5mm Copper tube – Usage in T3 Condition
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Zamil Air Conditioners is part of Zamil Industrial. Zamil Industrial has 4 verticals: Air conditioners, Steel, Insulation and Power & Telecom Solutions.

### Company Facts
- Zamil Industrial currently employs more than 15,000 people in 55 countries.
- The company derives about 25% of its revenues from outside Saudi Arabia.
- Sells products to over 90 countries.

### 2017 Financials

<table>
<thead>
<tr>
<th></th>
<th>US$</th>
<th>SAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover</td>
<td>1.17 billion</td>
<td>4.4 billion</td>
</tr>
<tr>
<td>Gross Profits</td>
<td>236.7 million</td>
<td>887.6 million</td>
</tr>
<tr>
<td>Net Profit</td>
<td>28 million</td>
<td>105 million</td>
</tr>
<tr>
<td>Shareholders’ Equity</td>
<td>0.5 billion</td>
<td>1.87 billion</td>
</tr>
<tr>
<td>Current Paid Up Capital</td>
<td>160 million</td>
<td>600 million</td>
</tr>
</tbody>
</table>

1 USD = SAR 3.75
• Zamil Air Conditioners is one of the largest manufacturer and market leader in Saudi Arabia for commercial, industrial and residential air conditioning products with a manufacturing capacity of 1Mn+ airconditioners.

• **Zamil product range covers the complete range of air conditioners from Windows to Screw Chillers (Capacity : 1tr – 580 Tr) & Centrifugal chiller up to 5000 Tr**

• We offer complete range of building automation controls, security, fire safety and corrosion resistance coating systems.

• **Zamil Projects** undertakes HVAC and electromechanical projects

• Joint ventures and associations with leading global players like GE, Mitsubishi etc

• Ikhtebar – an independent laboratory accredited by SASO was designed, commissioned and calibrated by Intertek, USA
## Climate condition in Saudi Arabia

<table>
<thead>
<tr>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Zone</th>
<th>Elevation</th>
<th>DB 1%</th>
<th>DB max</th>
<th>CDD18.3</th>
<th>CDD10</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL-AHSA</td>
<td>25.30N</td>
<td>49.48E</td>
<td>1</td>
<td>178</td>
<td>46</td>
<td>49.8</td>
<td>3573</td>
<td>6389</td>
</tr>
<tr>
<td>AL-MADINAH</td>
<td>24.55N</td>
<td>39.70E</td>
<td>1</td>
<td>636</td>
<td>44.2</td>
<td>47.7</td>
<td>3757</td>
<td>6715</td>
</tr>
<tr>
<td>DHAHRAN</td>
<td>26.27N</td>
<td>50.17E</td>
<td>1</td>
<td>17</td>
<td>44</td>
<td>49.3</td>
<td>3398</td>
<td>6258</td>
</tr>
<tr>
<td>GIZAN</td>
<td>16.88N</td>
<td>42.58E</td>
<td>1</td>
<td>7</td>
<td>37.9</td>
<td>42.3</td>
<td>4409</td>
<td>7451</td>
</tr>
<tr>
<td>MAKKAH</td>
<td>21.43N</td>
<td>39.77E</td>
<td>1</td>
<td>240</td>
<td>44.1</td>
<td>49.2</td>
<td>4758</td>
<td>7800</td>
</tr>
<tr>
<td>RIYADH OBS. (O.A.P.)</td>
<td>24.70N</td>
<td>46.73E</td>
<td>1</td>
<td>620</td>
<td>43.9</td>
<td>47.2</td>
<td>3342</td>
<td>6107</td>
</tr>
</tbody>
</table>

Data from SEEC Presentation

- Even Higher temperatures in remote areas
- Seaside areas have high temperature along with High humidity
- Sand storms
- Corrosive atmosphere in areas Petrochemical industries
Zamil’s Design philosophy for T3 Climate condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Indoor temperature DBT / WBT ( deg C )</th>
<th>Outdoor temperature DBT / WBT ( deg C )</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>27 / 19</td>
<td>35 / 24</td>
</tr>
<tr>
<td>T3</td>
<td>29 / 19</td>
<td>46 / 24</td>
</tr>
<tr>
<td>SASO Max</td>
<td>32 / 23</td>
<td>52 / 31</td>
</tr>
</tbody>
</table>

- Reliability Test: Any Major design change is subjected to a reliability test of 200 days at 60 Deg C
- Field trial for new technologies
- Burst pressure: compliance as per UL 484 / UL 1995
Why we explored & invested in 5mm?

