FILM COATINGS

OPAGLOS® 2

High Gloss Film Coating System

Technical Data

Poster Reprint

Determination Of Critical Process Parameters On The Application Of An Aqueous, High Gloss Film Coating System

Charles F. Vesey and Kurt A. Fegely, New Products Development, Colorcon West Point, PA

Objectives

To use a statistically-designed set of experiments to evaluate the individual and interactive effects of critical process variables on both the elegance of film coated tablets and the overall coating application process.

Methodology

Employing the use of a design of experiment (D.O.E.) technique, an experimental plan was developed to assist in investigating the effects of several film-coating process variables on the elegance of film-coated tablets. An O'Hara Technologies Labcoat II 24" side-vented coating pan, equipped with two Schlick nozzles (model # 930-33), was used for all coating runs.

Coating Pan Experimental Process Variables

		Range	
Variable Name	**Units**	**Low Level**	**High Level**
Atomization Air Pressure	psi	15	50
Pattern Air Pressure	psi	0	55
Gun-to-Bed Distance	inches	2	5
Spray Rate	$gmin^{-1}$	55	75
Inlet Air Temperature	°C	60	90
Process Air Flow	cfm	200	325

The process parameter ranges selected were designed to encompass and exceed those settings typically used with the particular coating equipment used in the study. All other process variables were held constant.

The CARD® software package by S-Matrix was used to generate a computer algorithm design. This design enabled our New Products Development (NPD) group to quantify all significant variable effects, including linear, curvilinear, and non-linear effects. The software generated an experimental design of 51 coating trials. Included in the design were five replicate pairs for purposes of determining experimental error.

All coating trials in the experiment used 11 mm double radius, 500 mg placebo tablets. A total batch weight of 17.0 kg was used for each coating trial.
The coating solution used in the experiment was a developmental high gloss film-coating system.
Response variables examined were gloss, surface roughness, product bed temperature, coating process efficiency (CPE), and film coating uniformity (CU).

Response Variable	Units
1. Gloss	GU
2. Surface Roughness	Ra
3. Product Bed Temperature	°C
4. Coating Process Efficiency	%
5. Film Coating Uniformity	mg

Determination Of Response Variable Values

Gloss

Following the spray coating process, tablets were analyzed for gloss using a Model 801A Gloss Analysis System (Tricor Systems, Inc). This system enables gloss measurement to be made regardless of the shape, texture, or color of samples to be analyzed. This system provides the experimenter with a reliable and consistent means to undertake a quantitative analysis on a traditionally qualitative property of coated tablets. Operation of this instrument is explained in greater detail elsewhere.(1)

Surface Roughness

Surface roughness measurements were performed on tablets using a Surfcorder, model SE-40G from Kosaka Laboratory LTD.

Surface roughness of film coated tablets can be quantified by determining various characteristic values, the most commonly used being arithmetic mean surface roughness (Ra). This may be defined as the arithmetic mean value of the departure of the roughness profile above and below a central reference line over a measured distance.(2)

The following is a graphic illustration of this concept

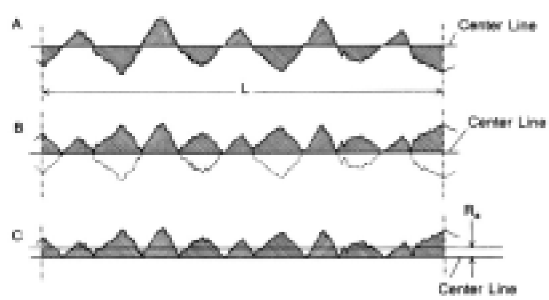


FIGURE 1.
GRAPHICAL DERIVATION OF R_a
(A) Profile with center line
(B) Lower portions of profile inverted
(C) R_a is the mean height of the profile

Ra is calculated according to the following

$$Ra = \frac{1}{l}\int_0^l |y(x)|\,dx$$

Following spray coating, twenty randomly selected tablets from each coating trial were used to determine surface roughness of that batch. A 1.0 mm transverse length with a 0.1 mmsec-1 drive speed and 0.8 mm cutoff were used in all tests.

Product Bed Temperature

Product bed temperature data were obtained from an average of recorded values collected during each coating trial using an infrared thermometer.

