Design and Fabrication of automated cylindrical wall painting machine

A Project Report

Submitted by

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in partial fulfillment of the requirement in the subject of
(ME1357) Design and Fabrication Project

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APRIL-2008

BONAFIDE CERTIFICATE

Certified that this project report entitled "**Design and Fabrication of Automated Cylindrical Wall Painting Machine**" is the bonafide work of

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(INTERNAL EXAMINER)

(EXTERNAL EXAMINER)

ACKNOWLEDGEMENT

First and foremost, we pay our sincere and humble salutations to the almighty for equipping us with all the strength and courage throughout our venture in our project work.

We express our profound gratitude to Dr.S.Sivanandan , Head.Of.Department. Mechanical Engineering Department, Kumaraguru College of Technology for able stewardship.

We owe our sincere debt to Prof. S. Bhaskar, Asst. Professor, Mechanical Engineering Department, Kumaraguru College of Technology for all his efforts put into this project work. He was our guide and source of inspiration, without whose rich experience and able guidance the project would not have been a success.

Last but not the least our sincere most thanks are due to our beloved parents without whose guidance and ever persuading efforts this project work would have been a layman's chore.

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ABSTRACT

Painting of industrial components in earlier times was a tough task, especially if they were cylindrical. It required a large work force to perform the painting operation. The workers had to be skilled in order to achieve high precision and smooth finishes. Painting of such components in industries for mass production becomes a time consuming factor as the workers have to spend their energy to paint. This thereby increases the production period of the components.

The setup we have developed helps overcome these problems effectively, that too in the least complicated and the least expensive way. The construction is very simple and less time consuming. The effectiveness of the paint job is also increased at reduced cost due to the reduction in the quantity of the paints used and also the removal of the need to pay wages. Also, the quality of the finish and the uniformity in the job is noticeably appreciable. We thus would like to develop this setup in order to overcome all the difficulties involved and make the painting job cheap, easy, quick and very effective.

CHAPTER 1

Literature Survey

1. Spray Painting

Spray paint is an aerosol product designed to be dispensed as a fine mist. Compared to conventional brush methods of painting, spray painting is faster and provides a more uniform application. While industrial spray painting relies on special air compressors that break the paint particles into a fine mist, commercial spray paints are self-contained aerosol cans that use liquefied gasses to atomize the paint.

It is a painting technique where a device sprays a coating (paint, ink, varnish etc.) through the air onto a surface. The most common types employ compressed gas — usually air compressed by an air compressor — to atomize and direct the paint particles. Spray guns developed from airbrushes and the two are usually distinguished by their size and the size of the spray pattern they produce — with airbrushes being hand held and used instead of a brush for very fine work such as photo retouching, painting nails or fine art.

1.1 Conventional spray gun

A spray gun combines the coating (paint) and compressed air from a separate air compressor in order to atomize the coating and direct it to the target surface. The coating is held either in a small bottle or container attached to the spray gun or in a separate pressurized container attached to the spray gun with a hose. General rule of thumb is that this type of gun puts 1/3 of the coating on the substrate being coated and 2/3 into the air.

1.2 HVLP (High Volume Low Pressure)

This is similar to a conventional spray gun using a compressor to supply the air, but the spray gun itself requires a lower pressure (LP). A higher volume (HV) of paint is therefore applied at a lower air pressure. This results in more paint landing on the target surface instead of staying airborne. A regulator is often required so that the air pressure from a conventional compressor can be lowered for the HVLP spray gun.

As a rule of thumb this method puts 2/3 of the coating on the substrate and 1/3 in the air. True HVLP guns use 8–20 cfm and a minimum 5 hp industrial compressor is required. HVLP spray systems are used in the automotive, marine, architectural coating, furniture finishing, and cosmetic industries.

1.3 LVLP (Low Volume Low Pressure)

Like HVLP, these spray guns also operate at a lower pressure (LP), but they apply a low volume (LV) of coating (paint). This is a further effort at increasing the transfer efficiency (amount of coating that ends up on the target surface) of spray guns.

2. Tools of the old trade

The brush and the roller are the tools most readily associated with the painter. Recent advances in manufacture have led to a standardisation of brushes, with many older brushes falling from fashion.

