Metrolog

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Evaluation of compressed air consumption reduction in air-electronic measurement applications with Metrolog P10 smart valve

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Summary

This application note details the experimental observations of compressed air consumption in a dimensional measuring system designed for 50mm internal diameter inspection, based on air-electronic measurement principle. Consumption of compressed air at rest, measurement, and free exhaust are analyzed.

The experimental tests are repeated with controlled air supply blocking using the Metrolog P10 smart valve.

Experimental observations point to compressed air savings over 60%.

Initial comments

Compressed air is one of the most expensive forms of energy to be generated and maintained, accounting for 10% to 30% of an industry's electricity cost [3)].

Typically compressed air generation systems have an efficiency lower than 15% in terms of converting electrical energy into pneumatic energy[(1)]. Assessment of opportunities to reduce consumption and air waste can be translated into significant financial savings.

The cost of compressed air generation is often underestimated due to many unaccounted fixed and variable costs. The main costs associated with generation and use of compressed air are:

- Depreciation of investments in machinery and distribution network;
- Financial costs associated with investments;
- Electric energy used by the air compression system;
- Electric energy used by treatment systems (dryers, heaters, etc.);
- Intrinsic air loss in the distribution network;
- Maintenance costs associated with machinery, distribution network, and its elements;

Additionally, compressed air savings directly translate into the reduction of carbon dioxide, sulfur dioxide, mercury and lead emissions, the main pollutants associated with the production of electric energy[(1)].

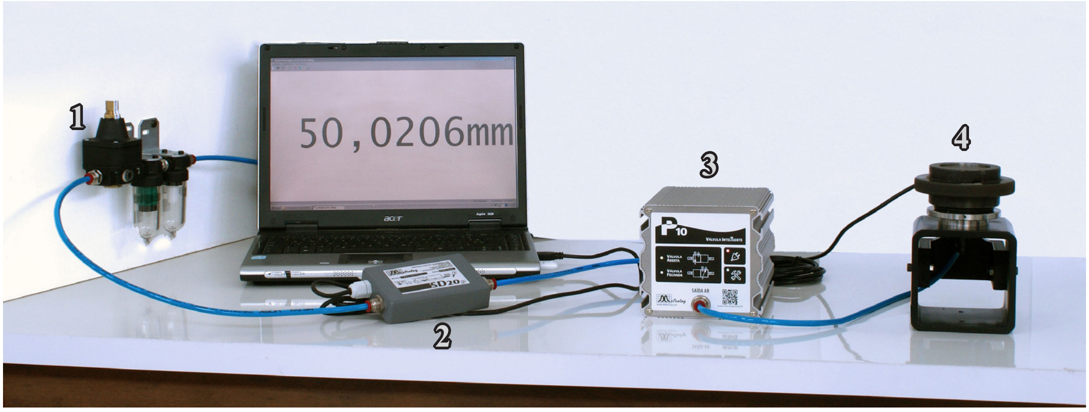
Specifically in dimensional measurement applications that employ compressed air, typically referred as air-electronic measurement, compressed air is often wasted during load/unload and positioning of parts in the measurement fixture.

Nas aplicações específicas de medição dimensional por meio do ar comprimido, usualmente conhecidas por medição eletropneumática, é comum o desperdício de ar comprimido durante troca e posicionamento de peças no ciclo de medição.

Idle situation, such as operator stops or end of working shifts, can also significantly contribute to air waste if the air supply blockage is neglected.

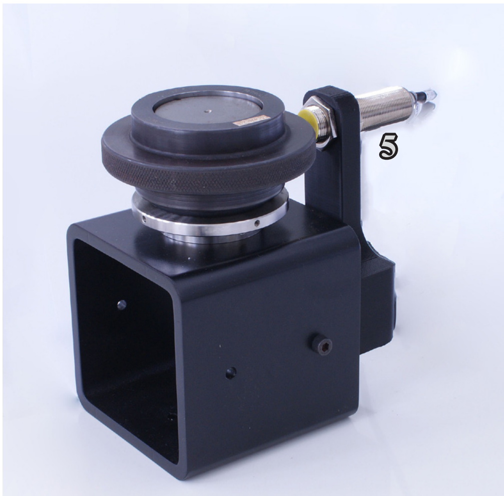
Test assembly

For evaluation of air consumption a simple measuring system was set up, composed of Metrolog REG1 set of filters and instrumentation pressure regulator (indication #1), a Metrolog SD20p-USB measuring system connected to a laptop (indication #2), a Metrolog P10 smart valve (indication #3) and an ID measurement plug (indication #4)



Picture 1-1. Test assembly

The measuring plug was designed for inspection of internal diameters from 50.020mm to 50.040mm. In addition, a Metrolog IS101 inductive sensor (indication #5) was positioned to detect part insertion / removal in the measuring plug.