Coating Process Efficiency (CPE)

CPE is generally defined as a measure of the determined actual coating applied expressed as a percentage of the theoretical amount of coating intended to be applied. CPE is computed as:

$$CPE = \left[\frac{wg_a}{wg_t} \right] \times 100\%$$

where wgt is the theoretical percent weight gain and wga is the actual percent weight gain, which is computed as:

$$wg_a = \left[\frac{wt_a - wt_b}{wt_b} \right] \times 100\%$$

where wtb and wta are the total batch weights before and after coating respectively.(3) All measurements were corrected for moisture content.

Film Coating Uniformity (CU)

CU is generally defined as the variation in weight gain of coated tablets within a coating trial. For the purposes of this experiment, CU will be expressed as the first standard deviation of the weight gain variation in milligrams and is calculated by:

$$sd = \sqrt{\frac{\sum \left[\left(wt_a - wt_b \right) - \bar{x} \right]^2}{n - 1}}$$

Where wta and wtb are the weights of the individual tablets after and before coating, respectively, n is the number of tablets measured and x is the average weight gain of the n measured tablets from the coating trial. (3) Again, all measurements were corrected for moisture content.

In each experimental trial, 100 tablets were marked to allow for tracking and retrieval of individual tablets by a method described in greater detail elsewhere.(4)(5) This method provided an effective means of determining the coating uniformity in each coating run thereby allowing the assessment of process changes on coating uniformity.

Results

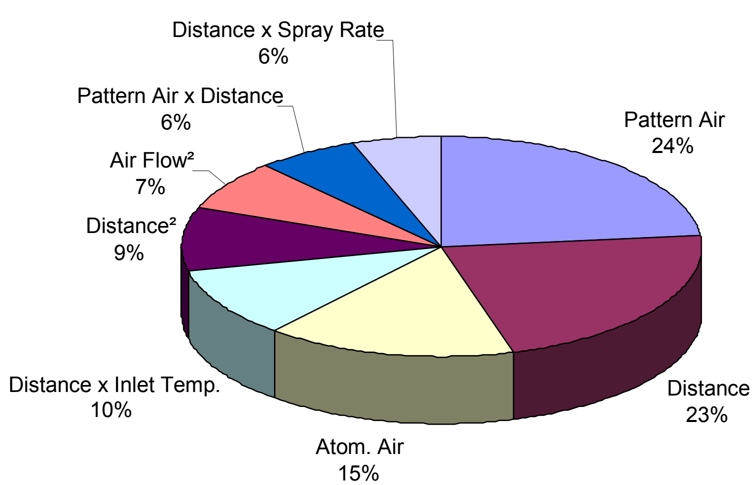
Summary Of Ranges In Values Of Response Variables Obtained

Response Variable	Units	Range
1. Gloss	GU	160 - 248
2. Surface Roughness	Ra	1.7 - 3.8
3. Product Bed Temperature	°C	29 - 65
4. Coating Process Efficiency	%	76 - 98
5. Film Coating Uniformity	mgs	0.7 - 4.1

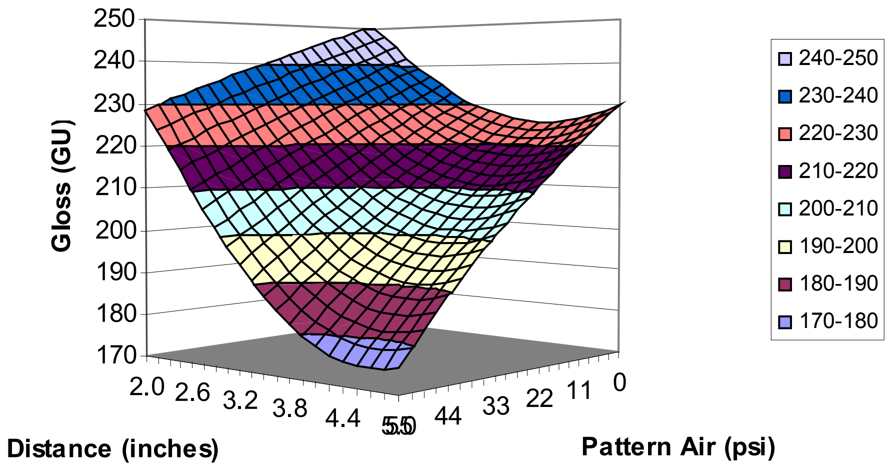
The CARD Analysis of Data software was used for the analysis of response data. As part of the analysis output, variable effect terms are ranked based on the relative strengths of their effects on the response being analyzed. Pie charts are used to illustrate this in each case. Response surface graphs were also generated comparing the interactive effects of the process variables on the individual responses.