The ground brush, also known as a pound brush, was a round or elliptical brush bound by wire, cord or metal. They were generally heavy to use, and required considerable usage to break them in. These brushes were predominantly used in the days before modern paint manufacture techniques; hand mixed paints requiring

more working to create the finish. These brushes still have use in applying primer; the brushes are useful in working the primer into the grain of the wood. Pound brushes required an even breaking in to create even bevel on both sides of the brush minimising the formation of a point which would render the brush useless.

Sash tools were smaller brushes, similar to a ground brush, and used mainly for cutting in sash or glazing bars found on windows.

Sash tools and ground brushes generally required bridling before use, and a painter's efficiency in this skill was generally used as a guide to their overall ability. Both these brushes have largely been superseded by the modern varnish brush.

Varnish brushes are the common flat brushes available today, used for painting as well as varnishing. Brushes intended for varnishing typically have a beveled edge.

Distemper brushes, used for applying distemper, were best made of pure bristle and bound by copper bands to prevent rust damage. Styles differed across the world, with flat nailed brushes popular in the North of England, a two knot brush (a brush with two ovular heads) popular in the South of England, and three knot brushes or flat head brushes preferred elsewhere. In the United States distemper brushes were known as calcimine, kalsomine or calcimine brushes, each term being the U.S. variant of distemper.

Fitches are smaller brushes, either ovular or flat and 1 inch wide, used in fine work such as to pick out the detail on a painted molding.

Stipplers come in various shapes and sizes and are used to apply paint with a stippled effect.

A duster or jamb brush was used to dust the area to be painted before work commenced.

Lime wash brushes were large brushes with a triangular head used to apply lime wash.

Stencil brushes, similar in style to a shaving brush and used for the purpose of stenciling walls or in the creation of hand-made wallpapers.

Brushes are best stored in a purpose made brush keeper, a box on which a wire could be suspended: the wire would be threaded through the hole in a brushes handle so as to suspend the brush in a cleaning solution without allowing the brush to sit on the bottom of the container and thus cause spreading of the bristles. The solution would also prevent hardening of the brushes and oxidization. These were generally rectangular and stored several brushes. A lid would enclose the brushes and keep them free from dust.

The airless spray gun is the latest tool in the painter's closet. It's powered by an electric, pneumatic or fuel powered motor which pumps paint through a hose into a gun which atomizes the paint to a fine spray. Graco is the leading manufacturer of this type of spray gun and equipment for contractors. With the airless spray gun it's possible to paint extremely large areas of surface in a short time.

3. Paints

Paints are liquefiable, or mastic composition which after application to a substrate in a thin layer is converted to an opaque solid film.

Paint is used to protect, decorate (such as adding color), or add functionality to an object or surface by covering it with a pigmented coating. An example of protection is to retard corrosion of metal. An example of decoration is to add

festive trim to a room's interior. An example of added functionality is to modify light reflection or heat radiation of a surface. Another example of functionality would be the use of color to identify hazards or function of equipment and pipelines.

As a verb, painting is the application of paint. Someone who paints artistically is usually called a painter or artist, while someone who paints commercially is often referred to as a painter and decorator, or house painter.

Paint can be applied to almost any kind of object. It is used, among many other uses, in the production of art, in industrial coating, as a driving aid (road surface marking), or as a barrier to prevent corrosion or water damage. Paint is a semi finished product, or intermediate good as the final product is the painted article itself.

Paint can also be mixed with glaze to create various textures and patterns. This process is referred to as faux finish and is quite popular with discerning homeowners, architects and interior designers.

CHAPTER 2

DESCRIPTION OF COMPONENTS

2.1 Lead screw

Screw

A screw is a shaft with a helical groove or thread formed on its surface and provision at one end to turn the screw. Its main uses are as a threaded fastener used to hold objects together, and as a simple machine used to translate torque into linear force. It can also be defined as an inclined plane wrapped around a shaft.

Lead screw

A lead screw is a screw specialized for the purpose of translating rotational to linear motion. The mechanical advantage of a leadscrew is determined by the screw pitch or lead.

A lead screw nut and screw mate with rubbing surfaces, and consequently they have a relatively high friction and stiction compared to mechanical parts which mate with rolling surfaces and bearings. Their efficiency is typically only between 25 and 70%, with higher pitch screws tending to be more efficient. A higher performing, and more expensive, alternative is the ball screw.

