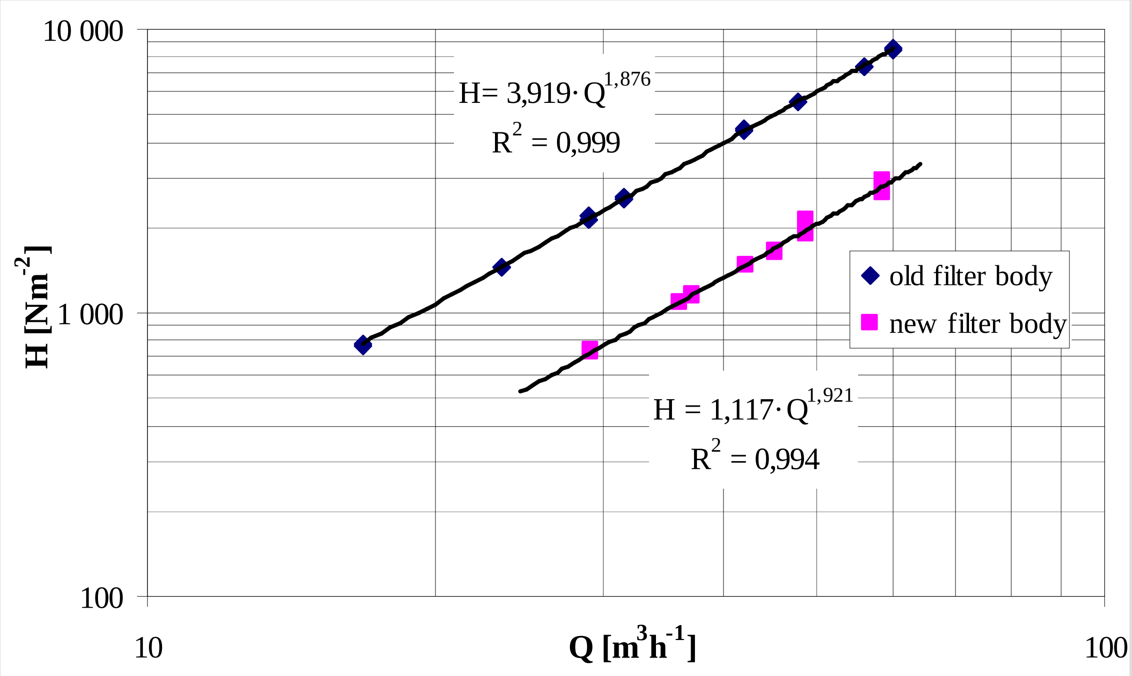
where:

Q – volumetric flow rate $[m^3 \cdot h^{-1}]$,
ρ – water density $[kg \cdot m^{-3}]$,
ρ_o – water density at 15 °C $[kg \cdot m^{-3}]$,
H – pressure loss [bar].

* The flow coefficient in metric units is defined as the flow rate in cubic meters per hour [m³/h] of water at a temperature of 15° Celsius with a pressure drop of 1 bar.

DN 80 filter body test results

(without screen inserts)



