Energy Saving: Pneumatic Systems

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Energy Saving in Pneumatic Systems

Ecologically Responsible Pneumatic Systems
Basic Pneumatic System – Start to Finish
Energy Saving Opportunities

\[
\text{Annual Cost} = \frac{BHP \times 0.746 \times \text{Hours of Operation} \times \text{Cost per kWh}}{\text{Motor Efficiency}}
\]
Pneumatic System Savings

The top target areas of energy savings in pneumatic systems that need to be “Analyzed and Improved” are:

1. Leaks
2. Air Blow
3. Excessive Pressure
4. Idle Mode Consumption
5. Design Issues
Ecologically Conscious Pneumatic Systems

Leaks

Solutions That Save
Leaks are the thieves in any compressed air system, causing the compressor to operate even during machine stoppage.

“Hotel Load”
Leak Detection

How do we find leaks?

Flow Meters tell us that leaks have developed. Review any flow data that you can get your hands on!

Parabolic Dish and Ultrasonic Leak Detector
Estimating Leakage Load

The compressor may be operating during periods of non-production due to leakage & other non-productive applications.
# Cost of Air Leaks & Potential Savings

## DISCHARGE THROUGH AN ORIFICE

<table>
<thead>
<tr>
<th>DIAMETER OF ORIFICE, INCHES</th>
<th>1/16</th>
<th>1/8</th>
<th>1/4</th>
<th>1/2</th>
<th>3/4</th>
<th>1 INCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESSURE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70 PSI</td>
<td>4.79</td>
<td>19.2</td>
<td>76.7</td>
<td>307</td>
<td>690</td>
<td>1227</td>
</tr>
<tr>
<td>Annual Cost To Operate</td>
<td>$590</td>
<td>$2,269</td>
<td>$9,062</td>
<td>$36,281</td>
<td>$81,545</td>
<td>$145,009</td>
</tr>
<tr>
<td>100 PSI</td>
<td>6.49</td>
<td>26</td>
<td>104</td>
<td>415</td>
<td>934</td>
<td>1661</td>
</tr>
<tr>
<td>Annual Cost To Operate</td>
<td>$765</td>
<td>$3,072</td>
<td>$12,290</td>
<td>$49,045</td>
<td>$110,382</td>
<td>$196,300</td>
</tr>
<tr>
<td>125 PSI</td>
<td>7.90</td>
<td>31.6</td>
<td>126</td>
<td>506</td>
<td>1138</td>
<td>2023</td>
</tr>
<tr>
<td>Annual Cost of Leak</td>
<td>$931</td>
<td>$3,734</td>
<td>$14,890</td>
<td>$59,800</td>
<td>$134,491</td>
<td>$239,082</td>
</tr>
</tbody>
</table>
Where to look for leakage?

Most Common Places for Leaks

- Connections & Fittings
- Hoses and tubing
- Air Preparation components
- Cylinder rod seals
- Other components
Case Study – Examples of Leaks
Case Study – Examples of Leaks
Case Study – Examples of Leaks
Case Study – Examples of Leaks
Case Study – Examples of Leaks
Case Study – Examples of Leaks

![Image of a repair tag indicating a cylinder leak on a machine or equipment.](image-url)
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Air Blow Solutions That Save
Air Blow - Savings

• Many plants use air blow to:
  – Move, cool, or guide product
  – Dry and clean product or conveyor belts
  – Cool electrical cabinets
  – Mix liquids
Air Blow - Savings

• To improve the efficiency of the current state of air blow:
  – Remove air blow unnecessary to production
  – Employ alternate technology if at all possible
    • If it can be done mechanically, it should be done mechanically
    • If air is the solution, use centrifugal blowers as an alternative to compressed air

• What to look for:
  - Air delivery mechanism too far from the point of impact
  - Inefficient air delivery mechanism
  - Pressure higher than necessary
  - Pressure subject to unauthorized increase
  - Violations of OSHA standards regarding orifice pressure
  - Supply tubing too long or too small or both
  - No provision for automatic shut-off
Air Blow Goal

Reduce pressure loss and air consumption while maintaining work surface impact.

With Nozzle

100 PSI

100 PSI

High-efficiency nozzle

Pressure Loss is minimal

Without Nozzle

100 PSI

60 PSI

20 PSI

Pressure loss is great

Or employ an alternate technology!
Air Blow - Savings

- No Regulator
- No Nozzle
- Too Far
- Misdirected

Air Consumption = 7 SCFM or $440 per year
Air Blow - Savings

- No Regulator
- High Pressure

Air Consumption = 13 SCFM or $818 per year
Air Blow - Savings

- Air Bars
- High Consumption
- High Pressure
- Necessary?

Air Consumption = 25 SCFM or $1,572 per year
Air Blow - Savings

- 45 PSIG
- Continuous
- Ineffective?

