OPTIMIZATION OF COMPACT HEAT TRANSFERRER WITH GENETIC ALGORITHM

ERFAN KHOSRAVIAN a1 AND TAYEBE KHANMOHAMADI b

aDepartments of Applied Mechanics, Payam Noor University, Tehran North

ABSTRACT

Because of the extent of heat transferer which are used in oil industry and petrochemistry, air craft, air conditioning, optimized designing of heat transferrer is essential. In this essay among all heat transferrer, compact one will be analyzed expenditure factor is very important in analyzing expenditure factor is very important in analyzing heat transferrer and pressure drop is one of a affective parameter on expenditure. In this essay instead of analyzing expenditure pressure drop parameter and other designing parameters will consider. Genetic algorithm method has been used. It is one of the most utilizeable optimized method.

Keywords: Heat transferrer, optimizing designing parameter, genetic algorithm, compact, compact transferrer

OPTIMIZATION PROCESS

Today's in the world of industry, human production should satisfy the needs, it should be competitive and the most optimized design in the world. Humans used experimental methods to optimize their designs since beginning till now, but these days due to hard competition of international companies, there is not any opportunity for these methods, and other methods of optimization should be brought under consideration. We can mention ant algorithm, genetic algorithm [1], differential evolution (DE) and other mathematical way as examples. Some various methods and combination of them are expanding for making optimizing of many process easier for example: genetic algorithm, ANNS, fuzzy logic [2], response surface methodology [3]. First three methods are base on artificial intelligence, in this essay genetic algorithm is used. Go and his colleague [4] used synergy field factor instead of expenditure factor, and they saw that maximum of this factor is better in comparison to total expenditure factor. In Ortega and his colleague's research [5], heat transfer of pipe crust is optimized geometrically by genetic algorithm, so pressure drop around crust and pipe has become minimum. In Mishra and his colleague research [6], thermodynamic second law for plate fin heat transfer is analyzed. Producing entropy in this heat transferrer for specified heat task and specified geometrical conditions is reduced by genetic algorithm. Reduction of entropy producing in heat transferrer causes pressure drop and lowering expenditure [7], in Zee and his colleague's primary outlay which is got minimum for research, the main factor to optimize is weight compact heat transferrer by genetic algorithm method.

In this essay we have tried to optimize compact heat transferrer by using genetic algorithm. The purpose of this essay is lowering expenditure of compact heat transferrer. The expenditure is not the main factor in this essay, the parameters which cause lowering outlay are analyzed indeed. Pressure drop in compact heat transferrer is an affective factor on expenditures. In this essay the main factor is gas pressure and we have tried to optimize heat transferrer by reducing it (gas pressure drop), in fact we suppose the weight of heat transferrer or its primary cost is unchangeable.

Corresponding author
The optimized designing processes of heat transferrer are including below stages:

1: to estimate heat interchanging surface and primary amount of variable parameters and other physical specification of flow, such as: internal and external temperature.

2: to evaluate initial investment, expenditure and main factors.

3: to use optimizing algorithm to obtain new quantities for variable parameters.

4: repeating previous steps to reach minimum quantities of main factor.

**flow physical specifications**

![Diagram](image)

**figure 1**: suggested optimizing algorithm

**COMPACT HEAT TRANSFERRER**

we can mention to airconditioning system, airplane's conditioning, cooler system of space ship electrical circuit, cryogenice. using compact heat transferrer is useful because it takes less space. producing initial expenditure depends on the weight of componants in heat transferrer, by keeping the volume constant, the primary outlay outlay would not change. mostly in heat transferrer the expenditure is rely on pump and compressor consumption. in compact heat transferrer gas pressure drop in position of increasing heat efficiency is very important. if the gas pressure drop reduces, the consumption power of compressor will decrease, so main factor is chosen.
as $\frac{Q}{z=\Delta P} \quad (1)$

**MATHEMATICAL MODELING**

First of all we try to find a suitable and correct formula for this ratio $z = \frac{Q}{\Delta P}$ to find heat transfer ($Q$) and air pressure drop ($\Delta P_a$) have been used these formulas:

$$Q = u_0A_0F(LMTD)c.p. \quad (2)$$

$$\Delta P_a = \frac{G_c^2V_1^2}{2g_c}[(1 + \sigma_c^2)(V_2^2/V_1^2 - 1) + \frac{4L}{D_1} \frac{V_n}{V_1}] \quad (3)$$

It's necessary to choose suitable formula for heat transfer coefficient of internal and external flow, so we should analyze Reynolds number according to its parameters.

