



## INTELLIGENT ENERGY SAVING WITH COMPRESSED AIR FLOW CONTROL SYSTEMS

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### ABSTRACT:

This research journal explores the implementation and benefits of intelligent energy-saving techniques using compressed air flow control systems in industrial applications. By incorporating advanced control algorithms, real-time monitoring, and optimization strategies, significant energy savings can be achieved while maintaining operational efficiency. This journal examines various approaches, technologies, and case studies to illustrate the potential impact of intelligent compressed air flow control on energy conservation and cost reduction.

### 1. Introduction:

Compressed air is a widely used utility in industrial processes. Compressed air powers a variety of equipment such as pneumatic cylinders in machine tools & process automation, air bearings, instrumentation gauges, spray painting, conveying, diaphragm pumps, portable tools such as screw drivers, grinders, hammers, rock drills, nailing & nut runners, movement of doors & hoists as well as vacuum pick-ups. Due to such a vast requirement, compressed air is often referred as industry's fourth utility. However, there are two major issues with generation & supply of compressed air. Firstly, it takes 7 units of electrical energy to produce 1 unit of equivalent pneumatic energy.

Further, a typical compressed air system wastes 50% of the air produced! This results in high energy consumption. Secondly, fluctuating air pressure caused by intermittent use of multiple pneumatic equipment affects their performance. A sudden air demand causes pressure drops at the point of use. Air Compressors detect it only when it travels upstream through the distribution network. The response is to Load a Compressor or increase in speed by VSD to meet the demand. It takes a while for the entire air system to attain the desired pressure. To overcome this lag in response time between Demand & Supply, compressed air system is maintained at higher level of pressure to meet the sudden demand, leading to wastage of compressed air and an inefficient energy system translating into inflated energy bills.

Inefficient use of compressed air can lead to substantial energy waste and increased operational costs. However, by integrating intelligent flow control systems, it is possible to optimize the use of compressed air and achieve significant energy savings without compromising productivity.

### 2. Fundamentals of Compressed Air Systems:

This section provides an overview of compressed air systems, including components such as compressors, receivers, dryers, filters, and distribution networks. It discusses the energy consumption associated with each component and highlights common inefficiencies in compressed air systems.

### 3. Intelligent Flow Control Techniques:

Various intelligent flow control techniques are discussed in this section, including:

- Variable speed drives (VSDs) for compressors: VSDs adjust compressor speed according to demand, reducing energy consumption during periods of low air demand.
- Pressure regulation: Maintaining optimal pressure levels throughout the system prevents energy waste caused by over pressurization.

- Leak detection and repair: Continuous monitoring for leaks and timely repairs help prevent compressed air loss and conserve energy.
- Demand-based scheduling: Scheduling production processes to align with compressed air demand patterns can optimize energy use.

#### 4. Advanced Control Algorithms:

This section explores the use of advanced control algorithms, such as model predictive control (MPC) and adaptive control, to further optimize compressed air flow. These algorithms leverage real-time data to anticipate demand fluctuations and adjust system parameters, accordingly, maximizing energy efficiency.

#### 5. Real-Time Monitoring and Optimization:

The integration of smart sensors, IoT devices, and data analytics platforms enables real-time monitoring of compressed air systems. By analysing data on air flow, pressure, temperature, and energy consumption, operators can identify inefficiencies and implement corrective actions to optimize system performance continuously.

#### Working:

Intelligent Flow Control System (IFC) reduces artificial demand by controlling the air flow & pressure being delivered to the plant. The IFC is designed specifically to operate at an intermediate point of the compressed air system i.e. on the downstream side of the air treatment equipment and upstream side of the main piping distribution system. ControlAiRTM IFC creates useful storage by introducing a controlled differential pressure across an upstream receiver and itself.

This storage isolates the Compressors from demand side fluctuations. Peaks are dealt with releasing the stored reserve energy instead of additional horsepower, facilitating the Compressors to run on reduced load. ControlAiRTM IFC provides air at a controlled differential and optimum pressure to the plant, which reduces the mass of air consumed by pneumatic equipment, tools & tools & number of leakages, which ultimately result in the reduction in energy consumed by Air Compressors.

**Principle & Working**

- Each IFC unit is controlled by a 16-bit Micro-processor which senses the varying demand of compressed air to the shop and then directs the flow control Modules to either open or close in order to regulate the downstream air flow and pressure.