Air Consumption = 22.5 SCFM or $1,415 per year

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (SCFM)</td>
<td>21.90</td>
<td>22.50</td>
<td>23.00</td>
</tr>
<tr>
<td>Pressure (psi)</td>
<td>43.30</td>
<td>44.61</td>
<td>45.20</td>
</tr>
</tbody>
</table>
Case Study – Other Findings

- No Regulator
- No Nozzle
- 55 SCFM

Air Consumption = 55 SCFM or $3,460 per year

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (SCFM)</td>
<td>54.50</td>
<td>54.81</td>
<td>55.30</td>
</tr>
<tr>
<td>Pressure (psi)</td>
<td>1.51</td>
<td>2.81</td>
<td>3.47</td>
</tr>
</tbody>
</table>
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Excessive Pressure Solutions That Save
Excessive Pressure

- Compensating for undersized piping system
- Compensating for dirty filters
- Increasing pressure to compensate for wear
- Increasing pressure “just to be sure”
- Increasing pressure for under-sized actuators

Note: Reducing pressure at every machine will reduce flow, which will reduce pressure drop, and may eliminate the need for expensive plumbing upgrades.
Causes of Excessive Pressure

Things to look for:

– Broken, unreadable or missing pressure gauges
– FRL components in poor repair
– Inappropriate settings
Excessive Pressure

• Broken or unreadable gauges
  – Unable to confirm correct setting
  – Operator may adjust pressure upwards

“just to be sure”
Excessive Pressure

- Clogged filter elements
  - More pressure is required to flow through clogged filter elements
- Leaking FRL components
Excessive Pressure

• Required pressure is labeled for many applications
  – Pressure gauges show higher setting than label
• Higher pressure consumes more air
Machines operating at pressure higher than necessary cause plant pressure to be elevated.

Difference in average flow = 18.74 SCFM = $3,152 annually!
Idle-Mode Savings

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Solutions That Save
Idle-Mode Savings

Examples

– Look for machines pressurized when not in use
– Look for air-blow operating unnecessarily
– Look for equipment running when no product is present
– Consider how machines pause during production (Vacuum?)
Idle-Mode Savings

- Idle-Mode Savings is an issue in every facility.
- If equipment is not running, then compressed air should not be supplied.
- Every machine needs an automated shut-off!
Design Issues

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Solutions That Save
Design Issues

Primary Considerations

– Oversized Cylinders
– Unnecessary use of Double Acting
– Lost Exhaust
– Excessive tubing length
– Pressure Control
Cylinder Sizing

55 lbs. / Sliding 16” / 1 second

Pneumatic Model Selection Program Ver4.0-System Model Selection-Standard cylinder

Title: Registrant: Date: 2013-07-11

Results of model selection

<table>
<thead>
<tr>
<th>Cylinder</th>
<th>Part number</th>
<th>Quan.</th>
<th>Fitting 1</th>
<th>Quan.</th>
<th>Fitting 2</th>
<th>Quan.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Com m ent:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Condensation Calculation Result

Absorption energy: 3.62 J
Allowable energy: 3.40 J
Judgment result: Out of the allowable range
Out of the allowable range: Review the opening conditions and the load conditions. Or use shock absorber.

Condensation Calculation Result

Condensation probability: 0.0 %
Condensation probability is very small

Input values

<table>
<thead>
<tr>
<th>Stroke: 400 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full stroke time: 1.00 s</td>
</tr>
<tr>
<td>Start up time: 0.07 s</td>
</tr>
<tr>
<td>90% Force time: 1.36 s</td>
</tr>
<tr>
<td>Max. velocity: 538 mm/s</td>
</tr>
<tr>
<td>Stroke: 0 mm</td>
</tr>
<tr>
<td>Opening: 100 %</td>
</tr>
<tr>
<td>Speed controller:</td>
</tr>
<tr>
<td>Position (R): On cylinder</td>
</tr>
<tr>
<td>Position (L): On cylinder</td>
</tr>
<tr>
<td>Pressure: 0.50 MPa</td>
</tr>
<tr>
<td>Air consumption: 5.015 (m³/min)(ANR)</td>
</tr>
<tr>
<td>Required airflow: 293.5 (m³/min)(ANR)</td>
</tr>
</tbody>
</table>

Cushion Calculation Result

Absorption energy: 7.77 J
Allowable energy: 0.91 J
Judgment result: Out of the allowable range
Out of the allowable range: Review the opening conditions and the load conditions. Or use shock absorber.

