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Paper Flow Simulation Using Abaqus

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Abbreviations :

| | |
|-----|------------------------|
| GSM | Grams per square meter |
| RPM | Rotations per minute |

Keywords : Paper Flow path, Explicit Dynamics, Skew.

Abstract

Paper transport is one of the areas under media handling methods where papers are transported by rollers through different path ways. The challenge in media handling is to transport the paper smoothly with out jam or in-plane deviation (paper skew). The smooth flow of paper is influenced by grade of paper, complexity of flow path, roller speed, roller pre-loads and significantly the roller material. It is also costly and difficult to develop a physical flow path testing. Hence, there is a high demand for computer simulation to study the paper flow behavior under different path configurations. In this study a typical printer flow path is considered for paper transport simulation and is carried out with different grades of papers. This study also determines the under driven and overdriven conditions of the paper through a flow path configuration. The paper flow simulation is carried in Abaqus V6.8. The Analysis results and lessons learned from this simulation in Abaqus are presented here.

Introduction

Analysis of contact is commonly performed in ABAQUS. In this study we have simulated the paper transport through thin channels with complicated contour in a printing machine. In these machines the paper is often pushed from a channel with no constraint on the leading edge from the time it leaves the channel until it reaches the next guide in the process. The paper is supported as a cantilever structure between the guides. In addition, if the paper is very flexible in bending under the gravity load, the paper undergoes large displacement, large rotation due to changing in boundary condition and push through nip rollers while transport. Because of the possibility of large deflections, this leads to a geometrically nonlinear problem.

The motivation for this work comes from high speed printers. The speed of the paper in these machines can approach two meters per second. We use the simulation to study the effects of different system parameters on the motion of the paper. These include the velocity at which the sheet exits the channel, accelerations to this "transport" velocity, exit angle, and sheet rigidity, etc. Results indicate that dynamic loads have a considerable influence on sheet trajectories.

Methodology

A Dynamic Explicit Analysis is carried out in both 2D & 3D space. A4 size paper of 350GSM (0.3949 mm thick) is considered for simulation. Based on the Fundamental flow path design considerations each pair of rollers consists of one Rigid (Idler) and Rubber (Drive). The analysis time is estimated as per flow path length and the roller RPM. Preload of the rollers are considered for the simulation to study the behavior of the paper motion between a set of rollers. Both Drive and Driven rollers are free to rotate about its own axis. The Drive rollers are rotating at constant speed with the applied angular velocity while the Driven Rollers are applied with the spring preload.

Friction between papers to Roller is 0.5, Roller to Roller is 0.5 & Guide to Paper is 0.2. The gravity effects are considered in the simulation. Paper flow speed = 100 Papers/min. The paper is modeled as beam elements with rectangular section properties in 2D case and shell elements in 3D case. The paper material is considered as linear elastic isotropic. Paper initial curl and skew also included in the simulation. Guides are considered to be rigid. For the Rubber material an incompressible Neo-Hookean Material model is used with the material constant of $C10=0.5N/Sq.mm$.

The Paper flow behavior in side the Paper Path channels, Potential stubbing points, influence of different parameter on the paper trajectory, curl paper behavior, skew correction on the paper are studied and reported.

Result Discussion:

In this study two cases of

- a. 2D - Paper path simulation
- b. 3D - Paper path simulation

have been analyzed. Accordingly two models were built, one in 2D & the other one is in 3D space according to the Paper path design. In both cases the paper is applied with gravity load while it is in side the thin channels of the Paper path.

a. 2D Paper Path simulation

Figure 1 shows the sketch of the typical paper path that is being used to transport paper from a printing machine to a finishing machine. The design comprises of transport rollers that pick the paper from the printer and transport through the nip rollers in side the thin channel paper path and pass it through another set of rollers called pre registration and registration rollers in a buckle chamber where paper buckles and skew correction happens. The main focus of the 2d analysis has been 300gsm paper as the stiffness of the 300gsm paper is meant that buckles could be formed and whether slip occurs in the pre-registration rolls figure 2 & simulation depicts the paper flow behavior inside this paper path design. – derive force on the pre registry, the registration nip force required to prevent the sheet opening the nip and pushing through, buckle levels and timings of these outputs provides a means of validation to the designs. Figure 2 also shows the simulation could be used for testing of the ability of the design to handle extreme levels of curl.