The high internal friction means that lead screw systems are not usually capable of continuous operation at high speed, as they will overheat. Due to inherently high friction, the typical screw is self-locking (i.e. when stopped, a linear force on the nut will not apply a torque to the screw) and are often used in applications where back driving is unacceptable, like holding vertical loads or in hand cranked machine tools.

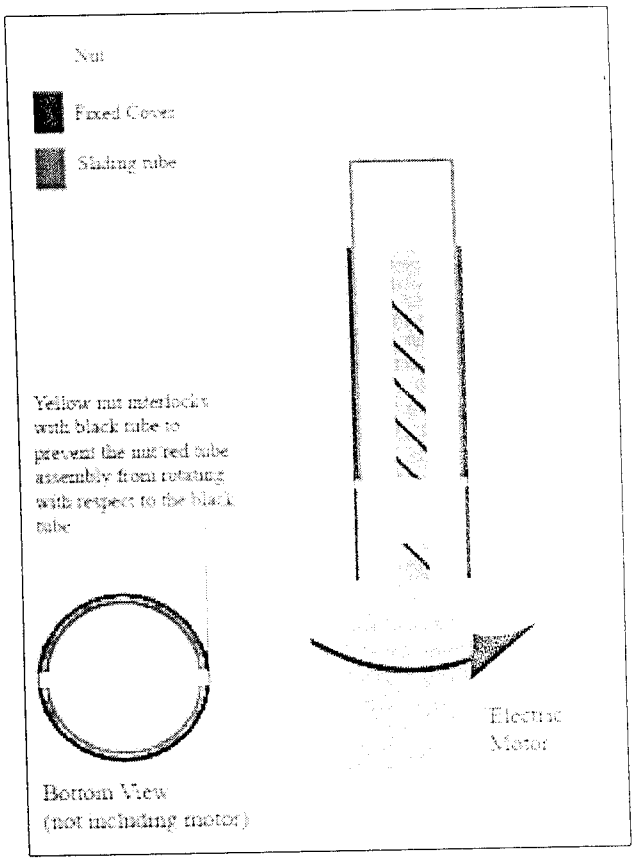
Lead screws are typically used well greased, but, with an appropriate nut, it may be run dry with somewhat higher friction. There is often a choice of nuts, and manufacturers will specify screw and nut combinations as a set.

Lead screw threads typically have an Acme profile. Backlash can be reduced with the use of a second nut to create a static loading force known as preload.

Lead screws are distinguished from other forms of linear transmission systems mainly by their reproducibility, their non-slip properties, high resolution and low installation dimensions. The precision of a transmission system depends largely on the quality of the drive screw and its nut. High efficiency, linearity, consistent torque and a long service life are factors which - although in principle mutually exclusive - together form the ideal characteristics of a perfect transmission system.

The static properties of the screw and nut assembly itself are determined by multiple, often conflicting factors: Minimal flank backlash between the nut and screw means optimum reproducibility but at the same time places increased demands on the screw thread geometry. A higher bearing percentage on the screw flanks improves axial load-bearing capacity and service life on the one hand, but is reflected on the other hand by greater sensitivity of the screw-nut system to production tolerances.

2.2 Illustration of the Screw Transmission Principle



2.3 Electric motor

An electric motor uses electrical energy to produce mechanical energy. The reverse process, that of using mechanical energy to produce electrical energy, accomplished by a generator or dynamo. Traction motors used on locomotives often perform both tasks if the locomotive is equipped with dynamic brakes. Electric motors are found in household appliances such as fans, refrigerators, washing machines, pool pumps, floor vacuums, and fan-forced ovens.

The AC induction motor is a rotating electric machine designed to operate from a three-phase source of alternating voltage. The stator is a classic three phase stator with the winding displaced by 120°. The most common type of induction motor has a squirrel cage rotor in which aluminum conductors or bars are shorted together at both ends of the rotor by cast aluminum end rings. When three currents flow through the three symmetrically placed windings, a sinusoidally distributed air gap flux generating the rotor current is produced. The interaction of the sinusoidally distributed air gap flux and induced rotor currents produces a torque on the rotor. The mechanical angular velocity of the rotor is lower then the angular velocity of the flux wave by so called slip velocity.

