# How has Industry 1.0 to 4.0 influenced particulate emissions and monitoring

## Part 2: Industry 2.0

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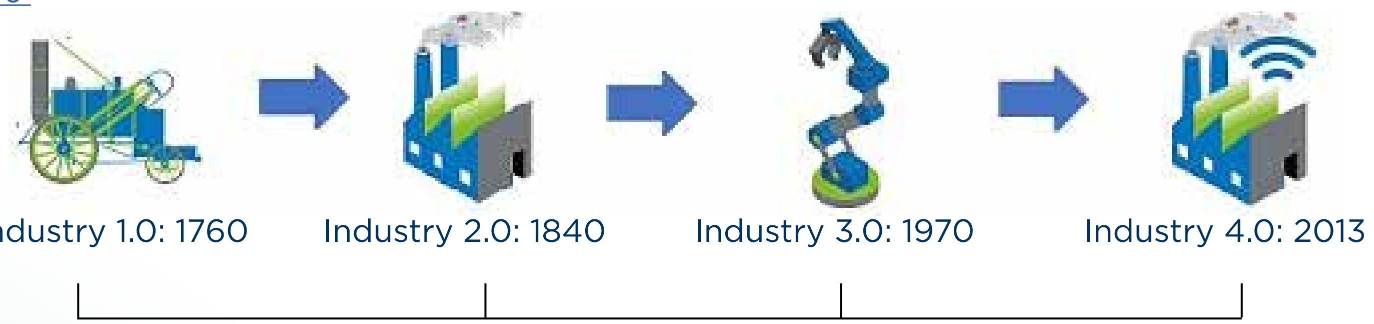
## Introduction

ENVEA have been at the forefront of environmental monitoring and process control over four decades and with the emergence of the industrial internet of things (Industry 4.0), ENVEA are yet again providing innovative solutions which harness the potential of this new industrial era.

At Clean Air Technology Expo taking place on 11-12 September at the NEC, Birmingham, ENVEA will be demonstrating its range of Particulate Emissions Instruments alongside its advancements in data capture, storage and analytics that will combine the world of industrial particulate and flow monitoring with the latest in smart technology.

In this series of articles, we will be exploring the relationship between industrialisation and particulates and how the rise of industrial processes has driven the emergence of particulate abatement, monitoring and regulation though each of the four industrial eras.

In this second article we will be examining Industry 2.0 in relation to particulates and how advancements in this era still influence industry in modern day manufacturing. Read the first article here




## Industry 2.0

Industry 2.0 (1840-1969) is marked by the evolution of the factory.

Building on the first industrial revolution, the expansion of rail and shipping alongside technological advancements in electrification and machine tools saw a large-scale transition to machine manufactured product. This paved the way for the concept of mass production, most notably within the automobile industry in the early 20th Century.

Fuelled by scientific discoveries in the world of physics and chemistry, this period also saw the introduction of many new industries.

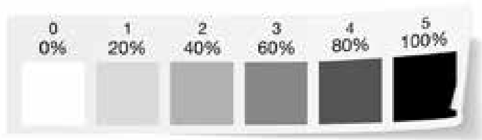
Large scale Power Generation, Steel, Rail, Dyeing, Paper, Fertiliser, Petroleum and Automobile industries were all created during this global surge in industrialization, which would define an unprecedented period of economic growth, improved living standards and productivity.

## Particulates during Industry 2.0

The rapid growth of industrial processes coincided with significant increases in airborne particulate concentrations in large cities and towns. It has been estimated that by the year 1900 ambient particulate levels had increased from 300$mg/m^3$ during the first industrial revolution to in excess of 600$mg/m^3$ in London. The demand for steam powered machinery in manufacturing processes led to massive increases in coal consumption reaching, at its peak, 160 million tonnes per year in the early 20th Century compared to 20 million tonnes per year in the early 1800's.

A greater understanding of the health implications on the population (in the UK) from factory emissions developed during the second half of the 19th Century. Control of emissions from factories was included in various acts of the UK parliament between 1847–1875. This culminated in the Public Health Act (1875) which included a section on abatement and which formed the basis of current day legislation. It would be a further 80 years before specific regulation requiring the prevention of airborne particulates would be enacted within the UK. The Clean Air Act (1956) included requirements to control the emission of dark smoke from stacks specifically stating that dust emissions should be minimized. This was focused on domestic emissions introducing smokeless zones where the use of smokeless fuels was required. It would not be until the later 1968 Clean Air Act that legislative requirements for installing arrestment plant on industrial processes with defined emission limits would come into force.

