Spray Equipment in the Modern Paint Shop

This article was written to give a brief overview of the most popular manually operated liquid spray equipment types in use today
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The modern spray finishing shop, through the pressures and requirements of cost effectiveness, Environmental Legislation and Health and Safety, walks an increasingly difficult path. The decisions made by its staff and management will influence the way in which the final customer sees their product as well as contributing heavily towards the overall cost of manufacture. Most spray finishing shops are still, despite public misconception, more full of people than automatic machines and manual equipment sales still greatly outstrips the quantity of automatic spray guns sold per annum. Let's look at this equipment and see how the modern finishing line should be influenced by the equipments capabilities. There are three distinct families of spray guns available Air Atomising, High Pressure (H.P.) and Electrostatic. Looking first at Air Atomising, it can itself be broken down into 3 sub-sections.

Conventional Air Atomising

Air atomisation equipment has come a long way since people like Dr Allen DeVilbiss and Joseph Binks first drew up their ideas in the late 1880's. While the darlings of the spray shop – the Binks 230's and DeVilbiss JGA's (officially known as 'Conventional' Air Atomising guns) - are still widely used around the World, their life-span has been severely influenced by the introduction in recent years of Environmental Legislation. While various other pieces of spray equipment are mentioned by name in this legislation, Conventional Air Atomising guns are not, and thereby the death-knell was sounded for their continued use. The problem was that they are just too inefficient at depositing coating onto components, and therefore are felt to be contributing too much to Environmental Pollution through Particulate and Volatile Organic Compound (VOC) emission. Therefore they had to go.

Past and Present 'Conventional Spray Guns – DeVilbiss JGA Binks 230, and DeVilbiss Compact

Past and Present HVLP Spray Guns – DeVilbiss JGHV-522Binks Mach 1, and Binks Mach 1SL

Spray guns such as these use a high-speed air jet, wrapped around the fluid column emitted from the fluid nozzle, to atomise the liquid into droplets. Other air jets then shape the droplet cloud into a long 'fan', rather than a circular spot, and push it towards the object being coated. The droplet size and resultant sprayed finish are acknowledged to be of a very high quality, desirable by the majority of spray finishers. However, the high speed air jets used also cause many of the finer droplets to 'bounce-back' from the surface causing clouds of spray fog – wasting expensive coating, contaminating the environment with particulate and VOC and creating dust and contamination over any horizontal surface.

In 1990 the UK Environmental Protection Act deemed that this type of atomisation method was too inefficient to be used for the majority of spray finishing work and so HVLP equipment started to make its mark on the spray industry. However, don't mourn over the demise of the sprayers favourite guns for too long, Conventional Air Atomising still lives. Let's face it, there are still many Governments in the World unwilling to put their full weight and approval behind Environmental Legislation to sell the gun to and, within the UK, there are acceptable finishing scenarios where this gun type is still necessary to apply certain difficult or specialist coating types.

HVLP Air Atomising

HVLP was not actually new in 1990. It had been around in other guises for many years using electric driven turbines to produce low pressure air fed to, and used by, relatively crude spray guns. However the low energy available at the gun head of these early guns was unable to achieve the fine atomisation of standard paint types for high production finishing. The equipment needed a boost of serious investigation and it got it from companies like Binks and DeVilbiss whose market dominance depended upon sales of their spray guns in the post 1990 EPA marketplace.

HVLP atomisation is carried out in a very similar manner to the 'Conventional' guns, except that the air jet speed is much lower. This lower velocity reduces the strength of the air barrier rejecting the droplets from the sprayed surface allowing more to land and resulting in an increased 'Transfer Efficiency' (T.E.). However, this slower velocity also results in slightly larger droplet size, sometimes leading to a lower standard of finish quality. In their enthusiasm for T.E. the EPA legislation limited the atomisation pressure inside the air cap of such guns to a maximum of 10 psi (0.7 bar). However, this limit seriously restricted the atomisation abilities of the guns when dealing with more difficult material types. Environmentally they were great, performance-wise they sometimes struggled.