2.3.1 Three Phase Motor

Three-phase electric power is a common method of electric power transmission. It is a type of polyphase system mainly used to power motors and many other devices. A three-phase system uses less conductor material to transmit electric power than equivalent single-phase, two-phase, or direct-current systems at the same voltage.

In a three-phase system, three circuit conductors carry three alternating currents (of the same frequency) which reach their instantaneous peak values at different times. Taking one conductor as the reference, the other two currents are delayed in time by one-third and two-thirds of one cycle of the electrical current. This delay between "phases" has the effect of giving constant power transfer over each cycle of the current, and also makes it possible to produce a rotating magnetic field in an electric motor.

Three phase systems may or may not have a neutral wire. A neutral wire allows the three phase system to use a higher voltage while still supporting lower voltage single phase appliances. In high voltage distribution situations it is common not to

have a neutral wire as the loads can simply be connected between phases (phase-phase connection).

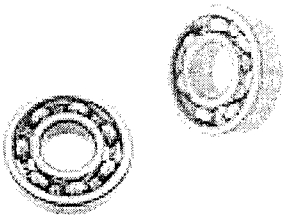
Three phase has properties that make it very desirable in electric power systems. First, the phase currents tend to cancel out one another, summing to zero in the case of a linear balanced load. This makes it possible to eliminate the neutral conductor on some lines; all the phase conductors carry the same current and so can be the same size, for a balanced load. Second, power transfer into a linear balanced load is constant, which helps to reduce generator and motor vibrations. Finally, three-phase systems can produce a magnetic field that rotates in a specified direction, which simplifies the design of electric motors. Three is the lowest phase order to exhibit all of these properties.

Most domestic loads are single phase. In North America and some other countries, three phase power generally does not enter domestic houses at all. Even in areas where it does, it is typically split out at the main distribution board.

2.4 Gear box

A reduction gear box is used. The main reason behind employing this gear box is to reduce the speed on the shaft as excessive shaft speeds on a threaded shaft may be disruptive to the action of the nut sliding along the length of the shaft. The gear reduction ratio is 1:5. The input speed from the motor is fed to the gear box by means of a belt drive. The speed of the motor is reduced from 1440 rpm to just around 720 rpm by means of a pulley belt drive. This speed is input to the gear box. The output speed obtained from the gear box is just around 150 rpm. The lead screw rod is coupled to the output shaft of the gear box by means of a suitable coupling arrangement. The casing of the gear box is manufactured out of cast iron.

2.5 Bearing



The bearing used is of the type SKF 6204. The bearing is used mainly to support the motion of the lead screw rod at the upper support plate provided at the top of the lead screw rod. The bearing helps the rod rotate freely about its own axis. This is done by the ball arrangements provided between the outer layer of the inner lining and the inner layer of the outer lining. Hence the bearing body remains stationary while the inner layer rotates in accordance with the screw rod inserted into it.

2.6 Belt drive

The belt drive used is of the open type and the material used is rubber. Rubber belts are made up of plies of fabric impregnated with vulcanized rubber and synthetic rubber. The main advantage of these belts is that they can easily be made endless. Saw mills, chemical plants, and paper mills largely use the rubber belts.

An open belt drive is provided in order to transmit power from the motor to the gear box. Two pulleys, one at the end of the motor shaft and another at the end of the gear box input shaft, are fitted. After the suitable belt is designed, it is fitted to the above mentioned pulleys. The belt drive helps transmit power to parallel shafts at a distance of 300 mm. more over a speed reduction of the order 1:2 is also performed by choosing the driven pulley diameter(fitted at the gear box input shaft end) twice that of the driver pulley diameter.

DEVICE SET- UP

SPRAY PAINTING MECHANISM

The device consists of two separate primary components:

- **The Paint Holding Setup**

  This setup consists of an electric motor which is run by the primary source of power. The rotation of this high speed motor is required to be reduced to the necessary level. For this purpose, a speed reduction gear box is used. The gear train is coupled to a vertical threaded lead screw rod which is enclosed in a rigid frame. A support rod provided is bridged to the screw rod by means of a shaft whose one end slides over the lead screw by means of a nut. A spray gun with paint tank fitted to an air compressor is mounted on the shaft. As the screw rod turns the spray gun traverses in the vertical direction

- **The Component Rotating Setup**

  The cylindrical component is rotated by means of a hand wheel coupled to the stand containing it by means of bevel gear. The gear ratio is selected depending upon the level of fine finish required. For lower fine finishes a gear ratio of 1:1 can be chosen. For accurate surface finishes, a higher gear ratio can be selected.

