Laserfin® Tubes

➔ Economies resulting from material savings compared to traditional welding processes

➔ Combination possibilities of different materials for tube and fin

➔ High weld integrity between tube and fin to avoid crevice corrosion

➔ No filler material required

ORIGINAL LASERFIN® MADE IN GERMANY
Schmöle GmbH

The Company

- More than 160 years of experience
- Outstanding quality
- 3 different finning processes
- 16 finning machines
- Different coiling and bending processes
- R & D partnership for your projects
- Highly skilled craftsmen
- Robust financial status and strong owners

The Product Range

<table>
<thead>
<tr>
<th>Finned tubes and heat exchanger</th>
<th>Tube systems and surface heat exchanger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled finned tubes</td>
<td>Tubes with different dimensions and profiles</td>
</tr>
<tr>
<td>Laser welded finned tubes</td>
<td>Tube register</td>
</tr>
<tr>
<td>Soldered finned tubes</td>
<td>Tube register with connecting elements</td>
</tr>
<tr>
<td>Corrugated tubes</td>
<td>Tube register on carrier</td>
</tr>
<tr>
<td>Finned coil</td>
<td>Module with additional options</td>
</tr>
<tr>
<td>Finned coil with fitting</td>
<td>Module with insulation</td>
</tr>
<tr>
<td>Coaxial heat exchanger</td>
<td>Space solutions</td>
</tr>
<tr>
<td>Heat exchanger up to 150 kW</td>
<td>Special constructions</td>
</tr>
</tbody>
</table>

Certification of Quality Management Systems

Our company is certified by independent bodies to the quality standards ISO 9001:2008 and PED 97/23/EC. Due to consistent quality awareness, we have gained a worldwide reputation as a reliable supplier.
Highest efficiency meets effectiveness.
Because of their high corrosion resistance, Laserfin® tubes can, in particular, be used for such applications which require longevity – environmental protection – aggressive media resistance.
Laserfin® Tubes

Application

Laserfin® tubes - exclusively manufactured by Schmöle GmbH - are suitable for heat exchangers of all kinds for cooling and heating of gases and liquids.

**Power Plants**
- Cooling towers or cooling water recoling plants with dry, dry/wet or wet operation*
- Sodium coolers for Fast Breeder power plants
- Flue gas cooling and heating in flue gas desulfurisation scrubbers (FGD) and nitrogen removing plants (DENOX)

**Chemical and Pharmaceutical Industry**
- Heat exchangers of all kinds for cooling and heating of liquids and gases
- Heat exchangers for nitric acid (HNO₃) plants, e.g. for the fertilizer industry
- Heat exchangers for milk powder production

**Food & Beverage**
- Heat exchangers of all kinds for cooling and heating of liquids and gases
- Heat exchangers for tank heating

**Heat Recovery Plants**
- Flue gas coolers
- Economizers
- Waste Heat Recovery Units (WHRU)

**Heating Industry**
- Primary heat exchangers in gas heating boilers
- Secondary heat exchangers for domestic water heating in condensing boilers

**General Engineering**
- Heat exchangers for gas cooling of industrial furnaces
- Heat exchangers for tank heating
- Oil coolers for vacuum plants, ship plants, pumps etc.
- Heat exchangers for oil preheating

* E.g. cooling towers using river water where due to the prohibition of discharge of heavy metals into river water, a galvanized carbon steel tube cannot be used.
Process Description

Schmöle Laserfin® tubes are manufactured by helically winding strip onto tubes. The heat transfer fins are attached to the surface of tubing in a unique* laser process within a protected atmosphere. This method produces high quality finned tubes in a process which is proprietary to Schmöle and is constantly being improved upon.

Fin and tube material can be selected according to specific design requirements.

The small heat-affected zone in connection with thin weld seams avoid any deformation of the material. This results in a high stability of shape and a great accuracy of size of the welded finned tube.

The use of Laser technique for the welding of finned tubes offers a number of advantages.

