TwisTorr molecular drag pumping technology

A new Technology for high performance Turbomolecular-Drag Pumps

Vacuum Product Division

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September 2010
TwisTorr molecular drag pumping technology

Outline

- Molecular drag pumps
- TwisTorr technology
- Today
- Potential
Molecular drag pumps

Introduction

Since over 20 years axial flow TMP’s often combined with down-stream (same shaft) MDP’s TMPDP resulting pumps improve

• Forepressure tolerance from 10 to 1000 pascal range
• Compression ratio for light gases
• Requirements for backing pumps (smaller with lower power consumption)
MacroTorr® (Gaede pump re-designed)

- Varian TMDP design
- Molecular drag stages axially in series
Molecular drag pumps
Holweck (2/2)

Holweck molecular drag TMDP design

- courtesy of Pfeiffer Vacuum
- with stages in series radially nested
Molecular drag pumps
Siegbahn (2/2)

Invention
• Manne Siegbahn disclosed the spiral vacuum pump invention in GB patent No. 332,879 in 1929

Working principle
• Molecular momentum transfer ("drag", "friction") pump, made of a smooth disk-shaped rotor with spiral grooves machined on a plane-geometry stator
  - Same principle as Gaede and Howeck.
  - Different geometry
TwisTorr technology
Introduction (1/2)

We have considered Siegbahn MTD since over ten years

• It perfectly fits our MacroTorr® design
• With much higher inlet conductance (potential pumping speed)

Result of tests consistently very frustrating

• Low performance
• High power consumption
TwisTorr technology
Introduction (2/2)

During the last five years
Silvio Giors with John Helmer
Performed theoretical and experimental studies on Spiral MDP

It became evident that tapered channels generate successive compressions and re-expansions

• With waste of power
• Even worse when putting stages in series
TwisTorr technology
Constant S channels (1/2)

Constant cross section channels not enough
• At lower radius speed and S are lower

Constant local pumping speed
design required to prevent
• Reverse pressure gradients
• High power dissipation when stages are used in series
TwisTorr technology
Spiral MDP design (1/2)

Constant S Channel Invention (*)

- Stator spiral channel cross section area $\sigma$ is increased from outer to inner radius to compensate rotor velocity reduction at smaller radius

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Spiral MDP design (2/2)
Rotor / Stator arrangement

• Each stator is positioned between two smooth disks
• Each disk is exploited twice in series (both surfaces)
• Fits perfectly on standard Macrotorr® design rotors

Stators with spiral grooves on BOTH sides.
• Centripetal AND Centrifugal combined in series improve compression
TwisTorr technology

Experimental tests (3/6)

Compression Ratio $k$

- TwisTorr increase MacroTorr® N2 compression by a factor up to 500
- TwisTorr increase MacroTorr® He and H2 compression by a factor 10+. 
TwisTorr technology
Experimental tests (6/6)

Pumping Speed

- Pumping speed up to 45 l/s is possible with an “open” 90° spiral design
- Results in agreement with channel calculations
TwisTorr technology
Feasibility test in commercial TMDP (1/3)

700l/s commercial TMDP

• 2 Macrotorr® stages replaced with 2 TwisTorr stages
TwisTorr technology
Feasibility test in commercial TMDP (2/3)

Tested TMDP’s

<table>
<thead>
<tr>
<th></th>
<th>Pump A</th>
<th>Pump B</th>
<th>Pump C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotational frequency</td>
<td>820 Hz</td>
<td>830 Hz</td>
<td>820 Hz</td>
</tr>
<tr>
<td>Rotor outer diameter</td>
<td>159 mm</td>
<td>161 mm</td>
<td>159 mm</td>
</tr>
<tr>
<td>Number of turbo stages</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Drag stage technology</td>
<td>MacroTorr®</td>
<td>Holweck</td>
<td>SMDP</td>
</tr>
<tr>
<td>Number of drag stages</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Drag section axial room</td>
<td>34 mm</td>
<td>60 mm</td>
<td>34 mm</td>
</tr>
<tr>
<td>Rotor height</td>
<td>100 mm</td>
<td>145 mm</td>
<td>100 mm</td>
</tr>
</tbody>
</table>
TwisTorr technology
Feasibility test in commercial TMDP (3/3)

Results

- TMDP equipped with TwisTorr stages largely outperform MacroTorr TMDP
- TMDP equipped with TwisTorr stages outperform longer Holweck TMDP
TwisTorr technology
Performance (1/2)