$$Re_0 = \frac{m_cD_1}{\mu_c \sigma_c WH} \quad (4)$$

By using this number and information in reference [8] which is shown in picture 2, a good function for $J$-Kolber coefficient and friction factor base on Reynolds number is presented which is acceptable with 0.3 tolerance

$$J = 0.144Re_0^{0.38} \quad (5)$$
finally by having acceptable formula for J-kolbern coefficient, we can find heat transfer, coefficient of external flow to compute heat transfer coefficient of internal flow we can use eagle and ferguson formula which it's used for pipe flow and water:

\[ h_i = c_0 (165 + 1.7 t_m) v_i^{0.805} \]  

\[ D = \frac{4a_c}{P} \]  

\[ a_c = (D_i - D_t) D_t + \frac{\pi D_t^2}{4} \]  

\[ a_k = (D_i - D_t) \pi 2 + \pi D_t r \]  

\[ (LMTD)_{c,f} = \frac{(T_2 - T_2) - (T_1 - T_1)}{\ln \frac{T_2 - T_2}{T_1 - T_1}} \]  

heat transfer surface is computed by this formula:

\[ A_0 = \pi D_i V_0 \]  

12) to find air pressure drop we should find friction factor, like before we should choose suitable formula of friction factor against reynolds number (picture3) if we have constant quantity parameters, we can compute air pressure drop.

\[ V_0 = LWH \]  

13) to find air pressure drop we should find friction factor, like before we should choose suitable formula of friction factor against reynolds number (picture3) if we have constant quantity parameters, we can compute air pressure drop.
\[ \Delta P_e = \frac{G \cdot V}{2 \cdot \rho_e \cdot ((1 + \sigma_s^2 \cdot \frac{V}{V_1}) - l) + f \cdot \frac{4L}{D_a} \cdot \frac{V^2}{V_1^2}} \]

\[ f = 0.586 \cdot \text{Re}^{-0.38} \quad (17) \]

The ratio of flow free surface to front surface for external flow (air) is computed by this:

\[ \sigma_s = \frac{A_s}{A_f} \quad (18) \]

\[ A_f = WH \quad (19) \]

Gas mass velocity is computed by this formula:

\[ v_m = \frac{1}{2} (v_1 + v_2) \quad (21) \]

**example**

There is a compact heat transferrer with the model of 11.32-0.737-SR, [8], external warm flow is air and internal cold flow is water, mass flow rate and inlet and outgoing temperature of cold and warm flows are constant and physical qualities of them are constant too, (supposedly) and they are computed in average temperature. Now we suppose the volume and height of compact heat transferrer are constant and the purpose is finding length and width of transferrer and the ratio of heat transferrer to air pressure drop should become maximum.
figure 4 (compact heat transferrer with model 11.32.0.737.SR and the type of flow formation)

thermophysical condition for this example
for air:
\[ T_1 = 127 \, ^\circ\text{C}, \quad T_2 = 24 \, ^\circ\text{C}, \quad m_0 = 50.4 \, \text{kg/sec}, \quad V_1 = 0.4232 \, \text{m}^3/\text{kg}, \quad V_2 = 0.3240 \, \text{m}^3/\text{kg}, \quad V_m = 0.3736 \, \text{m}^3/\text{kg} \]
\[ \alpha = 0.78, \quad c_p_0 = 1021.55 \, \text{J/kg} \cdot \text{C}, \quad \rho_0 = 0.1993 \times 10^6, \quad \beta_0 = 0.7, \quad \gamma_0 = 0.78, \quad \zeta_0 = 88508268 \, \text{m}^{-2/3} \]

For water:
\[ t_1 = 16 \, ^\circ\text{C}, \quad t_2 = 27 \, ^\circ\text{C}, \quad m_i = 25.2 \, \text{kg/sec}, \quad \rho_1 = 3.8923 \, \text{kg/m}^3, \quad \rho_1 = 138.2067 \, \text{m}^{-2/3} \]

RESULTS
the quantities of heat transfer rate and pressure drop
and geometrical dimensions before optimization:

\[ Q = 2340.07 \, \text{kw}, \quad P_0 = 14.749 \, \text{kpa} \]
\[ L = 0.4816 \, \text{m}, \quad w = 0.6096 \, \text{m}, \quad H = 1.6249 \, \text{m} \]

the quantities of heat transfer rate and pressure drop
and geometrical dimensions after optimization:

<table>
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<tr>
<th>L</th>
<th>W</th>
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</thead>
<tbody>
<tr>
<td>0.6151 m</td>
<td>0.4682 m</td>
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<tr>
<td>0.6154 m</td>
<td>0.4676 m</td>
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<tr>
<td>0.6096 m</td>
<td>0.4606 m</td>
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CONCLUSION
by comparing the mentioned results, we can find out
, if the volume and height of transferrer is constant ,
the ratio \( \frac{Q}{\Delta P_0} \) would increase 2.97 times.
by thinking about the result of genetic algorithm we will find out the rate of heat tranfer has decreased
about 18% , it means heat efficiency of compat heat transferrer has increased , and air pressure drop has reduced about 60%. 
REFERENCE


