The level of automation in powder coating using the example of movement technology
Comparing reciprocators, axis technique and robots

The high level of automation in powder coating is particularly clear from the movement technology used. To achieve an optimal coating quality, movement systems for the powder guns are now used in 95% of all automatic installations. The advantage: the moving guns enable a better distribution of the film thickness than a rigid gun arrangement. By targeted positioning and guidance of the guns with the applicable controller, the wish is to reduce the proportion of over spray to as close to zero as possible.

The movement technology on offer is as varied as the requirements of the market. Sometimes different systems are combined with each other even within one installation, in order to increase the level of automation. The illustration below shows the systems available.

See Table 1 (Appendix):

Further examination will exclude pneumatically operated axes as these are only used very rarely today.

Fig. 1.: System with reciprocators and parts sensing in front of the booth

Fig. 2: Multi-axis system with Z axes and rotary axis for each gun

Fig.3 Multi-axis robot system with twin gun for coating forklift truck sub-assemblies

Fig.4 Multi-axis system with Z axes and rotary axis for each gun

The criteria for the selection of movement systems are:

1. Size of work piece.
2. Geometry of work piece.
3. Planned level of automation for the coating.
4. Qualification of the plant personnel.

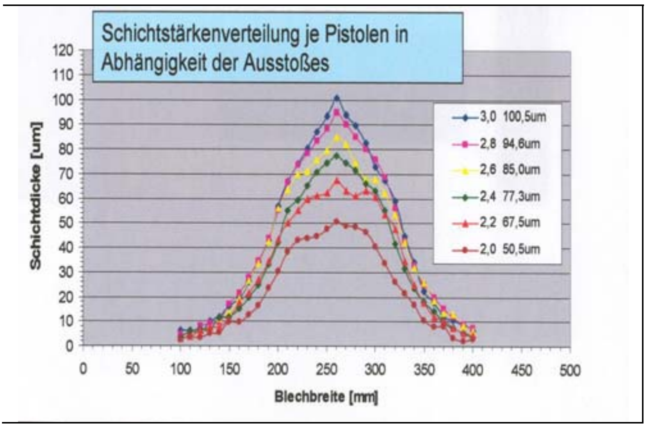
See Table 2 (Appendix):

Parameters which affect coating:

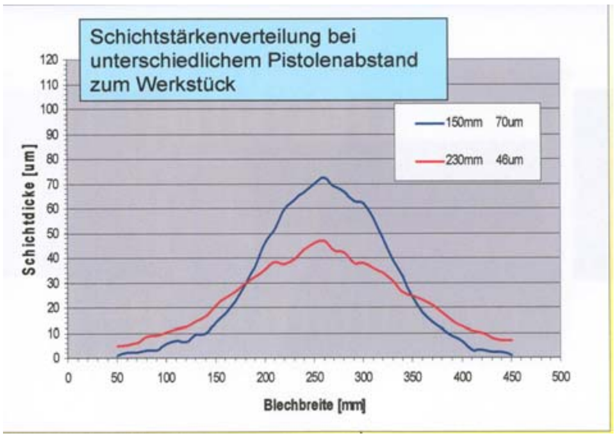
The powder coater however does not to ask the application supplier to deliver a specific piece of movement equipment, but rather a solution to his problem. This can be formulated was simply: to coat a specific number of work pieces or surfaces in a specific time, with little waste, little use of manual coaters and high quality.

The application supplier is thus asked to work out a suitable movement concept taking account of the existing budget. Along with the individual project designing however some of basic parameters always apply which are influenced by the movement technology. These have to be taken into account in the project design for the plant.

1. The right visible surface rating:
For each powder gun there are empirical values to which specific output rates have to be logically set relative to the work piece being coated a (e.g. flat components, profile sections) per period. The appropriate movement unit must be selected to suit the total number of guns arising from this. If the powder output is set too high, this is at the expense of increased wear (=high operating costs) and a poor distribution of the film thickness (Figure 5*).*



2. The right gun distance:
Here the following relationships can be named:
Distance too great:
Low penetration power into corners and edges.
Magnification of the picture frame effect.
Lower film thickness.
Greater over spray.
Distance too small:
Blow off effect.
Poor distribution of the film thickness
The effect of the gun distance on the film thickness and distribution is shown in Figure 5.



With an axis system and multi-axis robot, the gun distance can be filed optimally as a program parameter. For reciprocators on which several guns are fitted in groups, only the overall group can be set. This is achieved by an automatic depth control with which the whole reciprocator unit is run to a pre-defined distance from the work piece.

3. The right speed for the movement technology.

The speed of movement of a gun should from experience lie in a range of 20 - 40 cm/sec. With axis systems this speed can be set individually. With the most widespread reciprocator systems however the stroke speed is superimposed on the conveyor speed. This gives a so-called resultant sine curve. To get an optimal overlap of the individual tracks the right number of strokes must be calculated. An example of the result from this type of calculation is shown in Figure 6.