new

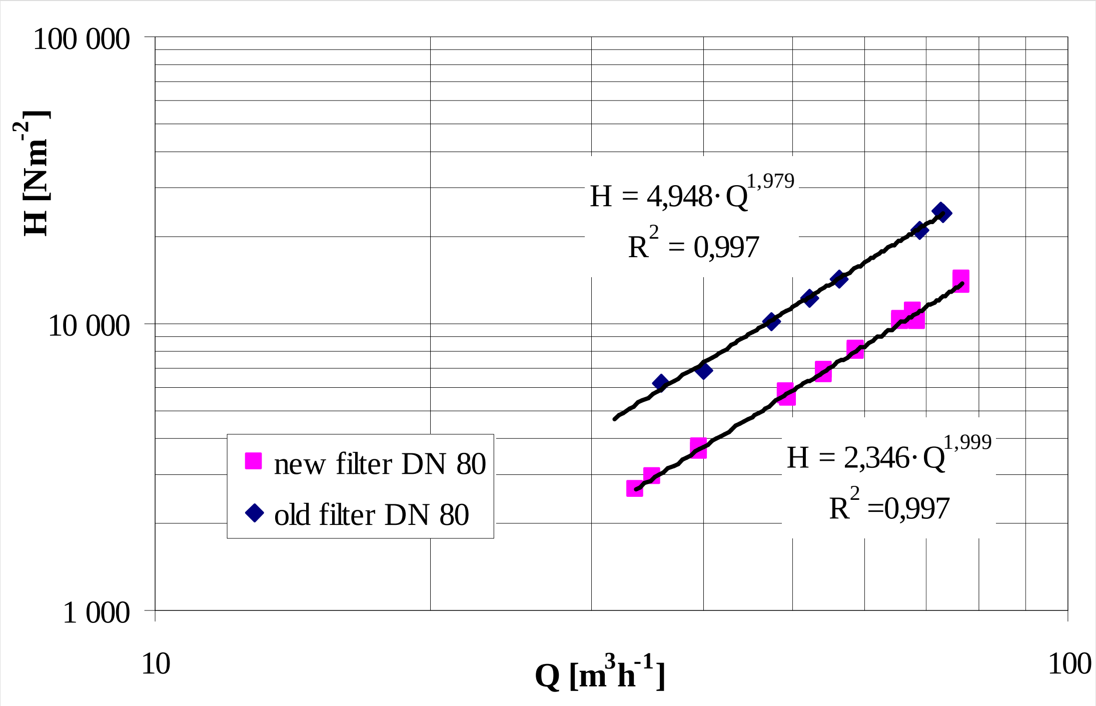
K_v = 347 $m^3 \cdot h^{-1}$

old

K_v = 199 $m^3 \cdot h^{-1}$

Relation between pressure loss and flow rate of new and old DN 80 filter body

DN 80 strainer test results



new

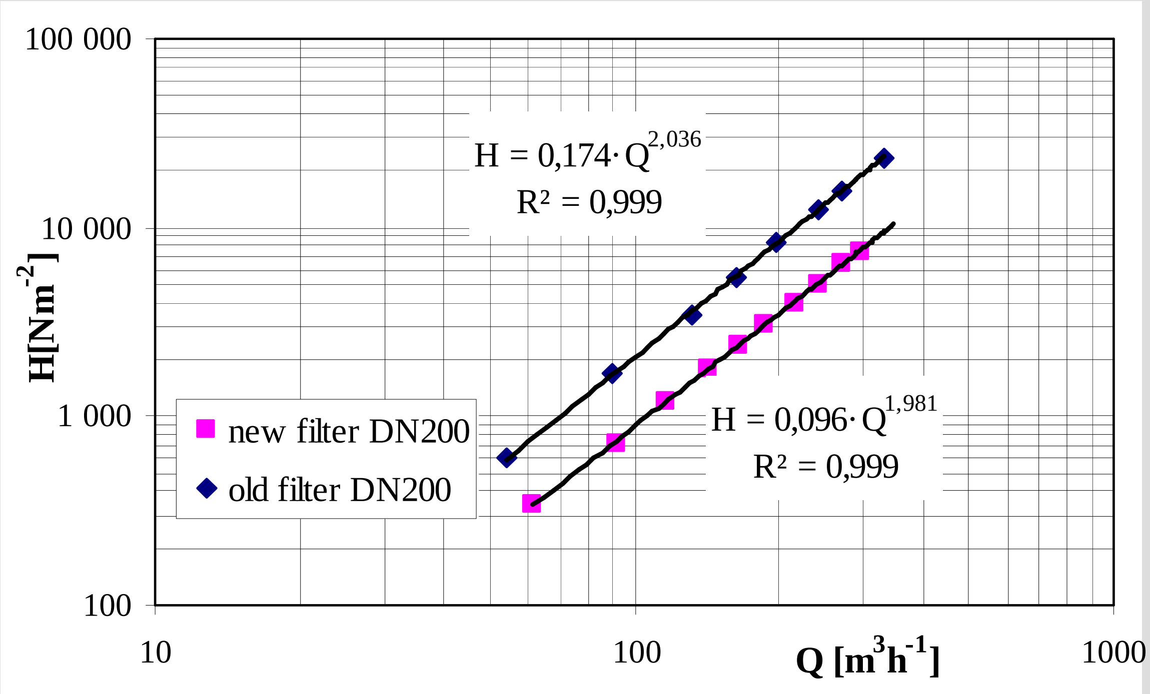
$K_v = 207\ m^3 \cdot h^{-1}$

old

$K_v = 146\ m^3 \cdot h^{-1}$

Relation between pressure loss and flow rate of new and old DN 80 strainers

DN 200 strainer test results



new
$K_v = 1069\ m^3 \cdot h^{-1}$
old
$K_v = 691\ m^3 \cdot h^{-1}$

Relation between pressure loss and flow rate of new and old DN 200 strainers

Dimension analysis and similitude

Two geometrically similar systems: real N with natural dimensions and model M with miniaturised dimensions, we state that the geometrical similitude shall be maintained, as for each of the two sections which are L_N and L_M long, the following relation shall apply (geometric scale λ):