1. Gloss

Rank Order Of Influence Of Process Variables On Gloss



Influence Of Pattern Air Pressure & Gun-to-Bed Distance On Gloss
Atomization Air = 33 psi; Spray Rate = 65 gmin^{-1}; Inlet Temp. = 75°C;
Air Flow = 263 cfm



Gloss values obtained ranged from 160 - 248.

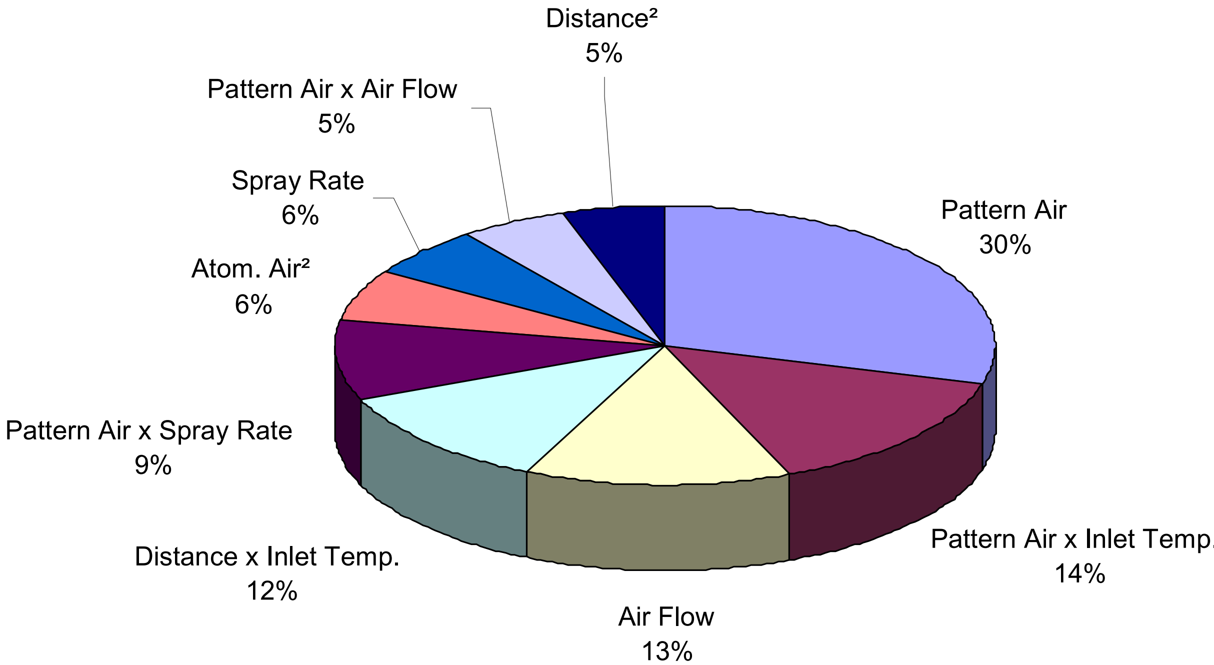
Rank order of influence indicates that gun-to-bed distance, pattern and atomization air pressures accounted for the majority of effects on gloss.

Increasing the gun-to-bed distance and/or pattern air pressure resulted in decreasing gloss values. This effect is likely to result from an increase in the incidence of a condition known as "spray drying" which can produce a dulled tablet finish.

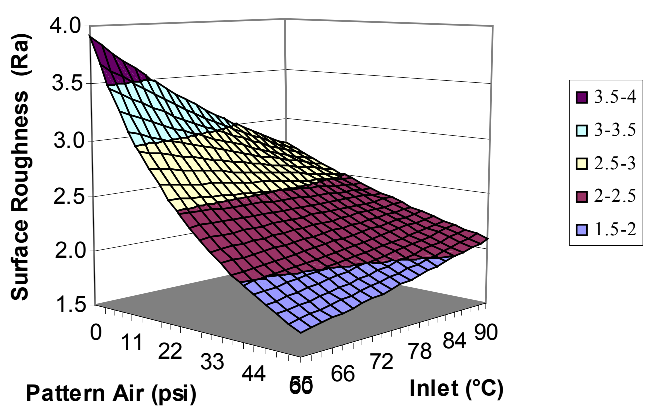
Increasing the gun-to-bed distance resulted in a longer distance a droplet of coating solution is required to travel, prior to impingement with the tablet bed leading to increased drying of droplets. Increasing pattern air pressure, which changes the shape of the spray pattern generated from a solid cone to an elliptical shape, will also increase travel distance.