Picture 1-2. Detail of the measuring plug and the inductive sensor IS101

Observed measurements, although not in the scope of this study, were made with a stable resolution of 0.0001mm. Compressed air switching by P10 valve did not cause observable calibration or zero variations on the system.

Note: *The compressed air consumption observed in the various test scenarios resembles measurement systems employing other equipment such as Metrolog CP1000DuP, M10P, M20-1P measurement columns or other Metrolog SD20p Series conditioners.*

Methodology and used standards

The air consumption values presented (mass or molar flow in Nm^3/h, normalized at ambient temperature of 0ºC, ambient pressure of 1atm and relative humidity of 0%, according to ISO1217-2009) were obtained by leakage tests with known reservoir size, and duration varying from 30 to 200 minutes depending on the test scenario.

For the dynamic tests, pre-tests were carried out with different operators to observe the typical measurement cycle time. The measurement cycle comprised the movement of the part (located next to the measuring plug), insertion in the device, readout observation after stabilization, removal, and return of the part to its original position.

Evaluating the average cycle times of the different operators, it was defined a total cycle time of **5.32s**, with 2.08s being consumed during the measurement process and 3.24s consumed during the workpiece movement. The measurement period was detected by the inductive sensor IS101, from the instant of part insertion to the instant of part removal .

After the measurement cycle time was defined, an automated system for insertion and removal of parts was implemented, allowing a controlled repetition of hundreds of measurement cycles.

In the tests involving static and dynamic measurements, two master rings with values of 50.020mm and 50.040mm were used. The use of master rings for the simulation of inspection parts was done to a proper evaluation of air consumption in tolerance limits, and due to the well defined and controlled geometry of the ring masters.

Observed results

Consumption of compressed air in static situations:

In the static tests, continuous compressed air supply was used, where the P10 valve was held open.

Scenario #1: Plug freely leaking air to the atmosphere (no part inserted)
Observed consumption: **0.89 Nm^3/h**

Scenario #2: Plug during measurement, with inserted 50.020 mm master ring
Observed consumption: **0.60 Nm^3/h**

Scenario #3: Plug during measurement, with inserted 50.040 mm master ring
Observed consumption: **0.66 Nm^3/h**

Consumption of compressed air in dynamic situations:

In the dynamic tests, an automated system was used for precise cycle repetition. The air supply was continuous in test scenarios #4 and #5 (P10 valve was held continuously open). In test scenarios #6 and #7 the previous tests were repeated, but with controlled switching of the compressed air supply using the P10 valve and the inductive position sensor IS101.

Scenario #4: Usual measuring cycle, without blocking compressed air supply during parts movements, using 50,020 mm master ring
Observed consumption: **0.80 Nm^3/h**

Scenario #5: Usual measuring cycle, without blocking compressed air supply during parts movements, using 50,040 mm master ring
Observed consumption: **0.87 Nm^3/h**

Scenario #6: Measurement cycle with interruption of the compressed air supply during parts movements (actuation of P10 valve), using 50.020 mm master ring:
Observed consumption: **0.30 Nm^3/h**

Scenario #7: Measurement cycle with interruption of the compressed air supply during parts movements (actuation of P10 valve), using 50.040 mm master ring:
Observed consumption: **0.32 Nm^3/h**

Results evaluation

The comparison of scenarios #4 and #5 against scenarios #6 and #7 allows an initial evaluation of compressed air consumption reduction while using the Metrolog P10 smart valve. In an ideal scenario, considering:

- Constant measurement cycle, with cadenced supply of parts for inspection;
- Initial calibration time is negligible compared to the total measurement period;
- Compressed air supply is blocked during operator stops (for rest, feeding, correction of unexpected problems);

it is possible to observe an average reduction of **62.8%** in the consumption of compressed air for the same measurement process.

In a real scenario, however, this economy may assume larger values, depending on the habits and procedures adopted by the operator. Free compressed air leaking during stops are common and can represent a considerable portion of the total air used by the measurement process. Brief stops necessary for moving parts or correcting unexpected problems can also gradually contribute to the share of wasted compressed air.

In a real scenario, it is reasonable to consider free leaking due to scheduled stops (scenario #1) around 15% of the total measurement time. In this situation the average reduction would reach **68.7%**, considering that the P10 valve would automatically block the compressed air during periods of inactivity.

Intermediate situations such as leaving the unused plug with an inserted part (scenarios #2 and #3), would slightly reduce the waste of compressed air, but without achieving considerable savings in the process.

Despite the possible variations in the effective percentage of savings, the control of the air supply enabled by the P10 smart valve translates into thousands of cubic meters of compressed air saved annually. In manufacturing systems with dozens of measuring points, the global economy can translate into significant cost savings, especially in electricity and maintenance costs of the compressed air network.

References

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(5) ISO1217-2009 – "Displacement compressor – Acceptance tests", 4th edition

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