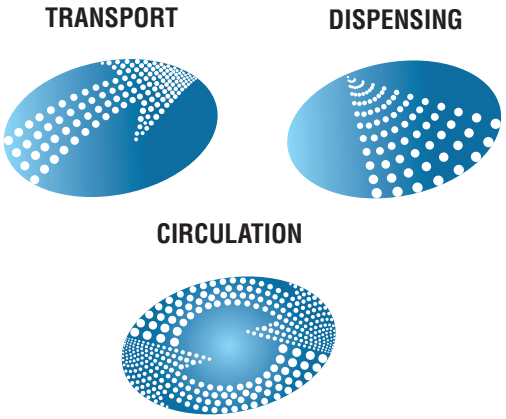


HDLV Technology

The Heart of a New Machine: Dense Phase Powder Transport

By Dan Cundill, Nordson Europe

It is rarely that a technological innovation comes along that will have a major impact on how powder coating systems work.

Until recently virtually all powder application has relied on mixing a large volume of compressed air with powder to "fluidise" it so that it can be moved by a simple venturi pump through a hose to the spray gun.

Now, "Dense Phase" powder transport, or High Density Low Volume (HDLV™) delivery offers a new approach that is already having a dramatic effect on powder coating results. Consider the following impressive list of advantages being seen in the field:

- Consistent powder output over time over a wide range of settings and even with low film thickness powders
- Increased transfer efficiency
- Reduced powder consumption
- Better coverage for difficult to coat parts
- Easier application requiring less operator effort
- Increased production throughput
- Faster colour change – pump provides its own purging
- Reduced maintenance costs
- Powder process control
- Large range of output from the gun by simply turning a knob on the controller, no mechanical adjustments
- Linear powder output: Double the setting, double the output

This article provides a brief overview of the evolution of powder coating transport systems and how the new Nordson HDLV™ equipment works to provide these added benefits. To do this we need to look first at the traditional method of powder delivery.

Traditional Powder Delivery

Those new to powder coating are often amused to watch solid powder coatings flowing like a liquid through a hose. "Fluidised" powder in a hopper looks as though it is gently boiling and seems as though it would be wet to the touch.

Powder stored in a container is fluidised. A pump is usually mounted directly on the hopper or cardboard box, which blows fluidised powder through hose to the spray gun.

The most common device for fluidising powder is the powder coating hopper in which compressed air is introduced from the base through a porous membrane. This air mixes with the powder to fluidise it. A second stream of air is introduced through a powder pump, which creates a vacuum in the pump chamber by way of the "venturi effect". (The same affect which sucks cigarette smoke out of a moving car when the window is opened.)

A venturi pump uses a pick up tube, typically 4.5mm in diameter, to suction the fluidised powder out of the hopper and into the pump chamber. From here it is propelled by more compressed air through the exhaust throat and in to the powder hose at speeds typically around 15 m /sec.

Nordson

In traditional systems, powder feed hoses ranging in diameter from 8mm to 12mm are used, depending on the desired flow rate. Improper hose sizing or inadequate airflow can cause settling out of the powder coating from the air-stream.

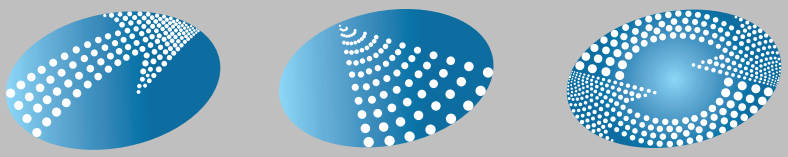
At the opposite end of the powder hose is the powder spray gun. This is engineered to emit the powder/air mixture with sufficient velocity to direct a stream of powder towards the part, in what is often referred to as a "cloud".

As you might imagine, just like a garden hose fitted with a nozzle, if the gun opening is too large the powder will trickle out – too small and the velocity will be too high.

The sprayed powder now passes through an electrostatic zone where, in the proximity of a high voltage electrode, it becomes charged and travels, in a "powder cloud" towards the grounded part.

Proper coverage including 'wrap' and the powder coatings ability to penetrate into various geometries is related to the combination of electrostatic charge and the aerodynamic forces affecting the powder cloud.

Powder Transport
Powder Dispensing
Powder Circulation



The road to Dense Phase

To develop dense phase technology we considered the three key areas of powder coating, and the issues involved with the traditional methods.

Powder Transport; Powder Dispensing; Powder Circulation

Engineers realised the advantages of Dense Phase technology in all of these areas early on, but there have been significant engineering obstacles to overcome in commercializing the technology.

