PARAMETER OPTIMIZATION FOR SPRAY PYROLYSIS DEPOSITION

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Abstract: In this paper is presented researches in the field of increasing the uniformity of the thin film. The aim of the research is to evaluate the dynamic behavior of the deposition system used. To obtain the homogeneous thin films widely used in applications it is necessary that the nozzle spraying trajectory to be established such as to promote uniform film deposit. For the process of simulation creates a closed loop in which input parameters from MATLAB affect the simulation of ADAMS and output parameters from ADAMS affect the input level of control system.
Key words: spraying trajectory, thin film, dynamic model, control system

1. INTRODUCTION

In this paper is presented researches in the field of increasing the uniformity of the thin film. The aim of the research is to evaluate the dynamic behavior of the deposition system used. For the process of simulation creates a closed loop in which input parameters from MATLAB affect the simulation of ADAMS and output parameters from ADAMS affect the input level of control system.

A sprayer is simulated as a spraying cone. The precursor solution is delivered from the nozzle with a small angle from the center axis "z", fig. 1. A2-D profile is resulted which reflect the thickness of the deposition when the sprayer is moved in a straight line at constant velocity over the plan. In accordance with the profile, the distance between the two ways of the trajectory should be adjusted to achieve certain uniformity [Manolache et al., 2007].

2. SPRAYING SYSTEM

In this part of the paper the spraying system was describing. To develop thin film uniformity is very important to approve the thin. To obtain the homogeneous thin films widely used in applications [Sheng et al., 2001], it is necessary that the nozzle spraying trajectory to be established such as to promote uniform film deposit, to spraying over the entire surface of the substrate. Homogeneity and film thickness can be controlled by the number of sprayings. Film thickness depends on the distance between spraying nozzle and substrate, substrate temperature, concentration of precursor solution, the amount of precursors spraying solution and spraying rate. Mainly, film thickness can be controlled by the number of consecutive sprayings. A trajectory in the spraying process includes the sprayer direction and the velocity with which this is shifted. The trajectory generation problem becomes how to find a percentage of the spray overlap and spraying velocity since the orientation can be determined using the method of generating direction.

Spraying velocity and percentage of the spray overlap are generated by optimizing the spraying process in a plan. Figure 1 shows the spraying cone of the nozzle, the accumulation of the solution in "w" point on the plan while the nozzle is

moving. For each point of the plan are at most two proximity trajectories contributing to the thickness of the coating point. The spraying velocity can be expressed as a function of overlapping for an average of thickness given. The used method can be applied for to optimize the overlapping and the rate of sprayer.

The profile spraying zones are generated by using a function of film accumulation rate. Specific expression of a function can be derived by changing the formula (1). The expression for deposition rate of spraying *f* to a point of surface *s* which is surrounded by a border of perpendicular intersections between the spraying cone and the surface (1), [Potkonjak et al. 2000]:

$$f(s, X(t)) = f_1(R) \cdot f_2(R),$$

$$f_1(R) = \frac{C(\Omega_1)}{R^2},$$

$$C(\Omega_1) = \frac{Q}{2 \cdot \pi \cdot \int_0^{\Omega_1} g(\Omega)(\sin\Omega / \cos^3\Omega)}, \quad (1)$$

$$f_2(\Omega) = \begin{cases} 1, & \Omega < \Omega_0 \\ 0.5\left[1 + \cos\left(\frac{\Omega - \Omega_0}{\Omega_1 - \Omega_0}\pi\right)\right], & \Omega_0 \le \Omega < \Omega_1 \\ 0, & \Omega \ge \Omega_1 \end{cases}$$

where Q (m^3/s) is spraying rate applied to the sprayer, H (m) is nozzle height from the surface, Ω *(radian)* is the angle between the nozzle and the cone axis point to the surface s, Ω_0 and Ω_1 are nozzle axis angles for the inputs and outputs of spraying cone. Function $f_2(\Omega)$ indicates that the spraying cone includes regions with different distributions of deposition: in a certain region of input deposition is proper than in a region of output because the deposition distribution decreases like a sinus [Potkonjak et al. 2000].