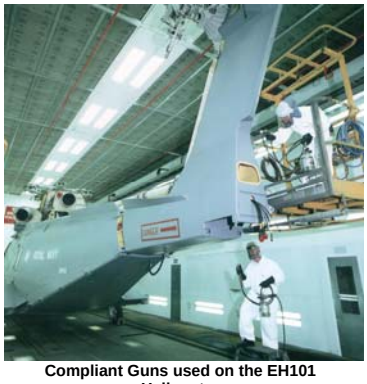
Through investigation and research HVLP gun atomisation was improved to handle many application requirements in the early 1990's. Indeed, sales history of both Binks and DeVilbiss show that a major percentage of the UK Air Atomising equipment market successfully switched to their HVLP equipment. However, the continual march of Environmental progress started to

leave HVLP equipment behind – revisions of the UK EPA further reduced the VOC contents of coatings. While not always increasing the viscosities of the coating this did increase the difficulty of atomising their increasingly higher solids content, heaviness, and stickiness. Something better was needed….

Compliant Air Atomising

In order to achieve small droplet atomisation of the High Solids (H.S.) and even Ultra H.S. materials coupled with high T.E. took a little more in-depth investigation. Use of only recently available design resources such as Laser Particle Analysis and Computational Fluid Dynamic Computer Software enabled ITW Finishing (as the combined Binks, DeVilbiss and Ransburg Companies are now called) to start to truly understand the 'rules of thumb' and empirical methods of spray gun design that they had successfully used for so many years previously. The true age of designer spray guns had finally started. So came about the development of 'Compliant' Air Atomising equipment – so called because they 'comply' with the Environmental Legislation. One of the paragraphs relating to spray equipment states that coatings may be applied 'by any other application technique providing that a Transfer Efficiency of 65% or greater be demonstrated to the satisfaction of the local authority'. ITW is one of the few equipment manufacturers that can offer this service to their customers and their local authorities by carrying out the test procedure documented in the recently introduced BSEN 13966 'Determination of Transfer Efficiency of atomising and spraying equipment for liquid coating materials'. The 'Compliant' air atomisation method is still generically similar to the old Conventional and HVLP air atomisation guns, but through the use of a scientific application of air pressure, velocity, orifice size, cavity shape and profile the results are an equipment type that sprays like the old gun, but has a lot more T.E. In fact, T.E. has been increased to the point where it is possible to meet the Dutch Environmental legislation requirement for a T.E. of 72%! The Compliant gun type is now the dominant type sold in the UK for EPA governed spray-finishing facilities.

Past and Present Compliant Spray Guns – DeVilbiss GTI and Compact



Compliant Guns used on the EH101 Helicopter
Photograph courtesy of GKN Westland

Air Atomisation Family traits

All of the Air Atomising Family (including the obviously limited HVLP) have the same important characteristics… control and flexibility. It is for this simple reason that 99% of all sprayers cherish and favour this particular equipment type. The ability to alter fluid flows from nothing up to 100's of cc/min, to be able to instantly change the size of spray 'fan', the ability to handle a wide range of coating types from optical coatings, water based adhesives, chocolate to flavours onto crisps; all of these factors contribute to the sprayers love of this gun type. The standard gravity and suction (some call them siphon) fed versions are the most widely used spray gun type in the world, with tens of thousands of them being fed into the world market place each year by ITW alone. Replace the 600cc or 1 Litre capacity cups with a 10 or 25 litre pressure feed container and the duration of spraying between refills lengthens considerably. Use a low-pressure diaphragm or piston pump, and the sprayer just keeps going while others top up the fluid reservoir. However, there are limitations to this seemingly perfect tool. The atomisation method starts to struggle once the fluid viscosity grows beyond a 'sensible' coating thickness (say 40 seconds Din4) for these gun types. Increasing viscosity and/or fluid flow requires increased air pressure to cope with it, thereby increasing the 'bounce-back' problem, reducing efficiency and blowing small components off of the bench and onto the floor! Modern High Solids materials are proving to be more demanding on the atomisation abilities of this gun type but so far they are able to keep up with the requirements in the majority of cases. However the death-knell of suction (siphon) guns has been clearly sounded by such materials, their heavier and denser nature make them more difficult to draw up the siphon tube - they feed far more easier downwards from a gravity cup gun. Controlled application of difficult to apply cosmetic finishes onto lipstick tubes or specialist 'stealth' coatings onto military aircraft all fall within the scope of this equipments ability. By the way, HVLP is still very much alive and being demanded for certain applications. These are often applications involving the application of water based coatings where the extra volume of air exiting the air cap has been found by the coatings manufacturers to be beneficial to the vaporisation and colour characteristics of the coating. However, for the major percentage of the Air Atomising market…Compliant type guns are seen as the way forward.

Looking now at another 'family' of guns – the 'High Pressure' (H.P.) variety – we can see that there are other methods to increase the T.E. of the coating process.