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* Patent applied for

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**The figure shows cross sections of Laser-welded finned tubes.**

<table>
<thead>
<tr>
<th></th>
<th>a) Fin</th>
<th>b) Weldseam</th>
<th>c) Tube wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube wall thickness</td>
<td>$s$</td>
<td>1.5 mm</td>
<td></td>
</tr>
<tr>
<td>Fin thickness</td>
<td>$\delta_R$</td>
<td>0.4 mm</td>
<td></td>
</tr>
<tr>
<td>Fin height</td>
<td>$h_R$</td>
<td>12.5 mm</td>
<td></td>
</tr>
<tr>
<td>Fin pitch</td>
<td>$m$</td>
<td>5.0 fins/inch</td>
<td></td>
</tr>
</tbody>
</table>

**The enlarged figure shows in particular the ratio of dimensions between tube wall thickness, fin thickness and heat-affected zone having a depth of 0.2 mm only.**
**Feature**

- 100% welding between fin and tube without using filler material
- Avoidance of gap corrosion
- Longer lifetime
- Easy to clean and sterilize
- Laserfin meets the requirements:
  - food & beverage
  - pharmaceutical industry
- No impurity of the weld seam, as the Laser-welding is carried out under a protective atmosphere
- Optimal heat transfer, reduced material
- Smaller footprint of heat exchangers
- Reduced investment costs
- Different materials for fin and tube
- Matching the challenges of your process
- Reduced downtime
- Reduced O&M costs
- Reduced investment costs
- Uncomplicated bending and coiling of the finned tube
- Tubes can be bended in the finned section
- Quick and easy to process
- Reduced bypass flow
- No material deformation due to a small heat affected zone and thin weld seam, only slight microstructural change in tube and fin
- Tubes are nearly unaffected by the welding process
- Small tube walls are possible
- Reduced footprint and weight of heat exchangers
- Less complications fabrication
- More than 10,000,000 Laserfin® tubes and more than 200,000 Laserfin® finned tube coils produced to date
- Proven design

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**Material combinations**

<table>
<thead>
<tr>
<th>Tube</th>
<th>Strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>Stainless Steel</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>Aluminium</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>Copper</td>
</tr>
<tr>
<td>Carbon Steel</td>
<td>Carbon Steel</td>
</tr>
<tr>
<td>Carbon Steel</td>
<td>Aluminium</td>
</tr>
<tr>
<td>Cu-Ni-Alloy</td>
<td>Copper</td>
</tr>
<tr>
<td>Cu-Ni-Alloy</td>
<td>Aluminium</td>
</tr>
<tr>
<td>Titanium</td>
<td>Titanium</td>
</tr>
<tr>
<td>Titanium</td>
<td>Copper</td>
</tr>
</tbody>
</table>

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**Dimensions**

- Tube outside diameter: 8.0 - 84.0 mm
- Fin outside diameter: 15.0 - 125.0 mm
- Fin pitch: 5 - 13 fin/inch
- Fin height: 5.0 - 17.0 mm
- Fin thickness: 0.4 - 1.0 mm
- Maximum tube lengths: 12.0 m

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**Forms of supply**

- In straight lengths up to 12.0 m
- With unfinned tube ends
- With unfinned intermediate sections
- In bent form, helical coils or meander
### Standard dimensions and materials

Following dimensions and materials (steel and aluminum) are available from stock and can be combined:

<table>
<thead>
<tr>
<th>Tube</th>
<th>Ø8x0.75mm Material 1.4404 (TP 316L)</th>
<th>Ø15x1.2mm Material 1.4404 (TP 316L)</th>
<th>Ø18x1.5mm Material 1.4571 (TP 316Ti)</th>
<th>Ø20x1.2mm Material 1.4404 (TP 316L)</th>
<th>Ø20x1.5mm Material 1.4571 (TP 316Ti)</th>
<th>Ø25x1.5mm Material 1.4301 (TP 304)</th>
<th>Ø30x1.5mm Material 1.4404</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip</td>
<td>5x0.5mm Material 1.4301 / 1.4404 / 1.4521</td>
<td>5x0.6mm Material 1.4404</td>
<td>6x0.5mm Material 1.4404</td>
<td>8x0.5mm Material Al 99.5</td>
<td>9x0.4mm Material 1.4404</td>
<td>9x0.6mm Material 1.4404</td>
<td>10x0.4mm Material 1.4571</td>
</tr>
</tbody>
</table>
|         | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |}