Increases in atomization air pressure produced higher gloss values by increasing the momentum of the atomized droplet, thereby reducing droplet travel time and potentially increasing impact spreading of the droplets, once they make contact with the tablet surface.

Rank Order Of Influence Of Process Variables On Surface Roughness



Influence Of Pattern Air Pressure & Inlet Air Temperature On Surface Roughness
Atomization Air = 33 psi; Gun-to-Bed Distance = 3.5''; Spray Rate = 65gmin^{-1}; Air Flow = 263 cfm



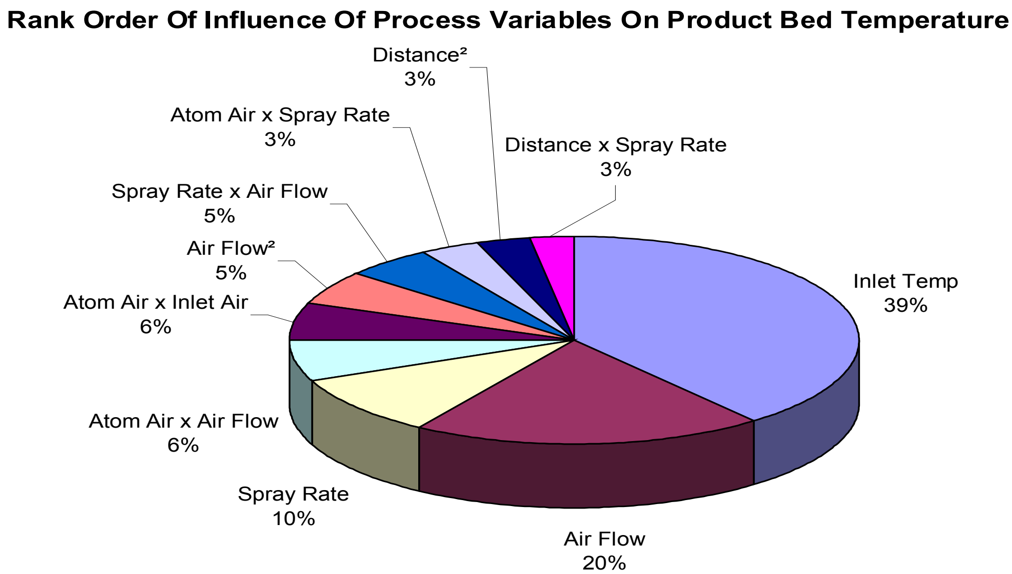
Rank order of influence indicated that no single process variable demonstrated a dominant effect on the resulting surface roughness. However, pattern air pressure did figure prominently as an individual and interactive affector.

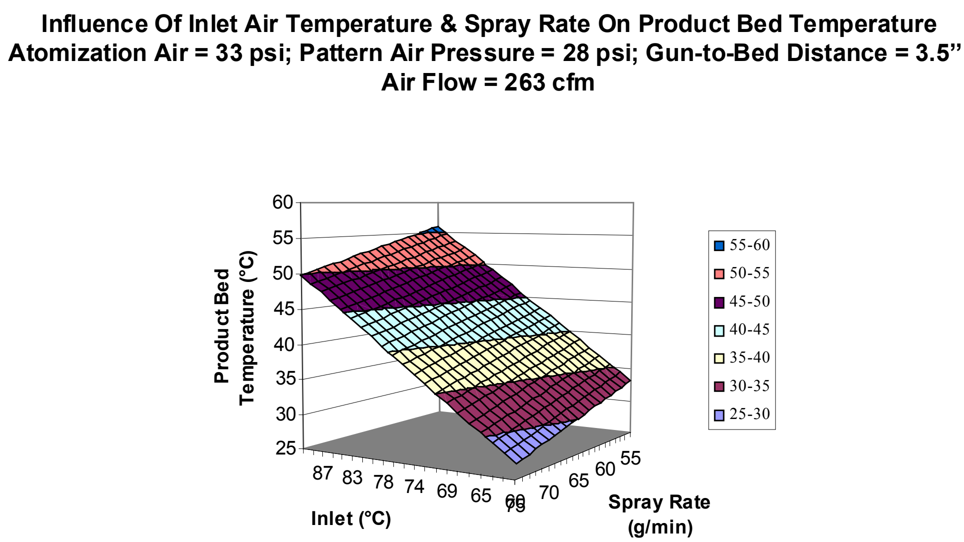
An increase in pattern air pressure resulted in a decrease in surface roughness. This observation is contradictory to results noted elsewhere.(6) And to the results for the effect of pattern air pressure on gloss. Increases in pattern air pressures have been associated with decreases in spray droplet momentum that can inhibit smooth coalescence of droplets.