Airless Spray equipment

By forcing liquid at very high pressures through a very small shaped orifice (normally from 0.009" to 0.029" (0.23 to 0.74mm), atomisation can also be achieved. Airless spray guns with their associated High Pressure (H.P.) pumps have been around for many years. Their high fluid delivery coupled with a slightly larger droplet size than produced by air atomising guns leads to a less controllable, lower quality finish. However its ability to rapidly apply high viscosity coatings makes it ideal for protective and anti-corrosive finishes on large objects. While normally sized in the 32:1 to 45:1 output ratio, the pumps can be as high as 73:1 ratio – i.e. for every 10psi (0.7 bar) of air going into the pump, 730psi (51 bar) of fluid pressure comes out! Application pressures of 2000-4500 psi (130-300 bar) are not uncommon. Due to the fact that there is no air artificially added at the head of the spray gun, there is almost no air barrier and

ITW Binks High Pressure Piston Pumps

bounce-back, making it an extremely high deposition process. The ability to successfully move and atomise high viscosity coatings makes it an essential member of the spray equipment team. However it also has its limitations – the airless atomisation method has a minimum fluid flow limit. Below this limit (which varies depending upon the viscosity and characteristics of the material being sprayed) distorted and incomplete spray patterns are produced that are unsuitable for spraying a component. Characteristic 'tails' (a blob of poorly atomised material at the top and bottom of the fan) are produced which can only be eliminated by increasing fluid flow rate. In addition, this minimum flow rate and the result of high pressure on the fluid needle results in a 'digital' trigger action – either on or off – which makes the gun unsuitable for delicate or intricate work where 'feathering ' of the gun is required to prevent overloading of the material on edges and in recesses. Lastly, the tungsten carbide orifice is of a set size and shape. This means that if you wish to change the spray fan size during spraying – you must remove and change the spray tip. Overall we have here an atomisation method that is a highly efficient applicator, but can be difficult to control.
For construction and heavy steel fabrication work, marine industry and the petrochemical industry Airless is unbeaten. In the past airless equipment has been used for aircraft exterior painting, wood finishing and leather finishing, but most of these market sectors have nowadays switched to Airless' smaller brother – Air Assisted Airless (AAA).

Air Assisted Airless Equipment
This equipment nicely fits the requirement for a combination of the total control and flexibility of Air Atomising and the T.E. and speed of Airless atomisation. The primary atomisation method used is airless (normally using 0.009" to 0.017" (0.23mm to 0.43mm)) , but by the use of multiple air jets at the gun head, the droplet size and its distribution is improved and the 'tails' eliminated far more easily, very often without the need to increase fluid flow. This equipment type uses H.P. pumps to supply the liquid, but normally only to a maximum of about 32:1 ratio typically producing pressures of 800psi to 2500psi (50bar to 170bar). Consequently the fluid viscosities sprayed and the fluid flows utilised are lower than with a pure Airless system. It is wrong to call this equipment a compromise between air atomising and airless, as it is really an equipment type in its own right. However its performance is a combination of the two, with successful atomisation and application of slightly higher viscosity coatings than air atomising, more rapid application of them and, most importantly, far less bounce-back than air atomising equipment. On some AAA Guns the fan size can be slightly altered by modification of air jet velocity and quantity, but the ability to infinitely vary the fan size to the same extent as an Air Atomising gun is not possible yet. Overall though, this equipment types very successful penetration into the wood and aerospace markets bears testimony to its ability to produce high quality finishes although, officially, its droplet size is slightly larger than that produced from air atomisation.

HP Family traits
With the increasing introduction of High Solids materials into the finishing market it may be assumed that their heavier rheology is better suited to High Pressure Equipment. This is perfectly true, but there is the counter argument that says that these materials require less liquid material applied to achieve the desired dry film build. It is often the case that the digital nature of the guns fluid needle mechanism, fluid flows and resultant finish quality when using some of these material counters this important requirement. For example – while OEM Yellow Goods (Earthmovers and Tractors) manufacturers use Air Assisted Airless equipment for finishing of large metal fabricated assemblies their suppliers of smaller fabrications and resin/composite components are forced through finish quality requirements to use the same finishing materials through Air Atomising Guns. Likewise, compliant solventbased and waterbased materials sometimes exhibit foaming or popping when applied using HP equipment. The higher the fluid pressure, the worse the problem. In the wood market it is common for Low pressure diaphragm pumps to be used in preference to avoid these problems and to give back extra control for intricate wooden components. Use of the small orifice tungsten carbide tips make blockage and plugging a constant threat and so extensive filtration of the coating is essential. To combat this problem 'twist' tips that can be easily unplugged have been developed. For high TE spray coating Airless and AAA equipment can only be bettered by the move to…