Sinusberechnung

Kunde: ______________________ Datum: 20.06.05

Pistolenabstand	300	mm		
Pistolenanzahl	2	Pistolen		
Förderergeschwindigkeit	7	m/min	117 mm/sec	8,6 sec/m
Hubhöhe	175	mm		
Werkstücke (siehe unten)	Abkantungen (20-30mm)			

k-Faktor	1	2	3	4	5	6	7	8	9	
mögliche Sinuseinstellungen		23,3		46,7		70,0		93,3		DH/min
HG Geschwindigkeit		14		27		41		54		cm/sec
HG Geschwindigkeit		8		16		25		33		m/min
Bahnabstand		150		75		50		38		mm
Weg (Fö) pro Doppelhub		300		150		100		75		mm/DH
Zeit pro Doppelhub		2,57		1,29		0,86		0,64		sec/DH
Zeit pro Einzelhub		1,29		0,64		0,43		0,32		sec/EH

	guter Bereich			mittlerer Bereich			schlechter Bereich		
HG Geschwindigkeit	20	40	cm/sec	40	50	cm/sec	50	1000	cm/sec
Sichtflächenleistung	0	0,8	m²/P/min	0,8	1	m²/P/min	1	1000	m²/P/min
Bahnabstand	0	75	mm	75	150	mm	150	1000	mm

Fläche ○
Abkantungen (20-30mm) ●
Profile ○

4. Avoidance of powder wastage.

The aim here is to spray powder only when a work piece is coming or to spray only in the direction of the work piece. This is the only way to avoid an unnecessarily high proportion of over spray. In multi-colour systems in over spray is separated out through the cyclone, but only to the level of the specific cyclone efficiency for. The relationship between application efficiency (over spray) and cyclone efficiency is a purely mathematical function and is shown in Figure 7. From the sample calculations it becomes clear that the primary goal must be to avoid over spray. With axis systems this is mostly always the case. Here application efficiencies of up to 80% are possible. In installations with standard reciprocators the primary controller has to help, in only switching on the guns when the work piece is in front of the gun. The lowest proportion of over spray is achieved by a combination of gap and height control. With gap control the guns are switched off automatically between two work pieces.

Tabelle für Pulververlust

Einflussparameter auf auf den Pulververlust

Beispiel:		1	2	3	4
Auftragswirkungsgrad Werkstück	AWG_{eff}	25%	30%	35%	40%
Abscheidegrad Zyklon		95,0%	95,0%	95,0%	95,0%
Ausstoß[g/min]/Pistole		180	180	180	180
Anzahl Pistolen		12	12	12	12
Umlauf[kg/min]		2,2	2,2	2,2	2,2
Rückgewinnung[kg/min]		1,5	1,4	1,3	1,2
Verlust[kg/min]		0,1	0,1	0,1	0,1
Verbrauch[kg/min]		0,5	0,6	0,8	0,9
Verlust[%]		13,0%	10,4%	8,5%	7,0%
Verlust/Schicht(7h)[kg]		34	32	29	27
Verlust/Jahr (230Tg./4€/kg) [€]		31298	29212	27125	25039

Einfluss Auftragswirkungsgrad und Zyklonabscheidegrad

$$\text{Verlust} = \frac{(1 - \text{Auftrag})^*(1 - \text{Abscheide})\ [\%]}{\text{Auftrag} + (1 - \text{Auftrag})^*(1-\text{Abscheide})}$$

	Abscheidegrad							
Auftrag	99,0%	98,0%	97,0%	96,0%	95,0%	94,0%	93,0%	92,0%
90,0%	0,11%	0,22%	0,33%	0,44%	0,55%	0,66%	0,77%	0,88%
80,0%	0,25%	0,50%	0,74%	0,99%	1,23%	1,48%	1,72%	1,96%
70,0%	0,43%	0,85%	1,27%	1,69%	2,10%	2,51%	2,91%	3,31%
60,0%	0,66%	1,32%	1,96%	2,60%	3,23%	3,85%	4,46%	5,08%
50,0%	0,99%	1,96%	2,91%	3,85%	4,76%	5,66%	6,54%	7,41%
45,0%	1,21%	2,39%	3,54%	4,66%	5,76%	6,83%	7,88%	8,91%
40,0%	1,48%	2,91%	4,31%	5,66%	6,98%	8,26%	9,50%	10,71%
35,0%	1,82%	3,58%	5,28%	6,91%	8,50%	10,03%	11,50%	12,94%
30,0%	2,28%	4,46%	6,54%	8,54%	10,45%	12,28%	14,04%	15,73%
25,0%	2,91%	5,66%	8,26%	10,71%	13,04%	15,25%	17,36%	19,35%
20,0%	3,85%	7,41%	10,71%	13,79%	16,67%	19,35%	21,88%	24,24%
15,0%	5,36%	10,16%	14,53%	18,48%	22,06%	25,37%	28,40%	31,19%
10,0%	8,26%	15,25%	21,26%	26,47%	31,03%	35,06%	38,65%	41,86%
5,0%	15,97%	27,54%	36,31%	43,18%	48,72%	53,27%	57,08%	60,32%

Der Abscheidewirkungsgrad ist abhängig von der Pulverpartikelgröße. Speziell kleiner 10 µm sinkt der Abscheidegrad verhältnismäßig stark.

Quelle: Wagner/PM/Topp

With height control this even happens during the lifting movement or respectively with a vertical gun arrangement each gun is assigned a height range. The gun will then only be switched on when there is a work piece within this height range. Position measurement systems must be installed in the movement system for this, so that the right position or ON/OFF switching commands can be given through a work piece sensor.

Along with these parameters, which can be influenced by suitable movement technology, there are of course many others such as e.g. earthing, powder composition, nozzle systems, flow characteristics, charging, to name only a few. The effects of these however will not be explained here.

This summary is intended to contribute to a general understanding of the use of movement technology and to give the user a checklist for critical questions to application suppliers.

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