$$L_N = \lambda \cdot L_M \qquad (2)$$

scale of the K_v flow coefficient:

$$\frac{K_{vN}}{K_{vM}} = \frac{Q_N \cdot \sqrt{\frac{\rho}{H_N \cdot \rho_0}}}{Q_M \cdot \sqrt{\frac{\rho}{H_M \cdot \rho_0}}} = \frac{Q_N}{Q_M} \cdot \sqrt{\frac{H_M}{H_N}} = \lambda \cdot \sqrt{\lambda^2} = \lambda \cdot \lambda = \lambda^2 \qquad (3)$$

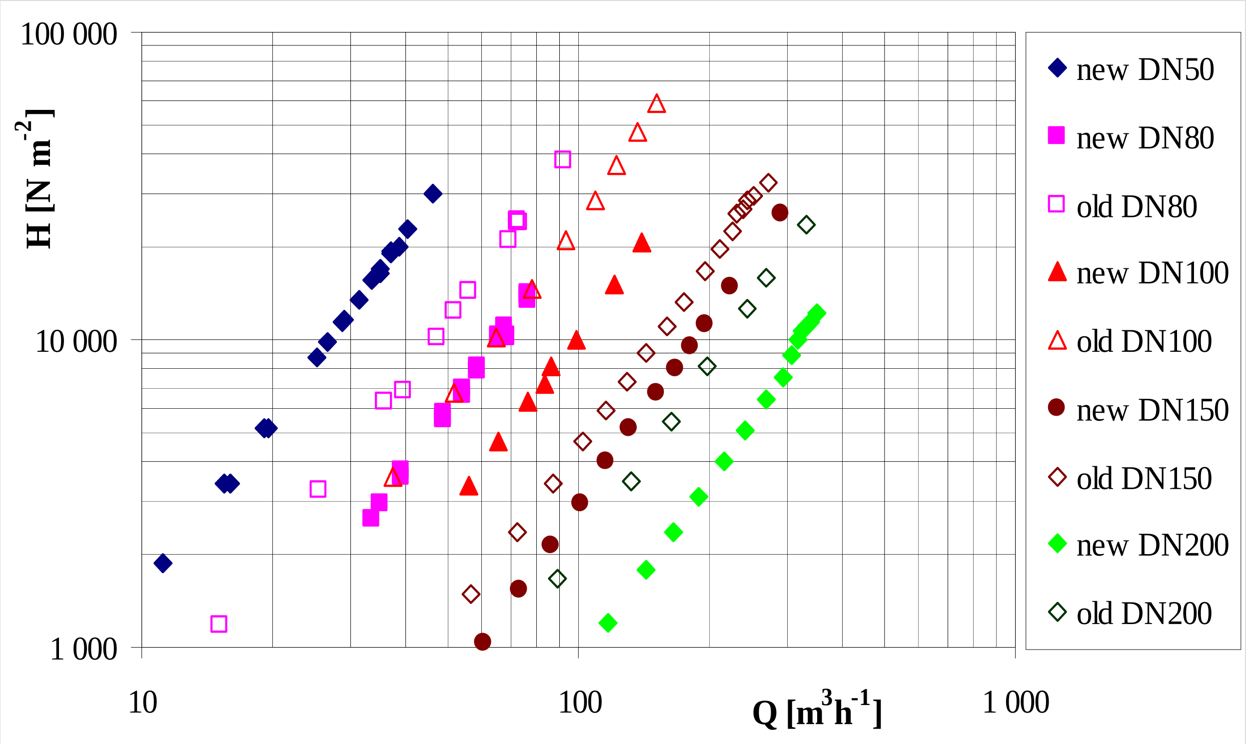
Estimation of strainer flow coefficients on basis of the adopted scale of similitude in reference to the measurements of the DN 80