Electrostatic
While not normally an atomiser in its own right, this system brings a very important contribution to the spray finishing industry. Electrostatic attraction is something that can be coupled with all of the earlier described equipment types to increase their TE. Harold Ransburg started his first experiments in the 1930's but it was not until the 1950,s that the first truly operational piece of equipment was available for use. The principle of charging the atomised liquid negatively which, in turn, is attracted to a grounded surface or component (i.e. the opposite polarity) is easy to understand. This results in the bounce-back being reduced and 'reclaimed'. By use of electrostatic equipment coating costs can be reduced, workshop contamination can be reduced, paint can be sprayed around corners, coating times can be reduced… all true. However there are just a few conditions that must be met if all this is to come true. The component should be conductive, or should have a conductive element in close proximity to it for attraction to take place. Electrostatic attraction on tubes will take place providing that the spay fan of the fun is bigger than the diameter of the tube and that the velocity of the droplets is low enough to be influenced by the small attraction force present. Penetration into cut-outs and recesses is possible… providing that there is no other grounded surface to interfere with the desired flight path of the paint droplet. Waterbased coatings can be successfully applied, in some cases more easily that their solventbased counterparts, but there are a few additional hurdles to overcome and rules to be followed with this highly conductive liquid if success it to result. O the customers process has to meet certain conditions if all of the promise is to come true.

Electrostatic traits

How much is reclaimed depends upon the primary atomisation method and settings of the equipment. The lower the forward velocity and kinetic energy of the paint particle being projected from the front of the gun, the more likely the particle is to be deflected from its original course. Typically, however, this will result in 5 to 15% added to the original TE of the equipment.

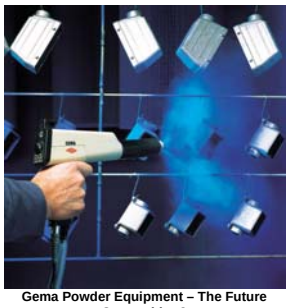
The visible evidence of electrostatic 'wrap-around' depends upon the type of component being coating. The greatest evidence is seen on tubular components of up to approx. 50mm diameter. It is possible that complete coverage will be possible from a single pass of the gun. However equal, if not better 'hidden' results are present on large flat surfaces. Not all liquid coatings are suitable for electrostatic application – the majority are, but don't assume that yours will present no problems.

And the greatest hurdle – the spray operator themselves! Unless the operator understands the various rules and procedures associated with electrostatic spraying they will be suspicious and uncertain of the equipment, and maybe even darn right dangerous to your spray coating operation! The performance of the equipment will increase in proportion to the operators knowledge and understanding.

Conclusions

So, there you have it – the main choices available to the spray finishing shop today. All of the above equipment has its automatic counterpart for use on robots and machines. The only reason that we've not discussed them here is time and space. Likewise the cost of purchase of the equipment discussed has had to be left unmentioned for the same reason. However its best to say that, in TE, you still get what you pay for. Many equipment manufacturers are now designing products that are Waterbased, as well as Solventbased, compatible. The market share of Waterbased materials is slowly growing, and not to do so will only do damage to their sales figures.

The range of spray equipment discussed has the ability to apply liquid coatings with various efficiencies and qualities. However the person behind the spray gun will always have the last word on the efficiency and performance of the equipment, whatever the designer intended. Poor operators can turn £1000's of equipment into an expensive White Elephant! With careful use of BSEN13966 and modern design and measuring equipment at last a true, and unbiased, comparison can be made of their different strengths and weaknesses. Together they can meet the finishers needs. Ahh, but liquid spray coating will always be wasteful and harmful to the environment I hear you say. True, I have no defence against this accusation. Modern liquid coatings are becoming better, with lower VOC content and the changeover to water as a carrier medium. However, at the end of the day, all liquid coatings are environmentally unfriendly. For those who would instantly turn to our Gema Powder Equipment Division and environmentally friendly powder coatings as the ultimate solution I would challenge them to find a powder coating that can be applied for such a huge range of film builds, colours, effects properties and different purposes as liquid coatings. ITW Finishing are confident that liquid spraying equipment is going to be needed for a long time yet and that they will have the liquid (and powder) application equipment to meet the future need.



Gema Powder Equipment – The Future Competition?