The new Spiral molecular drag pump evolved from Siegbahn concept

- High compression ratio, including light gases
- High pumping speed
- High differential pressure

Is a very compact stage

multiple stages in series are easily integrated in TMDP
TwisTorr technology
Performance (2/2)

Compactness

• Shorter rotor
  - Smaller and lighter TMDP
  - More stable rotor to spin faster

• Same rotor
  - More pumping stages
  - High compression ratio
Today
New pumps

Based on TwistTorr technology
two TMDP’s have been designed and are being introduced

• Turbo-V750 TwistTorr platform
The technology has been used to achieve outstanding performance in competitive dimensions

• Turbo-V2300 TwistTorr platform
The technology has been used to achieve outstanding dimensions with competitive specifications
Today
New Turbo-V 750 and 850 TwisTorr (1/3)

Drag section:
New TwisTorr technology
N. 2½ TwisTorr stages
(Patent Pending)

Corrosion resistant cooling loop:
mandrel expanded SST pipe (patent pending)

Suspension:
• Inverted fitting (patent pending)

IP54 on-board 48 Vdc integrated electronics:
• 48 V electrical motor
• Field Oriented Control of motor
• Rotational speed: 825 Hz
Today
New Turbo-V 750 and 850 TwisTorr (2/3)

Compression Ratio’s

![Graph showing compression ratios for different gases (Nitrogen, Argon, Helium, Hydrogen) as a function of foreline pressure.](image-url)
### Today
#### New Turbo-V 750 and 850 TwisTorr (3/3)

<table>
<thead>
<tr>
<th></th>
<th>Varian TV551 DN160</th>
<th>Varian New TV750 TwisTorr DN160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed x N2</td>
<td>550</td>
<td>700</td>
</tr>
<tr>
<td>Speed x Ar</td>
<td></td>
<td>680</td>
</tr>
<tr>
<td>Speed x He</td>
<td>600</td>
<td>680</td>
</tr>
<tr>
<td>Speed x H2</td>
<td>510</td>
<td>580</td>
</tr>
<tr>
<td>K ratio N2</td>
<td>$1 \times 10^9$</td>
<td>$&gt;10^{11}$</td>
</tr>
<tr>
<td>K ratio Ar</td>
<td></td>
<td>$&gt;10^{11}$</td>
</tr>
<tr>
<td>K ratio He</td>
<td>$1 \times 10^7$</td>
<td>$2 \times 10^8$</td>
</tr>
<tr>
<td>K ratio H2</td>
<td>$1 \times 10^6$</td>
<td>$2.5 \times 10^6$</td>
</tr>
</tbody>
</table>

H = 255 mm (with integrated electronics) (= TV 551 pump only, without Nav CNT)
Today
New Turbo-V 2300 TwisTorr (1/2)

H = 276 mm
109 mm shorter than TV 3KT pump
## Today

### New Turbo-V 2300 TwistTorr (2/2)

<table>
<thead>
<tr>
<th></th>
<th>Varian TV3KT (obsolete)</th>
<th>Varian New TV2300 TwistTorr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed x N₂</td>
<td>2050</td>
<td>2050</td>
</tr>
<tr>
<td>Speed x He</td>
<td>2400</td>
<td>1800</td>
</tr>
<tr>
<td>Speed x H₂</td>
<td>2300</td>
<td>1500</td>
</tr>
<tr>
<td>K ratio N₂</td>
<td>1x10⁸</td>
<td>8x10⁸</td>
</tr>
<tr>
<td>K ratio He</td>
<td>1.2x10⁵</td>
<td>8x10⁵</td>
</tr>
<tr>
<td>K ratio H₂</td>
<td>1.5x10⁴</td>
<td>4x10⁴</td>
</tr>
<tr>
<td>Max N₂ Foreline</td>
<td>1 mbar</td>
<td>4 mbar</td>
</tr>
<tr>
<td>Run Up Time</td>
<td>&lt;9 min.</td>
<td>&lt;6 min.</td>
</tr>
</tbody>
</table>
TwisTorr technology allows to build TMDP’s virtually to “any” specification after numerical modelling

- Pumping Speed
- Throughput
- Compression Ratio
- Foreline tolerance
Potential
Near future (2/2)

Overcome the traditional limitation in TMDP’s

• Compression ratio for light gases

Flexible design

• Interchangeable stators
• One rotor

For different applications

• Different requirements
• Different specifications