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**Notes:**
- The table represents various dimensions and materials available from stock.
- Standard dimensions and materials can be combined as listed.
- Materials include TP 316L, TP 316Ti, TP 304, TP 316L, and Al 99.5.
Laserfin® tubes can among others be manufactured in following dimensions:

<table>
<thead>
<tr>
<th>Schmöle Code No.</th>
<th>Base tube</th>
<th>Finned tube</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outside Wall thickness</td>
<td>Outside diameter</td>
</tr>
<tr>
<td></td>
<td>[mm]</td>
<td>[mm]</td>
</tr>
<tr>
<td>5 25 15</td>
<td>15.0</td>
<td>1.2</td>
</tr>
<tr>
<td>7 25 15</td>
<td>15.0</td>
<td>1.2</td>
</tr>
<tr>
<td>9 25 15</td>
<td>15.0</td>
<td>1.2</td>
</tr>
<tr>
<td>5 40 20</td>
<td>20.0</td>
<td>1.5</td>
</tr>
<tr>
<td>7 40 20</td>
<td>20.0</td>
<td>1.5</td>
</tr>
<tr>
<td>9 40 20</td>
<td>20.0</td>
<td>1.5</td>
</tr>
<tr>
<td>11 40 20</td>
<td>20.0</td>
<td>1.5</td>
</tr>
<tr>
<td>5 45 25</td>
<td>25.0</td>
<td>1.5</td>
</tr>
<tr>
<td>7 45 25</td>
<td>25.0</td>
<td>1.5</td>
</tr>
<tr>
<td>9 45 25</td>
<td>25.0</td>
<td>1.5</td>
</tr>
<tr>
<td>11 45 25</td>
<td>25.0</td>
<td>1.5</td>
</tr>
<tr>
<td>5 50 25</td>
<td>25.0</td>
<td>1.5</td>
</tr>
<tr>
<td>7 50 25</td>
<td>25.0</td>
<td>1.5</td>
</tr>
<tr>
<td>9 50 25*</td>
<td>25.0</td>
<td>1.5</td>
</tr>
<tr>
<td>11 50 25</td>
<td>25.0</td>
<td>1.5</td>
</tr>
<tr>
<td>5 55 30</td>
<td>30.0</td>
<td>1.8</td>
</tr>
<tr>
<td>7 55 30</td>
<td>30.0</td>
<td>1.8</td>
</tr>
<tr>
<td>9 55 30</td>
<td>30.0</td>
<td>1.8</td>
</tr>
<tr>
<td>11 55 30</td>
<td>30.0</td>
<td>1.8</td>
</tr>
</tbody>
</table>

* The possibility of finning with certain strip materials has to be verified in the individual case.

** = 7.9 kg/dm³

** Tube codification

<table>
<thead>
<tr>
<th>Schmöle-Code No.</th>
<th>5</th>
<th>40</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fin pitch 5 fins / inch</td>
<td>Fin outside diameter 40 mm</td>
<td>Tube outside diameter 20 mm</td>
</tr>
</tbody>
</table>

** Tolerances**

- Length l₁: < 2 m, 2-8 m, > 8 m
  - Tolerance: + 2 mm, +1 %, < 5 mm, +0.8 %
Heat transfer

The heat transfer function $\frac{Nu}{Pr^{0.333}}$, referred to the outer heat transfer coefficient $\alpha_a$ for forced gas flow through Laserfin® finned tube bundles with staggered tube arrangement, can be determined according to graph 1 and equation 4.

The curve in graph 1 corresponds to the following equation for Laserfin® tubes having a tube outside diameter of 20 mm, a fin outside diameter of 40 mm and a fin thickness of 0.4 mm:

$$\frac{Nu}{Pr^{0.333}} = 1.013 \cdot Re^{0.382}$$  \hspace{1cm} (1)

The outer heat transfer coefficient $\alpha_a$ for air as function of the Reynolds number can be taken directly from graph 2.

The flow velocity $v_e$ is referred to the smallest flow cross section $f_e$ in the Laserfin® finned tube bundle.