- In early 2014, there were fillers that R22 may be banned in KSA. R410a with higher operating pressure required a Copper tube with higher burst pressure (Burst pressure requirement for Cu Tube for T3 was 2700 psi+)
- Air conditioners cost were under pressure and market was not very receptive to Microchannel Heat exchangers
- Saudi had already upgraded the MEPS twice.
  - With Window AC chassis limitation, achieving higher level of T3 performance with same coil size was becoming a challenge.
  - With Higher MEPS in splits, the unit size and weight were an area of concern.
Why we explored & invested in 5mm?

• Cost advantage : Copper
  • Cu Weight reduction : upto 25 % for equivalent performance
    • Gm / meter :
      • 5 mm : BWT : 0.22 mm, 34 g/M, BP : 2900 psig
      • 7mm : BWT : 0.25 mm, 52.5 g/M, BP : 2500 psig
      • 5/16” : BWT : 0.27mm , 68 g/M, BP : 2200 psig
    • Actual Cost reduction is lesser due to high fabrication cost of 5mm.
Why we explored & invested in 5mm?

- Cost & Design Advantage: Aluminium
  - Fin pitch can be reduced to increase the primary surface area
    - Eg. Pitch of 3/8” & 5/16” tube is 25.4mm and 7mm is 21mm. 5mm can be 18.4 mm and even lower. Hence, no. of tubes per coil can be increased

- Window AC: Small improvement in airflow due to reduced tube dia and fin width

[Diagram showing fin pitches and dimensions for 5mm, 7mm, 5/16”, and 3/8” fins]
Why we explored & invested in 5mm?

- Cost advantage
  - Aluminium weight reduction if one reduces the fin width
  - Refrigerant quantity reduction: 20 – 30% per unit
  - Reduced refrigerant quantity gives advantage while using Flammable refrigerants where there are quantity constraints.
  - Weight reduction: Outdoor unit weight reduction by 2-3 Kg.
  - Discharge pressure at T3 and SASO Max reduces by 3 to 5%
  - To comply to UL 484 & UL 1995, Burst pressure requirement for Window AC with R410a refrigerant goes above 2500 psig. 5mm is the only cost effective option
Why we explored & invested in 5mm?

- **Productivity improvement:**
  
  Fin Press output gets increased

<table>
<thead>
<tr>
<th>Fin Width for AL and MHG coils</th>
<th><strong>30.625&quot;</strong></th>
<th><strong>777.875 MM</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Machine capacity 60 Tons</th>
<th>Fin Length = 404.80 mm &amp; speed 220 SPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hole Dia</td>
<td>5/16&quot; (7.938 mm)</td>
</tr>
<tr>
<td># of holes in Fin length</td>
<td>16</td>
</tr>
<tr>
<td>Fin width</td>
<td>15.875</td>
</tr>
<tr>
<td>Pitch</td>
<td>1&quot; x 5/8'</td>
</tr>
<tr>
<td>Actual # of rows</td>
<td>48</td>
</tr>
<tr>
<td>Increase in capacity WRT 5/16&quot; by # of rows</td>
<td>25%</td>
</tr>
<tr>
<td>Drop in Capacity WRT 5/16&quot; by increase in holes</td>
<td>19%</td>
</tr>
</tbody>
</table>
Zamil : Our journey so far…

- Design validation :
  - System balancing
  - 200 days Reliability & Field trial
- Production :
  - 2016 – 2018 : 350K+ Window Acs manufactured
  - 2017-18 : 20K+ Splits manufactured

Usage across
- All compressor type : Reciprocating, Rotary and Scroll
- Refrigerant type : R22 and R410a
- Markets : Saudi Arabia, UAE, Oman, Qatar and Bahrain

Note : In 2016, we also ordered one more fin press and fin die
1. Fin Press*
2. Fin Die *
3. Expander
4. Hair Pin Bender
5. Return Bender
6. Ring Loading machine

6 months later, we purchased one more Fin press and Fin die
Challenges

• Copper tube:
  • Supply Chain: Limited suppliers with limited capacity available.
  • Fabrication cost of 5mm is much higher than 7mm. Due to productivity issues, suppliers prefer to produce more of non-5mm copper tubes. (More Kg output/hr for higher dia tubes)

• Design
  • Pressure drop of 5mm is higher hence need to redesign the condenser circuit

• Production:
  • Handling of tubes is critical
  • Lacing of coils is a bit slower. Due to the smaller dia of tube, it tends to warp while pushing into the fins.
The principal activity of the company is the production of tissue paper.