Pumping Powder Poses Problems…It's hard to say, and it's even harder to fix. Gases and liquids are relatively easy to pump and a wide range of piston, diaphragm, peristaltic and other designs are available to choose from. But powder particles become tiny abrasives when they come into contact with most pump components and these pumps used with powder could require a great deal of maintenance.

That's why most traditional powder pumps have relied on a venturi design with no moving parts, rather than piston and diaphragm pumps. But venturi pumps require a high volume of air by nature and dense phase transport is not possible with them. They also wear rapidly making frequent manual adjustments to gun settings necessary.

One of the major goals when developing the Nordson HDLV™ pump was clean-ability and serviceability, so the interior components of the HDLV™ pump are easily removed, cleaned and replaced.

To overcome the wear problem, the Nordson HDLV™ powder pump draws on material advances in high tech polymers. We collaborated with a polymer formulator in Ohio, USA; an area rich in elastomer technology because of the tyre business headquartered there, to develop a special polymer material. Nordson found they could injection mold this material to design wear-resistant materials for the dense phase powder pump. The HDLV™ pump uses a pinch valve design to provide precise control and consistent displacement of powder with each pump cycle – without mechanical movement or powder contact and without venturis.

Like a human heart (see page 4r), the HDLV™ pump operates by suctioning powder into the pinch valve which may be opened and closed as much as every 250 milliseconds.

The HDLV™ pump can be operated at a wide range of cycle times to deliver powder anywhere from 20 g / min to 350 g / min.

However, a nagging problem with powder delivery systems has long been their dependence on the supply air from the factory to control their performance.

As the compressor varies output, which can be considerable, so does the pump's output. It's the old "garbage in – garbage out" principle in action. Even in venturi pump design, Nordson engineers decided this problem was important enough to develop a closed-loop airflow module (iFlow) to serve as "cruise control" for powder pumps. iFlow turns fluctuations in input air into electronic control signals, which are used to compensate the pump operation.

This means that due to the consistent airflow entering the pump, and the absence of wearing venturis inside it, the HDLV™ pump does do not see the typical loss of powder output over time, unlike venturi pumps. Fig 1.3 shows the powder output over time from a HDLV™ pump compared to a traditional venturi pump.

In traditional powder pumps, adjusting both the atomizing air and the flow rate, which interact with each other, can vary the powder volume. In designing HDLV™, Nordson engineers created a design on experiments (DOE), to evaluate the optimum combination of air controls to deliver consistent volumes for any flow rate required from 0% to 100% flow. The digital control technology allows these pre-determined parameters to be used in controlling the HDLV™ pump with the simple adjustment of a single flow rate control knob; taking the guesswork out and building in repeatability and uniformity.

A systems approach to Dense Phase

One of the mistaken ideas of dense phase powder coating has been to approach it on a component basis. An HDLV™ pump alone is nowhere near as effective a tool as an HDLV™ pump coupled with appropriate control and spray equipment.

Considering that a conventional spray gun is designed to exhaust a much higher volume of powder / air it's not useable with the low air volume produced by an HDLV™ pump without modification. The powder entering the large cavities of a conventional gun would slow down dramatically and barely trickle out of the nozzle making it impossible to paint.

To fully benefit from the potential of HDLV™ the powder hose and gun need to be adjusted for this as well. Many of the dense phase benefits come as a result of the efficient charging and soft powder cloud produced by the added dwell time and higher powder density at the gun tip. Added air only increases the powder velocity and dilutes the powder charge – eliminating gains in efficiency and better coverage.

Providing the entire array of benefits offered by Dense Phase powder transport required the design by Nordson of a new spray gun, named Prodigy™, designed to handle low air volumes. The ProdigyTM gun is specifically designed to work with the HDLV™ pump to provide superior electrostatic charging and transfer efficiency.

The benefits of a complete Dense Phase powder transport system

Using a large volume of air with powder has been the status quo for years because it made life simple. Lots of air with less powder is easy to pump and move through hoses and spray guns.

Dense phase transport uses significantly less air to do the same job. While conventional venturi style systems typically use between 5-7 m3/hr (3-4 CFM) of air for delivery, HDLV systems use between 0.8-1.69 m3/hr (0.5 – 1.0 CFM) to deliver an equivalent amount of powder. Using a smaller volume of air has some significant benefits.

Hose sizes can be reduced. The hoses used for HDLV™ transport are typically 6mm compared to 12mm in diameter on traditional systems. Smaller diameter hoses mean a smaller cross sectional area to be cleaned during color change. This makes for much more rapid color changes with less chance of contamination.