To explain these results, it is postulated that an excessive droplet velocity may have led to a splattering of the coating solution at the point of impact with the tablet bed. Droplet fragments which left the initial point of impact would have had a significantly lower mean velocity than initially. It is these droplet fragments that may have impacted other tablets and not fully coalesced, which lead to a rougher coating.

Other process parameters that could have led to droplet fragmentation are decreased gun-to-bed distance and coating solu
viscosity.

3. Product Bed Temperature





Product bed temperatures ranged from 29 - 65°C.

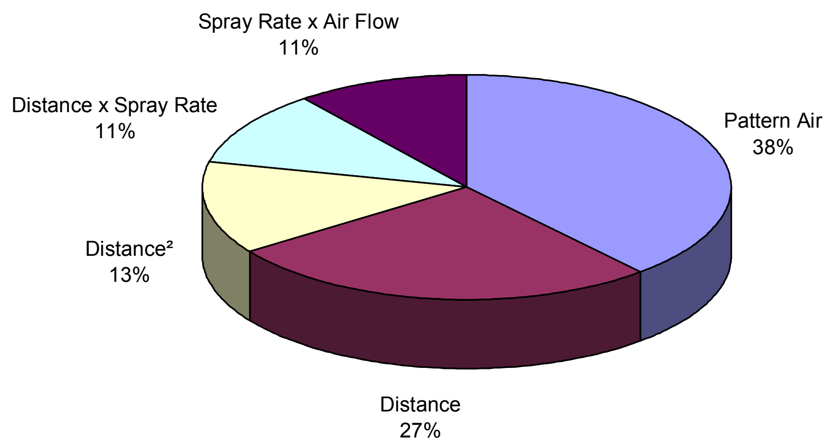
Inlet air temperature, air flow volumes, and spray rates accounted for the majority of effects on product bed temperature.

Increases in inlet air temperatures or volumes resulted in increases in product bed temperatures, as expected.

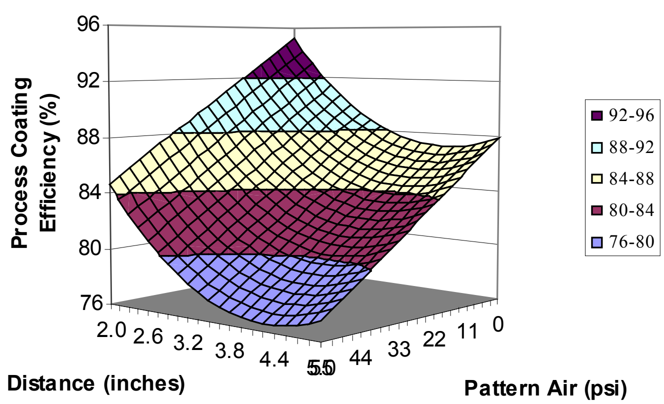
Increases in coating-solution spray rates lead to decreases in product bed temperatures.

4. Coating Process Efficiency

Rank Order Of Influence Of Process Variables On Coating Efficiency



Influence Of Pattern Air Pressure & Gun-to-Bed Distance On Coating Efficiency Atomization Air = 33 psi; Spray Rate = 65 gmin^{-1}; Inlet Air Temperature = 75°C; Air Flow = 263 cfm