	DN 50	DN 80	DN 100	DN 150	DN 200
λ	0,625	**1**	1,25	1,875	2,5
K_v [m³/h]	81	**207**	323	728	1294

and DN 200 filters

	DN 50	DN 80	DN 100	DN 150	DN 200
λ	0,25	0,4	0,5	0,75	**1**
K_v [m³/h]	67	171	267	601	**1069**

Test results of the entire filter series



Relation between *H* pressure loss and *Q* flow of old and new filters

Test results of the entire filter series

Calculated values of the K_v [$m^3 \cdot h^{-1}$] flow coefficients of respective filters according to DN diameters

	DN 50	DN 80	DN 100	DN 150	DN 200
Old filter	-	146	202	475	691
New filter	85	207	307	585	1069
Coeff. growth K_v [%]	-	42	52	23	55

Test results of the entire filter series

K_v coefficient estimation error on basis of the adopted scale of similitude in reference to the measurements of the DN 80 filter

	DN 50	DN 80	DN 100	DN 150	DN 200
Estimation of K_v [$m^3 \cdot h^{-1}$]	81	207	323	728	1294
Measurement of K_v [$m^3 \cdot h^{-1}$]	85	207	307	585	1069
Estimation error %	5	0	-5	-24	-21

and the DN 200 filter

	DN 50	DN 80	DN 100	DN 150	DN 200
Estimation of K_v [$m^3 \cdot h^{-1}$]	67	171	267	601	1069
Measurement of K_v [$m^3 \cdot h^{-1}$]	85	207	307	585	1069
Estimation error %	21	17	13	-3	0

Conclusion

- The values of parameters of the prototypes of the new DN 50, DN 80, DN 100, DN 150 and DN 200 filters have proven their enhanced hydraulic properties.

- By means of dimensional analysis and the similitude concept, on basis of a given product it is possible to obtain K_v values of strainer at a maximum tolerance of 10%.

- This estimation error is connected with mesh size of screen inserts and geometric similarity of strainers.

Thank you for your attention

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While applying the same liquid, the criterion of similitude may be expressed as follows:

$$\frac{u_N \cdot d_N}{\nu} = \frac{u_M \cdot d_M}{\nu} \qquad (2)$$

where: *u* – average cross-sectional speed, *d* – pipeline diameter, *v* – kinematic liquid viscosity coefficient.

This leads to the following speed scale (λ – geometric scale):

$$\frac{u_N}{u_M} = \frac{1}{\lambda} = \lambda^{-1} \qquad (3)$$

and water flow rate scale:

$$\frac{Q_N}{Q_M} = \frac{u_N A_N}{u_M A_M} = \lambda^{-1} \cdot \lambda^2 = \lambda \qquad (4)$$

The power scale may be expressed by means of a relation:

$$\frac{F_N}{F_M} = \frac{\mu \cdot u_N \cdot D_N}{\mu \cdot u_M \cdot D_M} = \lambda^{-1} \cdot \lambda = 1 \qquad (5)$$

and finally, the pressure scale:

$$\frac{p_N}{p_M} = \frac{\frac{F_N}{A_N}}{\frac{F_M}{A_M}} = \frac{F_N \cdot A_M}{F_M \cdot A_N} = 1 \cdot \lambda^{-2} = \frac{1}{\lambda^2} \qquad (6)$$

By employing the relation provided in (6), pressure level scale or pressure loss scale may be determined:

$$\frac{H_N}{H_M} = \frac{\frac{p_N}{\rho \cdot g}}{\frac{p_M}{\rho \cdot g}} = \frac{p_N}{p_M} = \frac{1}{\lambda^2} \qquad (7)$$

whereas by means of the relation between (3) and (7) the scale of the K_v flow coefficient is obtained:

$$\frac{K_{vN}}{K_{vM}} = \frac{Q_N \cdot \sqrt{\frac{\rho}{H_N \cdot \rho_0}}}{Q_M \cdot \sqrt{\frac{\rho}{H_M \cdot \rho_0}}} = \frac{Q_N}{Q_M} \cdot \sqrt{\frac{H_M}{H_N}} = \lambda \cdot \sqrt{\lambda^2} = \lambda \cdot \lambda = \lambda^2 \qquad (8)$$