CHAPTER 5

BILL OF MATERIALS

Table 5.1

Sl. No.	PART NAME	DESCRIPTION	MATERIAL	No. OF
1	Lead Screw	Pitch 4 mm	Mild Steel C45	1
2	Support Rod	Dia 26 mm	Mild Steel C45	1
3	Motor	3 Phase, AC Supply	-	1
4	Gear Box	(1:5)	-	1
5	Deluxe Spray Gun		-	1
6	Steel frame	(420 x 315 x 230)	Mild Steel	2
7	SKF 6204 Bearing	ID 20 mm		6
8	Bevel gear pair	Speed Ratio 1:1	Mild Steel C45	1
9	Hand wheel	Hub Shaft dia 20mm	Steel	1
10	Emulsion paint		-	350 ml
11	Air Compressor	(2-4 bar pressure)	-	1
12	Tube	-	Plastic	10m
13	Pulley	Groove dia 50 mm	Mild Steel C45	2
14	Belt		Rubber	1
15	Shaft	Dia 20 mm	Mild Steel C45	2
16	Support Pieces	Thickness 3mm	Mild Steel C45	-

DESIGN CALCULATIONS

1. MOTOR TORQUE CALCULATION

Power of the motor = P = 0.5hp = 400W
Speed of the motor = N = 1500rpm.

a) Torque of the motor

$$T = \frac{Px60}{2\pi \times N}$$

$$= \frac{400 \times 60}{2\pi \times 1500}$$

$$T = 2.546 \text{ N.m}$$

b) Torque for turning the slider

$$T = F \times r$$

$$= (1.5 \times 9.81) \times 0.15$$

$$T = 2.39 \text{N.m}$$

Where,

F- Force on the screw rod in N
r - Distance between the screw rod and the spray gun.

c) Input torque to the gear box (Tgi)

As the speed reduction in the belt drive is 1:2
Tgi = 5.092N.m

d) Torque developed in the gear box (Tgo)

As the speed reduction in the gear train is 1:5,
Tgo = 25.46 N.m

2. BELT DRIVE CALCULATIONS

Speed of the pulley 1, N1 = 1500 rpm
Speed of the pulley 2, N2 = 750 rpm
Diameter of pulley 1, d1 = 50.8 mm
Diameter of pulley 2, d2 = 101.6 mm
Centre distance between two pulleys, c= 300mm

a). Velocity of the belt v,

$$v = (\pi d1 N1)/60$$

$$v = \frac{\pi x 50.8 x 10^{-3} x 1500}{60}$$

v =3.98m/sec

For this velocity, a belt with 3 plies is selected.

Load rating = 9.2 x 10 kw/mm/ply

b). Design power

$$\text{Arc of contact} = 180° - \frac{(d1-d2)}{c} \times 60°$$

$$\theta = 169.84°$$

Arc of contact factor, $K\alpha = 1.04$
Load correction factor, Ks = 1
Small pulley factor, Kd =0.5
Rated Power = 400W
Design Power $= \frac{\text{Rated power x Ks}}{K\alpha \times Kd}$

Design power = 770 W

c). Length of the belt (L)