The influence of the fin efficiency $\eta_R$ on the outer heat transfer coefficient $\alpha_a$ is already considered in the graphs 1 and 2 and in the equations 1 to 6.

Radiation coefficient

The influence of the heat radiation on the heat transfer has not been taken into account in the outer heat transfer coefficient $\alpha_a$. As shown in graph 3 the heat radiation is insignificant for gas temperatures below 100°C, however it is not negligible at bigger temperature differences. In this case the radiation coefficient $\alpha_s$ may be added to the outer heat transfer coefficient $\alpha_a$.

$$\Delta p = \zeta \cdot \frac{\rho}{2} \cdot v_e^2 \cdot n$$  \hspace{1cm} [Pa]

The resistance coefficient $\zeta$, may be taken from graph 4.

Pressure drop

The pressure $\Delta p$ for cross flow of gases through Laserfin® finned tube bundles with staggered tube arrangement is calculated according to the following equation:

$$\Delta p = \zeta \cdot \frac{\rho}{2} \cdot v_e^2 \cdot n$$  \hspace{1cm} [Pa]

Fin efficiency

Graph 5 shows the fin efficiency $\eta$ of stainless steel being a function of the outer heat transfer coefficient $\alpha_a$ with the fin thickness $\delta_R$ as parameter.

From graph 5 it follows that for an operating point $\alpha_a = 60$ W/(m²K) halving the fin thickness from 0.8 to 0.4 mm reduces the fin efficiency $\eta_R$ by only 17%.

The utilization of the material savings possible with Laserfin® Finned Tubes, e.g. using a fin thickness of 0.4 mm, will result in a considerably more favourable price/performance ratio compared with traditionally welded finned tubes having fin thicknesses of 0.8 mm or more.

Nomenclature

- $A_e$ [m²]: External surface
- $A_i$ [m²]: Internal surface
- $A_{qi}$ [m²]: Inside sectional area
- $a$ [m²/s]: Thermal diffusivity $a = \frac{\lambda}{(c_p \cdot \rho)}$
- $c_p$ [kJ/(kgK)]: Specific heat (Constant pressure)
- $d_1$ [mm]: Tube outside diameter
- $f_e$ [cm²]: Smallest flow cross section
- $h_R$ [mm]: Fin height
- $m$ [fins/inch; mm]: Fin pitch
- $n$ [-]: Number of tube rows
- $s$ [mm]: Tube wall thickness
- $t$ [s]: Point of time of the temperature march
- $v_e$ [m/s]: Flow velocity in the smallest cross section
- $\alpha_a$ [W/(m²K)]: Outer heat transfer coefficient
- $\alpha_s$ [W/(m²K)]: Heat transfer coefficient (Radiation)
- $\delta_R$ [mm]: Fin thickness
- $\Delta p$ [Pa]: Pressure drop
- $\zeta$ [-]: Resistance coefficient
- $\eta$ [-]: Fin efficiency
- $\theta_g$ [°C]: Gas temperature
- $\theta_r$ [°C]: Tube temperature
- $\theta_w$ [°C]: Water temperature
- $\lambda$ [W/(mK)]: Thermal conductivity
- $\nu$ [m²/s]: Kinematic viscosity
- $\rho$ [kg/m³]: Density
The curves correspond to the following equations:

➔ Fin thickness 0.8 mm
\[ \alpha_a = 1.624 \cdot \text{Re}^{0.363} \quad [\text{W/(m}^2\text{K})] \quad (2) \]

➔ Fin thickness 0.4 mm
\[ \alpha_a = 1.374 \cdot \text{Re}^{0.363} \quad [\text{W/(m}^2\text{K})] \quad (3) \]

Definitions:

\[ \text{Nu} = \frac{\alpha_a \cdot d_1}{\lambda} \quad \text{Nußelt number} \quad (4) \]

\[ \text{Pr} = \frac{\nu}{\alpha} \quad \text{Prandlt number} \quad (5) \]

\[ \text{Re} = \frac{v \cdot d_1}{\nu} \quad \text{Reynolds number} \quad (6) \]
Presentation of the heat flow by means of finite element analysis

The 100 % weld integrity between tube and fin strip results in a considerably better heat flow for Laserfin® Finned Tubes compared with traditionally welded finned tubes. In order to make, in this respect, both a qualitative and a quantitative statement, a comparative study by means of finite element analysis had to be conducted.