The first method of monitoring particulate emissions from industrial processes was defined in 1888 by Maximilien Ringelmann. The Ringelmann Scale required the operator to view the smoke plume from the stack at distance and compare this to a chart of varying shades of grey with each shade representing the concentration of particulate matter within the plume. The method was adopted into various industries in the early 20th Century and specified in US and UK standards for PM monitoring during the 1960's across industry. The Ringelmann scale was the basis for the first in-stack monitoring system using Opacity technology to provide continuous particulate monitoring.




*The Ringelmann Scale: early method of monitoring particulate emissions*

## Technological advancements during Industry 2.0

There were many technological advancements during the Industry 2.0 era that supported the massive expansion of manufacturing output. Many of these technologies and inventions are still in use today.

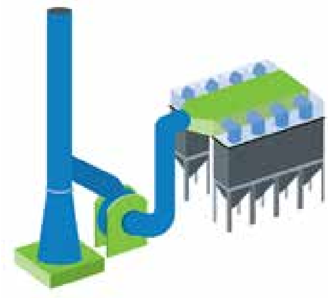
Electrification of factories grew rapidly during the early 20th Century. The invention of the electric motor enabled the concepts of mass production to be implemented with more reliable and efficient conveyer systems transporting materials through the production process which would lay the foundations for the automated factories of the future.

The development of the modern steam turbine by Charles Parsons in 1884 coincided with the introduction of the first commercial power stations in New York and London. Parsons designs would ultimately be adapted and form the basis of large-scale power stations globally.

Steel production was revolutionised by the large-scale implementation of the Bessemer process. Patented in 1856 by Henry Bessemer, the process significantly reduced the cost and increased the speed of steel production at a time when the demand for steel in railway construction and machine tools was expanding significantly. Subsequent methods would eventually supersede this process, but this advancement is credited with supporting the rapid expansion of global trade.

As the volume of industries emitting particulates through their manufacturing processes expanded and with the increased regulation on PM emissions, the need for industrial emissions abatement grew. Methods for reducing emissions from industrial stacks, including abatement methods to prevent dust emissions, emerged during the Industry 2.0 era.

In 1921, 3 filter designs were patented by Wilhelm Beth from Lübeck, Germany. Known as Dust Collectors, these designs would form the basis of the modern-day bag filter. These early designs could not be fully utilised within industry until the invention of fabrics suitable within higher temperatures in the 1970's. The concepts would lead to filtration of particulates that both reduced emissions to air whilst effectively capturing the product integral to the manufacturing process.



Scientific and Technological advancements during the second industrial revolution would ultimately drive the transformation of industrial processes globally. Whilst particulate levels continued to rise into the early 20th century, regulations, population dispersal and emissions control technology would see ambient levels of particulate matter in western industrialised nations fall rapidly after 1900 and continue to fall into the new millennium.

## Particulate Emissions Control in 2019

In 2019 emissions abatement is well established in all manufacturing processes producing airborne particulate. Alongside Electrostatic Precipitators (ESP), discussed in the previous article (Industry 1.0) and the modern-day baghouse, based on the initial designs of Wilhelm Beth, there are numerous other technologies now in operation globally. These include Wet Scrubbers which wash particulates and soluble pollutants from the gas stream. Dry scrubbers introduce a reagent, such as hydrated lime, to the gas stream acting as an absorbent material which neutralises acidic and often corrosive gases. These systems then require another form of filtration to remove the particulates from the process. Cyclones utilising vortex separation are also widely used as an effective method of separating solids and liquids from a gas stream.

For manufacturing processes, such as those first introduced during the second industrial revolution (Industry 2.0), baghouses are one of the most commonly used methods of abatement. There are many variations in design, size and operation, but all use the concept of gathering particulate on the fabric bags as the process gases are passed through the baghouse. As the bags collect particulate over time, they require cleaning to dispose of the particulate collected. In modern day bag houses, there are multiple methods of automated bag cleaning mechanisms. This includes shakers, pulse jet and reverse jet methods all of which force the PM to the base of the bag house where it is collected and often transported away via a screw feed conveyer system.