But most importantly, a denser and lower velocity powder cloud results in better charging efficiency. Powder densities in conventional systems average around 3.2 Kg / m^3, while the density of powder in the dense phase system is 7.2 Kg / m^3 – well over double the powder density. The associated charge density means that aerodynamic forces are secondary to the electrostatic forces and as a result a "softer" and more thoroughly charged powder cloud is achieved.

This phenomenon results in both better transfer efficiency and in better electrostatic coverage including the ability to penetrate into more difficult recesses normally prone to faraday cage problems.

The high efficiency of the Nordson HDLV™ system means that more product can be coated with the same volume of powder. It's also easier for manual operators to coat difficult parts requiring less time and muscle than conventional spray guns.

Powder consumption is reduced, productivity increases and profits are higher.

Being a powder coating operator on a dense phase system is a much happier profession than on a conventional powder line. Since electrostatic wrap and coverage is improved, the job of coating is easier. The powder volume is higher and it's easier to do the job with less muscle power.

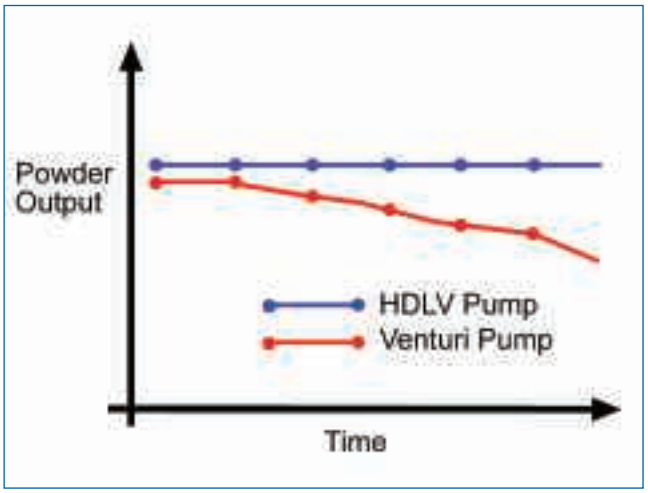


Fig 1.3 Comparison of powder output over time with different types of pump.

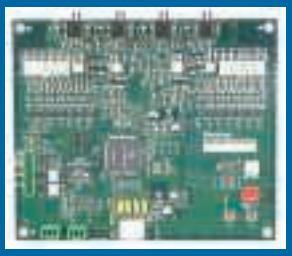
The Heart of A New Machine

Perhaps the measure of how far a technology has evolved is how closely it begins to resemble its creator. Modern airplanes can virtually land and take off by themselves. Predictive cruise control in cars allows them to "look" ahead and slow down or speed up with the pace of traffic. Our computers remember our preferences and correct our spelling mistakes. The next generation of powder coating systems now contains hardware that looks very much like our own vital organs; a heart, a brain, and sophisticated circulatory system. Sound far fetched? Take a look at the latest dense phase technology from Nordson.

The Heart / The HDLV™ Pump

At the center of Dense Phase technology is the HDLV™ (High Density Low Volume) pump. It resembles a human heart in that it consists of two side-by-side pumps each with an upper and lower chamber working together to provide precise, carefully synchronized powder transport

The Brain / Electronic Flow Control



Like the human heart, the HDLV™ pump is controlled by an electronic brain, which is able to measure changes in the system and take corrective measures to keep the pump working properly. The HDLV™ pump is controlled by sophisticated electronic circuitry that includes iFlow closed-loop flow control. If the surrounding conditions such as plant compressed air delivery changes, the controls provide the necessary compensation to keep the HDLV™ pump working consistently.

Conclusion

Advances in powder coatings keep coming; feeding off the controls and material science advances in other industries.

High Density Low Volume air delivery of powder coatings is now made possible by devices like the HDLV™ pump and iFlow electronic controls.

A properly designed Dense Phase system including pump, hoses and properly engineered spray gun can provide a wide range of benefits including faster color change, reduced contamination, better transfer efficiency, improved coverage and faraday cage application. These advantages stemming from the reduced hose sizes, softer powder cloud, and longer electrostatic dwell time, bring with them other commercial benefits such as reduced labour, lower powder consumption, more uniform paint coverage and increased profitability.

The new ProdigyTM handgun systems*, which incorporate HDLV™ pump* technology, are available from Nordson in summer 2005.

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*Patents Appplied For

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