$$L = 2C + \frac{\pi}{2}(d1 + d2) + \frac{(d1-d2)^2}{4c}$$

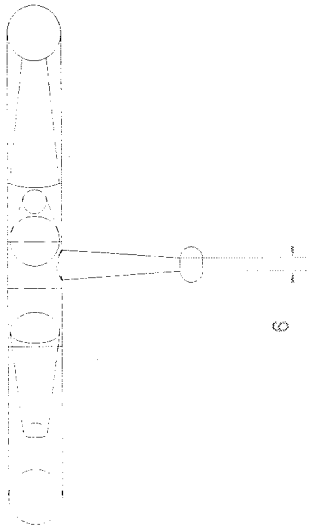
L = 841.53 mm

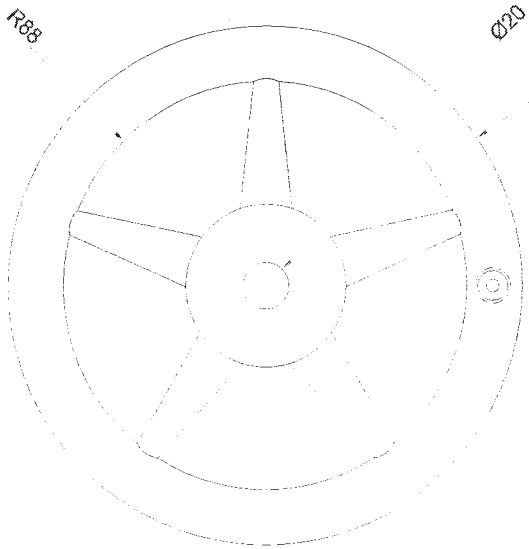
CHAPTER 6

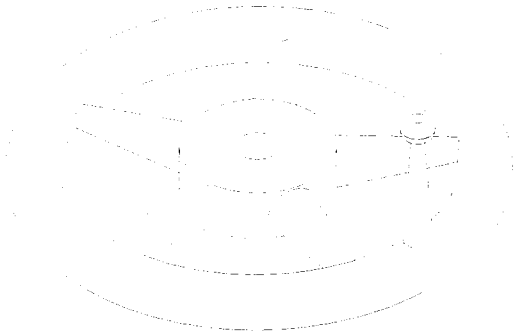
LIST OF DRAWINGS

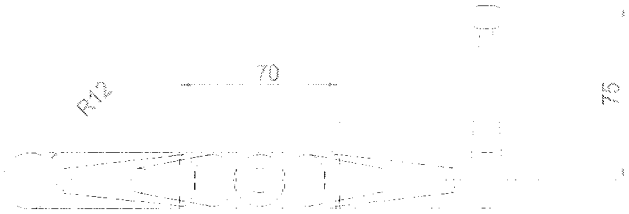
Table 6.1

DRAWING NO.	DRAWING NAME	PAGE NO
1	Assembly view	
2	3-Phase Motor	
3	Gear Box	
4	Lead Screw	
5	Slider Arrangement	
6	Pulley	
7	Top Plate	
8	Hand Wheel	
9	Work piece Holder	
10	Bevel Gear	
11	Component Frame	
12	Set Up Assembly View	









ALL DIMENSIONS ARE IN 'mm'

Checked by	Approved by - date	Date
	SCALE - 1:0.3	4/7/2008

NONMANUAL CYLINDER PAINTING APPARATUS

HAND WHEEL

Edition

Sheet 1 / 1

CHAPTER 8

Practical Applications & Advantages:

- The set up developed is capable of painting cylindrical components in a very accurate manner.
- The set up reduces the need of skilled labour in industries for painting.
- Powder coating, nickel coating and other coating processes which need skilled workers to operate it is possible even with the use of raw hands.
- The painting time is reduced by a large factor.
- Mass production in industries is made possible.
- The worker exhaustion which causes lack of accuracy is eliminated.
- Since the distance between the paint spray gun and the work component remains constant, the spray of paint is uniform.
- The screw rod motion and the use of a three phase AC induction motor allows for two layer coating ensuring the paint spray in the exact same path in both the upward and downward motion.
- The level of maintenance required for the set up is very less and simple. The support rod needs to be greased regularly for the free movement of the bush. The lead screw rod needs to be oiled regularly.

CHAPTER 9

CONCLUSION

9.1 Advantages:

- Finer accuracy and paint finishes are obtained.

- The need for skilled labour is reduced for an intricate process is eliminated.

- The space occupied by the set up is very less.

- Large components can be painted with an unnerving accuracy and at one go without any need for a break.

- Worker supervision is minimal.

- Mass production is made possible.

- LVLP Spray Gun use of lower volume of air finely atomizes paint creating a smooth finish with minimum overspray. This means very little overspray will be produced, saving on paint cost and environmental hazards.

- LVLP (Low Volume, Low Pressure) Spray Gun can operate at less than 10 psi at the nozzle cap as compared to HVLP which operates at 10 psi at the air cap and is usually pushed higher.

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