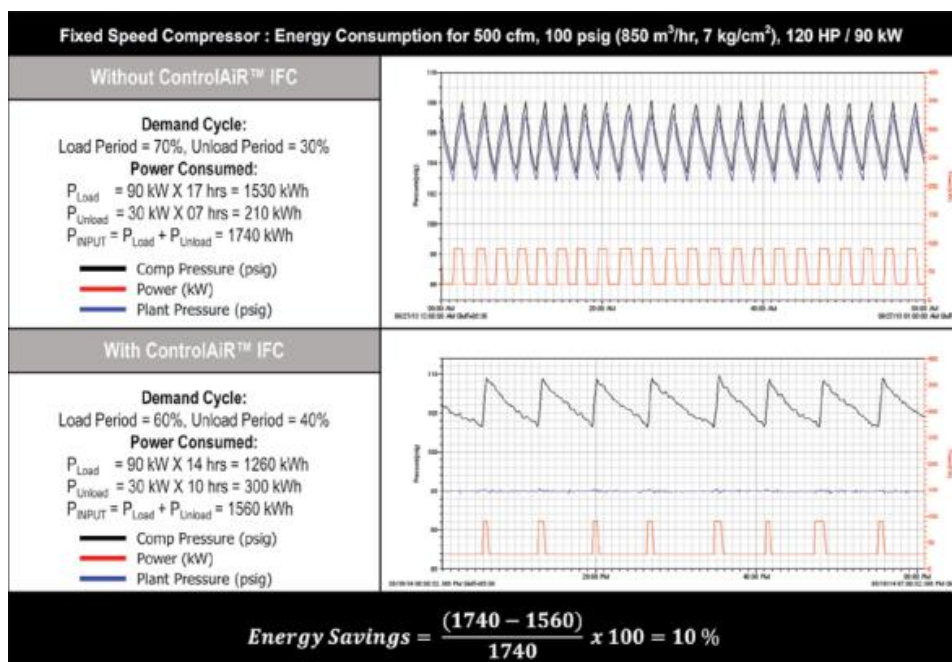
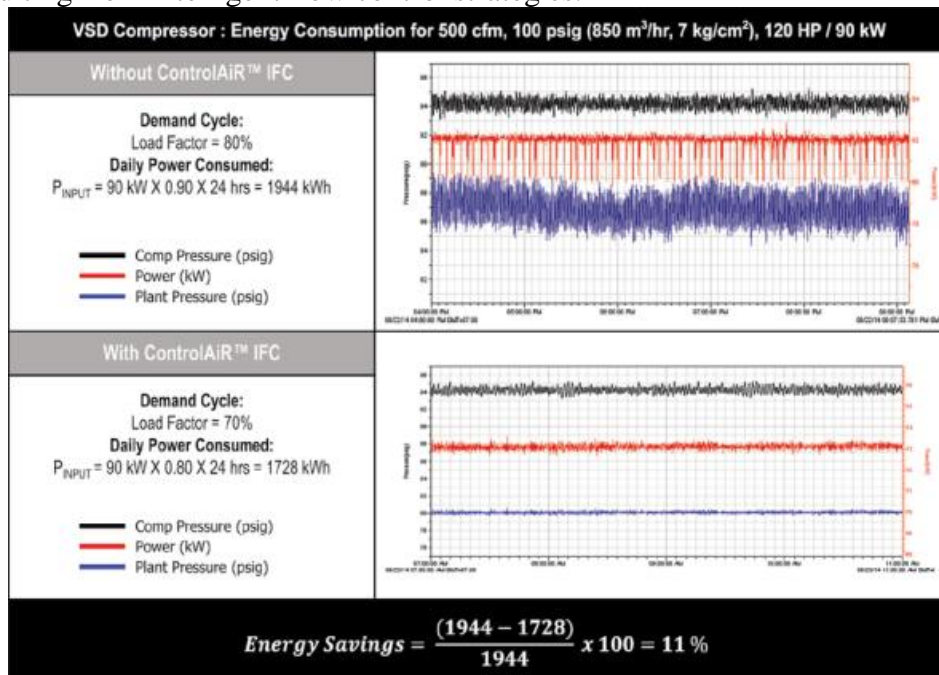
#### Benefits

- Saves Compressed Air Energy by 4~25 % through reduction in Artificial Demand
- Constant air pressure to pneumatic tools within the range of +/- 1 psig (0.07 barg)
- Improves the response time of system to meet instantaneous demand
- Reduction in compressor's operation and maintenance

- Reduction in compressed air leakages
- Works with all brands and types of compressors
- Payback period between 1~2 years
- Improves VSD Performance

**Case Studies:**

Several case studies from different industries are presented to demonstrate the practical implementation and benefits of intelligent compressed air flow control systems. These case studies highlight the achieved energy savings, reduced maintenance costs, and improved operational reliability resulting from intelligent flow control strategies.





**Challenges and Future Directions:**

Despite the potential benefits, challenges such as initial investment costs, system complexity, and operator training need to be addressed to facilitate widespread adoption of intelligent compressed air flow control systems. Future research directions, including the development of advanced control algorithms and integration with renewable energy sources, are also discussed.

**Conclusion:**

Intelligent energy-saving techniques using compressed air flow control systems offer significant potential for reducing energy consumption and operating costs in industrial applications. By leveraging advanced control algorithms, real-time monitoring, and optimization strategies, organizations can achieve sustainable energy efficiency while maintaining productivity and competitiveness in the market.

**References:**

A comprehensive list of references citing relevant research papers, articles, and industry reports on intelligent compressed air flow control systems.

This research journal provides a comprehensive overview of intelligent energy-saving techniques with compressed air flow control systems, highlighting their importance, implementation strategies, benefits, and prospects.