Coating thickness F for any point s is result of spraying pyrolysis deposition throughout the whole movement of the sprayer $X(t)$:

$$F(s) = \int_0^T f(s, X(t))dt, \quad (2)$$

where T is the time of spraying, specifying that accumulation continues only when the point is inside the spraying cone.
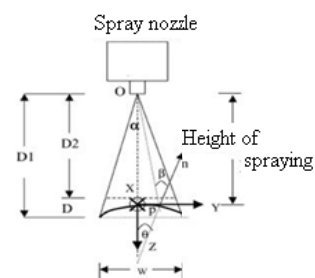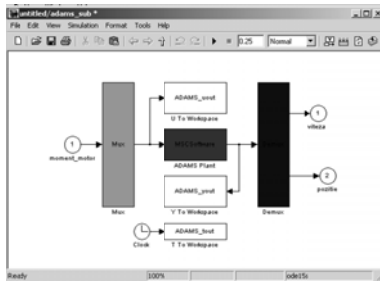

Fig. 1. Spraying cone of the nozzle

Fig. 2. Control block from Simulink

In figure 2 is represented the block diagram of inputs and outputs virtual prototyping for the application deposition where is used a robot. The spraying principle is based on the input data referring to the motor torque of the spraying system. Output variables of the system are the position and the velocity.

The nozzle has to have two translations: one on the X axe and one on Y axe. For simulating the real behavior of the spraying system, in order to obtain more realistic results, we have developed the control system, in the concurrent engineering concept, using ADAMS/Control and MATLAB/Simulink. For connecting the mechanical model and the control system, the input and output parameters have been defined. The control torque developed by driving motor represents the input parameter in the mechanical model. The outputs, which are transmitted to the controller, are the position and velocity.

Information about the input/output parameters are saved in specifying format files of MATLAB software (*.m).

ADAMS software can also generate the command file type (*. cmd) or (*. adm) which will be used during the simulation. With these files the control block was created in Simulink in order to make the link between control and mechanical system (fig. 2.).

3. CONTROL SYSTEM

ADAMS supports motor torque from MATLAB and adapts mechanical model like a response to these parameters. Meanwhile, ADAMS provides position and velocity for MATLAB to be integrated in Simulink model.

This process of simulation creates a closed loop in which input parameters from MATLAB affect the simulation of ADAMS and output parameters from ADAMS affect the input level of control system [Getting started using Adams/Control, MSC Software Publisher, 2005] and [Getting started using Adams/View, MSC Software Publisher, 2005].

In this case, what is studied, it used a motor torque as an input variable, a spraying position and velocity for output variables. Upon completion of the mechanical connection between the mechanical model and control system, it obtained the characteristics diagrams which are evaluating the dynamic behavior of the deposition system used. In the figures 3 are represented in report with time the torque variations (fig. 5.8. e), the angular velocity (fig. 3. *a, b*), the end-effector positions (fig. 3. *c, d*). Figures 3. *a, c* and *e* are distributions of variables provided by MATLAB-SIMULINK, and figure 3. *b* and *d* are provided the software ADAMS-View after the block simulation realized in MATLAB software.

4. CONCLUSIONS

The application is a relevant example regarding the implementation of the virtual prototyping tools in the design process of the spraying systems. One of the most important advantages of this kind of simulation is the possibility to perform virtual measurements in any point or area of the spraying systems, and for any parameter (motion, force and energy).
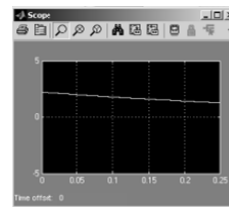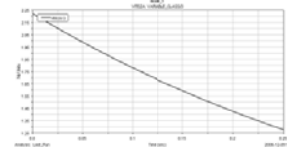

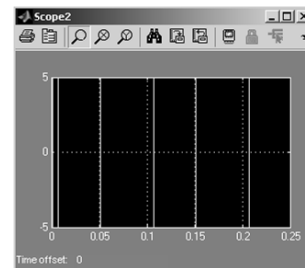a. Position – Matlab
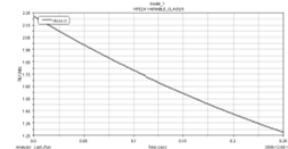
b. Position - ADAMS/View
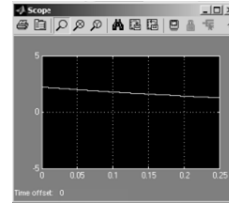
c. Velocity – Matlab

d. Velocity - ADAMS/View

e. Torque - ADAMS/View

Fig. 3. Input and output from ADAMS/View and Matlab

The optimization based on the optimum field for position and velocity leads to an efficient spraying system, without developing expensive hardware prototypes. The aim of the following researches is to model the control spraying system for figured surfaces having like aim the rising of the deposition technique efficiency.

5. ACKNOWLEDGEMENTS

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