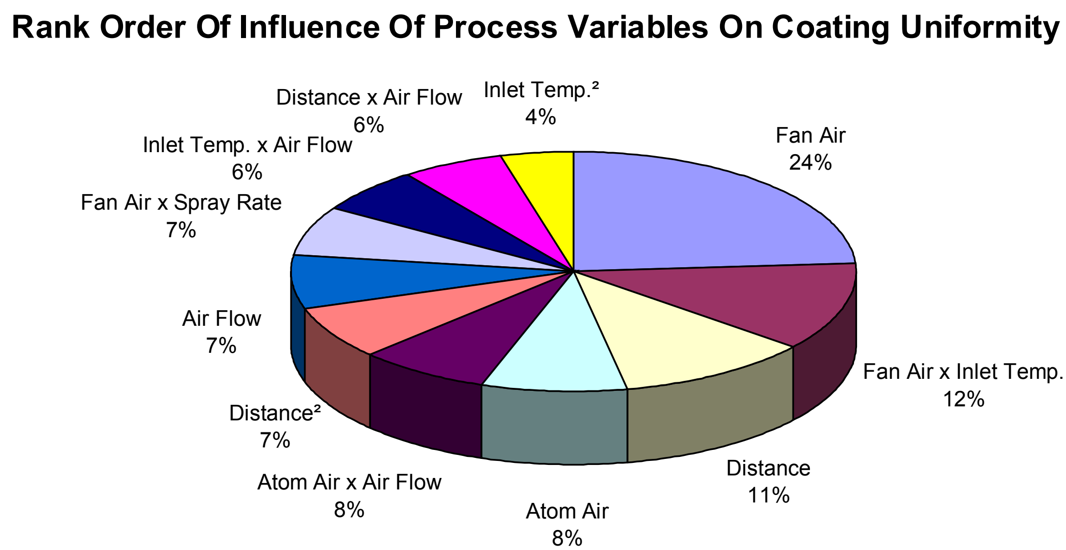


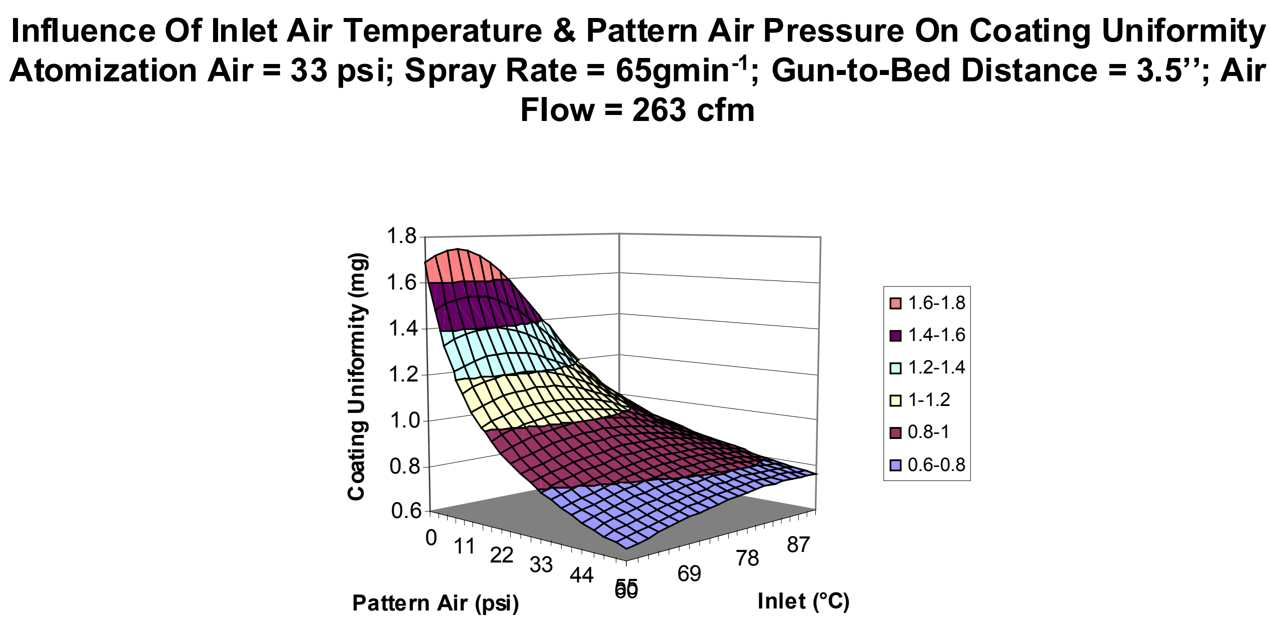
Process coating efficiency values ranged from 76 to 98%.