The heat flow for finned tubes having an air gap of 0.05 mm between tube and fin root (weld integrity 0 %) has been compared with the heat flow of crevice free welded Laserfin® tubes (weld integrity 100 %).

The march of temperature, starting with 250 °C at the fin tip is shown as a comparison of graphs 6 and 7 (weld integrity 0%) with 8 and 9 (weld integrity 100 %).

The following data has been used as a basis for the finite element analysis:

نظرًا للملاءمية بين الفولاذ والوسط الداخلي، فإن الهواء بين الفولاذ والفاصل فيه أفضل نتائج في نظام الأقل للحالة الحرارية. وعلى هذا النحو، تبين النتائج المقارنة بين نظام الأقل للحالة الحرارية والفاصل فيه أقل له دقة مقارنة بالفاصل فيه أقل له دقة. وتشير النتائج إلى أن استخدام Laserfin® لاسماً بالكامل قد يؤدي إلى توفير مواد وآلات أقل حجمًا وتكلفة أقل.

Graph 10 shows the ideal march of temperature in a Laserfin® tubes compared with an unwelded finned tube.

The considerably reduced material thickness of fin and tube wall as well as the 100 % weld integrity made possible by the Laser-welding procedure result in substantial material and weight savings when using Laserfin® tubes compared with traditionally welded finned tubes.

These material savings do not only lead to reduced heat exchanger costs but also to further advantages as a result of smaller and cheaper total installations.

The following data has been used as a basis for the finite element analysis:

→ Inner medium: water of turbulent flow

→ Tube outside diameter $d_1 = 25.0$ mm

→ Tube wall thickness $s = 1.5$ mm

→ Fin height $h_R = 10.0$ mm

→ Fin thickness $\delta_R = 0.4$ mm

→ Starting temperature of the inner medium $\vartheta = 20.0$ °C

→ Point of time of the temperature march $t = 57.3$ s after start of energy input
Graph 6:
Heat flow through finned tubes:
Weld integrity 0%

Graph 8:
Heat flow through Laserfin® tubes:
Weld integrity 100%

Graph 7:
Heat flow through finned tubes:
Weld integrity 0%

Graph 9:
Heat flow through Laserfin® tubes:
Weld integrity 100%

Graph 10:
March of temperature in finned tubes:
Inspections and Testing

Schmöle executes inspections and testings according to:

➔ ASTM
➔ DIN EN
➔ ASME

Certification

A TÜV Welding certification acc. PED 97/23/EC / AD 2000 - HP 2/1 / DIN EN ISO 15614-11 can be carried out.

This product description is based on our own research and the relevant literature which was applied with the necessary care.
Nevertheless, we strongly recommend testing the suitability of the product under your actual operating conditions. This refers particularly to the suitability of the material chosen for the intended application. The relevant standards and regulations for the operation of heat exchangers have to be respect.
The product is subject to modifications without notice, particularly if they are made for reasons of quality improvement increase in efficiency or simplification of production.

Our sales and technical departments are available for any further advice you may need.

Schmöle GmbH
The Company

Schmöle GmbH is considered to be one of the leading manufacturers in the fields of finned tubes and heat exchangers.

Our clients expect both our involvement in solving their application-specific problems as well as a constantly being improved products and processes.

With 160 years of experience and a continued commitment to intensive research and development and modern manufacturing procedures, supported by a certified quality system, we shall continue to meet these challenges.

Schmöle GmbH has two product divisions:

**Product Division 1:** Finned tubes
   Heat exchangers

**Product Division 2:** Ceiling cooling batteries
   Surface heat exchanger

Quality Management

Manufacturing at Schmöle is accompanied by tests laid down in a Quality Assurance plan which is established for the individual product, containing all operations and examinations.

Schmöle, since 1993, is known for a certified Quality Management System according to DIN EN ISO 9001 as well as approval according to PED 97/23/EC.

By consistent development of the Quality Management System, Schmöle is familiar to its customers as a reliable business partners and manufacturer of high quality products.
We are looking forward to advise you!

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