Input values

<table>
<thead>
<tr>
<th>Stroke: 400 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full stroke time: 1.00 s</td>
</tr>
<tr>
<td>Start up time: 0.06 s</td>
</tr>
<tr>
<td>90% Force time: 1.02 s</td>
</tr>
<tr>
<td>Max. velocity: 782 mm/s</td>
</tr>
<tr>
<td>Stroke: 0 mm</td>
</tr>
<tr>
<td>Opening: 100 %</td>
</tr>
<tr>
<td>Speed controller:</td>
</tr>
<tr>
<td>Position (R): On cylinder</td>
</tr>
<tr>
<td>Position (L): On cylinder</td>
</tr>
<tr>
<td>Pressure: 0.50 MPa</td>
</tr>
<tr>
<td>Air consumption: 5.015 (m³/min)(ANR)</td>
</tr>
<tr>
<td>Required airflow: 156.3 (m³/min)(ANR)</td>
</tr>
</tbody>
</table>

System characteristics

| Max. pressure: 0.50 MPa |
| Max. acceleration: 10.1 m/s² |
| Max. velocity: 782 m/s |
| Mean velocity: 538 m/s |
| Max. pressure: 0.50 MPa |
| Max. acceleration: 3.8 m/s² |
| Max. velocity: 782 m/s |
| Mean velocity: 538 m/s |
| Friction factor: 0.7 |
| Transfer: 0.3 |
| Sliver opening: 0 deg |
| Mounting angle: 0 deg |
| Locking load: 55.0 lb |
| Resilience force: N |
| Mounting angle: 0 deg |
| Locking load: 55.0 lb |
| Resilience force: N |
| Mounting angle: 0 deg |
| Locking load: 55.0 lb |
| Resilience force: N |
| Mounting angle: 0 deg |
| Locking load: 55.0 lb |
| Resilience force: N |
| Mounting angle: 0 deg |
| Locking load: 55.0 lb |
| Resilience force: N |
| Mounting angle: 0 deg |
| Locking load: 55.0 lb |
| Resilience force: N |
| Mounting angle: 0 deg |
| Locking load: 55.0 lb |

Condensation Calculation Input Value

Condensation probability: 0 %
Condensation probability is very small

Comment:

SMC Version: 4.0.01

Sizing

Version: 4.0.01

Fitting 1

Quan.

Quan.

Quan.

Fitting 1

Results of m odel selection

| Title : Registrant : Date : 2013-07-11 |
|-------------|-------------------------------------|
| Pneumatic Model Selection Program Ver4.0-System Model Selection-Standard cylinder | |
| Com m ent: | |

Condensation Calculation Result

Absorption energy: 0.30 kg/°C
Allowable energy: 0.30 kg/°C
Judgment result: Out of the allowable range
Out of the allowable range: Review the opening conditions and the load conditions. Or use shock absorber.

Condensation Calculation Input Value

Condensation probability: 0 %
Condensation probability is very small

Comment:

SMC Version: 4.0.01

2” bore / ~10 SCFM

1-1/4”" bore / ~5 SCFM
Design Issues

Look for applications where double-acting cylinders are employed vertically.

Ways to save:

- Gravity Down?
- Single Acting Cylinder?
Look for applications using very large cylinders. Can these be modified?

Design Issues

75% Savings
Design Issues

Look for excessive tubing Length

• Consider that air used to fill the tubing on the way to the actuator does no work!

• The conductance of tubing decreases dramatically with an increase in length
### Design Issues – Tubing Size

Right Sizing Tubing Diameter

– Example 4 cylinder case erector

The savings is a reduction of 4.14CFM or 17.3%.

By using a cylinder with integrated valve, the savings would have been $1179 ($320 additional)

<table>
<thead>
<tr>
<th>Metric</th>
<th>3/8&quot; Tubing</th>
<th>1/4&quot; Tubing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Pressure</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Bore (inch)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Stroke (inch)</td>
<td>3.41</td>
<td>3.41</td>
</tr>
<tr>
<td># of cylinders</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Tubing Length (inch)</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td>Tubing I.D. (inch)</td>
<td>0.25</td>
<td>0.16</td>
</tr>
<tr>
<td># of elbow fittings</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Rate: Cycle Time (sec)</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>CFM Required</td>
<td>24</td>
<td>19.86</td>
</tr>
</tbody>
</table>

Annual Cost of Operation:

- 3/8" Tubing: $4,979
- 1/4" Tubing: $4,120

**ANNUAL SAVINGS**: $859
Design Issues - Pressure

- Extend and retract strokes frequently do not require the same operating pressure. A reduction in pressure on the non-working side of the cylinder will lead to significant energy savings.
Electricity accounts for approximately 80% of the total cost of operating a pneumatic system. A small increase in the amount spent on parts and labor will considerably reduce the electricity cost.
Additional Resources

University of Minnesota
Fundamentals of Fluid Power Online Course
https://www.coursera.org/course/fluidpower

National Fluid Power Association
http://www.nfpa.com/

International Fluid Power Society
http://ifps.org/
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Questions?

Solutions That Save