Rank order of influence indicates that pattern air pressure and gun-to-bed distance accounted for 78% of the effects on coating efficiency.

Not surprisingly a shorter gun-to-bed distance and lower pattern air pressures, ensuring complete delivery of coating material to the product bed, resulted in higher process coating efficiencies.

5. Coating Uniformity





Coating uniformity values ranged from 0.7 - 4.1 mg with an ideal coating level being 25mg.
Rank order of influence indicates that no single process variable demonstrated a dominant effect on coating uniformity.

Highest film-coating uniformities were achieved at moderate gun-to-bed distances and higher pattern air pressures.

Conclusions

The results obtained in this study illustrate how the coating process conditions selected can influence both product quality and the thermodynamics of the coating process.

Results help identify some of the processing conditions necessary to produce the desired high gloss film coating, while maximizing coating uniformity and coating process efficiency.

Information presented in this study also demonstrates that process coating conditions necessary to obtain one aspect of the desired final dosage form appearance may not compare favorably with those needed to produce other appearance aspects.

Understanding such effects provides the foundation for designing a smooth, glossy, highly elegant film coated pharmaceutical dosage form.

References:

Tricor Systems Inc., "Model 801A Surface Analysis System," User's Manual 1.1 (1996)
G. Cole, J. Hogan, and M. Aulton, "Film Coat Quality," Pharmaceutical Coating Technology 13, pp 363-406, 1995
C.A. Signorino and L.J. Forcellini, "Evaluating the Uniformity of Aqueous Film Coating," Pharmaceutical Technology 10, pp 48-53, 1996
S.C. Porter, R.P. Verseput, C.R. Cunningham, "Process Optimization Using Design of Experiments," Pharmaceutical Technology 10, pp 60-70, 1997
G.L. Fourman, C.W. Hines, and R.S. Hritsko, "Assessing the Uniformity of Aqueous Film Coatings Applied to Compressed Tablets," Pharmaceutical Technology 19(3), pp 70-76, 1995
T.L. Reiland and A.C. Eber, "Aqueous Gloss Solutions: Formula and Process Variables Effects On The Surface Texture Of Film Coated Tablets," Drug Development And Industrial Pharmacy, 12(3), pp 231-245, 1986

Acknowledgments
The authors are grateful to Robert Gottschalk, Karen Hunsberger, and Susan Schriver for their assistance with this project.

World Headquarters
Colorcon
415 Moyer Blvd., P.O. Box 24, West Point, PA 19486-0024
Tel: 215-699-7733 Fax: 215-661-2605 Website: www.colorcon.com

Locations	Telephone	Facsimile
United States		
Santa Ana, California	714-549-0631	714-549-4921
Indianapolis, Indiana	317-545-6211	317-545-6218
Humacao, Puerto Rico	787-852-3815	787-852-0030
Stoughton, Wisconsin	608-887-8970	608-887-8984
Canada		
St. Laurent, QC, Canada	514-337-8341	514-337-9159
Europe		
Dartford, Kent, England	44-1322-293000	44-1322-627200
Massy, France	33-1-6447-9750	33-1-6932-5983
Idstein, Germany	49-6126-9961-0	49-6126-9961-11
Gallarate, Italy	39-0331-776932	39-0331-776831
Budapest, Hungary	36-1-200-8000	36-1-200-8010
Istanbul, Turkey	90-216-465-0360	90-216-465-0361
Barcelona, Spain	34-9-3589-3756	34-9-3589-3792

Locations	Telephone	Facsimile
Asia/Pacific		
Singapore	65-6438-0318	65-6438-0178
Fuji-gun, Shizuoka, Japan	81-5-4465-2711	81-5-4465-2730
Shanghai, China	86-21-5442-2222	86-21-5442-2229
Goa, India	91-832-288-3434	91-832-288-3440
Gyeonggi-do, Korea	82-31-296-2173	82-31-296-2178
Latin America		
Buenos Aires, Argentina	54-11-4552-1565	54-11-4552-3997
Cotia, Brasil	55-11-4612-4262	55-11-4612-3307
Bogota, Colombia	571-418-1202	571-418-1257
Caracas, Venezuela	58-212-237-9842	58-212-238-2259
Cuajimalpa, D.F., México	52-55-3000-5700	52-55-3000-5701 /02

fc_poster_opaglos2_process_prarmeters_06.02 Ver. 1