Whilst baghouses are extremely effective, they do require regular maintenance to ensure optimal performance. Bags will deteriorate over time and a gross bag filter failure can led to excessively high emissions and loss of valuable product. As well as monitoring and maintaining the filter media, ensuring the operation of automated mechanisms for bag cleaning and transportation from the collector is essential. The costs associated with plant shutdown, replacement bags, lost product and high emission events have led to the development of technologies to manage the performance of bag houses. This includes managing preventative maintenance scheduling, reducing the time required to identify and replace failed filter media and providing early warning of potentially high emission events.

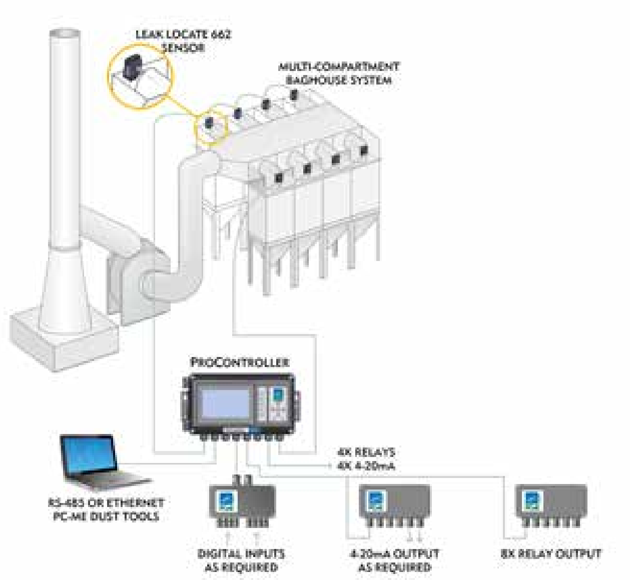
## Industry 4.0 in Particulate Monitoring

With its *ElectroDynamic*™ technology, ENVEA provide a wide range of particulate monitors providing both real time continuous dust concentration measurement and indicative monitoring to identify PM levels both within and immediately after bag filters.

*Instruments from the PCME LEAK LOCATE and LEAK ALERT range*

The PCME LEAK LOCATE and LEAK ALERT range enables operators to monitor directly on the outlets from each compartment of bags giving real-time trends of particulate levels within specific sections of the baghouse.

For baghouses with online cleaning cycles the dust levels exiting each outlet will increase with each cleaning pulse. These emission peaks are logged by the sensor. As the condition and performance of bags within each compartment deteriorate the resulting dust levels will increase. By utilising ENVEA software tools, operators can therefore identify compartments that are starting to deteriorate and manage the maintenance of their baghouse accordingly.




Gross filter failures can be identified as soon as they occurs enabling the operator to bypass the compartment and investigate and resolve the issue before it leads to a high emissions event.

This data, when viewed over time, can provide trends which can be used to measure the rate of deterioration and assist in the assessment of expected mean time to failure.

*ElectroDynamic™ sensor installation in multicompartment baghouse*

The effective management of baghouse performance utilising the LEAK LOCATE system can therefore reduce costs and inefficiencies associated with filter failure whilst providing valuable process data to further improve the efficiency of the manufacturing process.

In addition to particulate monitoring, ENVEA now offer a range of bulk powder flow measurement instruments. By installing the SOLIDFLOW 2.0 system on the screw feed conveyer at the base of the bag filter, operators can monitor the mass flow of material collected as it is transported away from the bag house. Additional sensors such as the FlowJam (flow/no flow) sensor and ProGap level detection instrument can also be installed within the ducting and hoppers to ensure material flow is continuous and no blockages or overflow occurs all of which can affect ongoing operation of

*FlowJam and ProGap ensure continuous material flow*

By combining the data and trends provided through the ENVEA range of process instruments, operators can manage their processes at each stage of filtration providing the interconnected factory concept synonymous with Industry 4.0.

To learn more about developments towards Industry 4.0, view the process dust and solid flow instruments discussed and discover the latest developments in analytical software please visit us on Stand 138 at Clean Air Technology Expo taking place on 11-12 September at the NEC, Birmingham.

In our next article we will be examining Industry 3.0, the rise of factory automation, the establishment of continuous particulate measurement instruments and how the concept of networked systems are evolving beyond the server room.

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