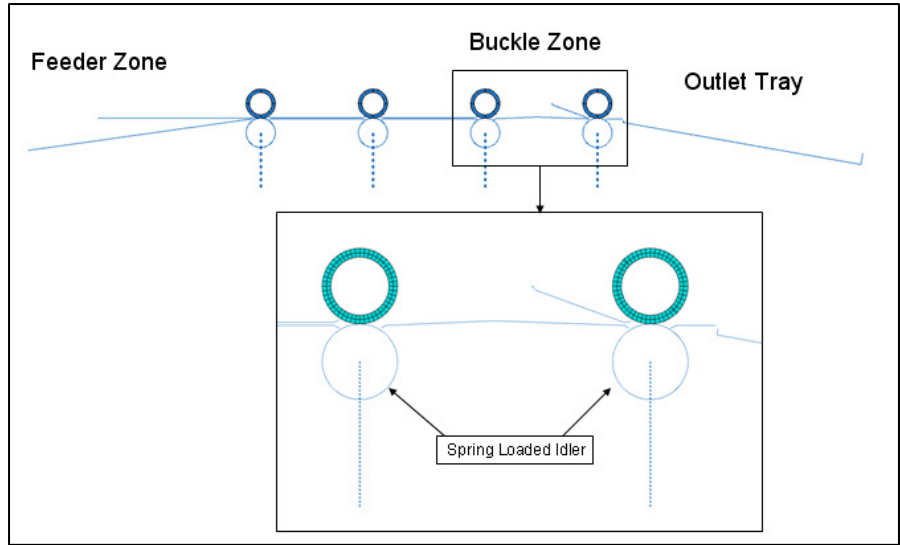


Figure 1 : Typical flow path

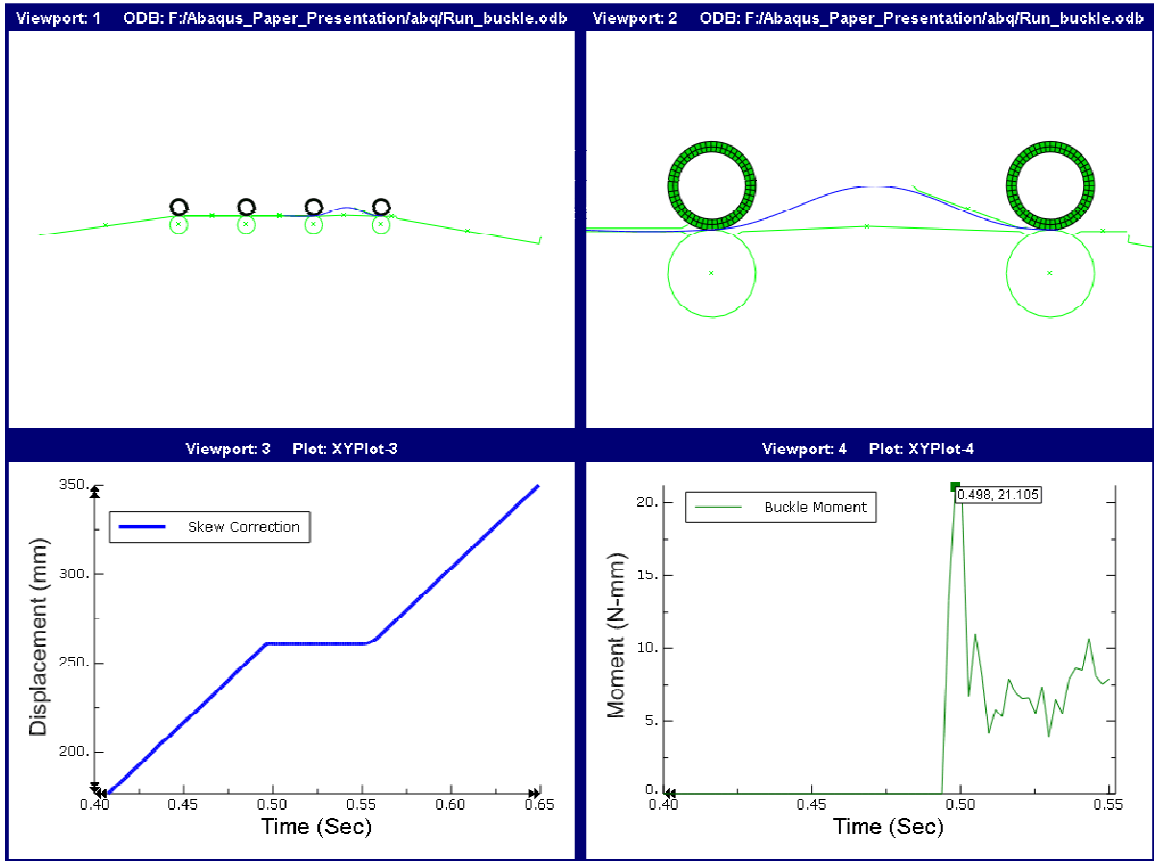


Figure 2 : 2D Buckle

b. 3D Paper Path simulation

Figure 3 shows the typical paper path in 3D space. As the models are in 3D, the relative de-skewing performance is possible to predict. As such, the following outputs were also used to validate the designs:

The required drive force of the pre-registry rolls to create the buckle, buckle chamber design to accommodate the length of buckle feed for the 300gsm paper, the length of buckle feed for the 300gsm paper to fill the paper path and corrects the skew, buckle chamber design to accommodate the length of buckle feed for the 300gsm paper, the length of buckle feed that would create slip at the pre-registry before the 300gsm fills the paper path, the registration nip force required to prevent the sheet opening the nip and pushing through. Figure 4 and 5 shows the pre-registry slip and registry nip force results from the two designs. Slip occurs when the buckle becomes large enough to fill the paper path as shown in the screen shot.

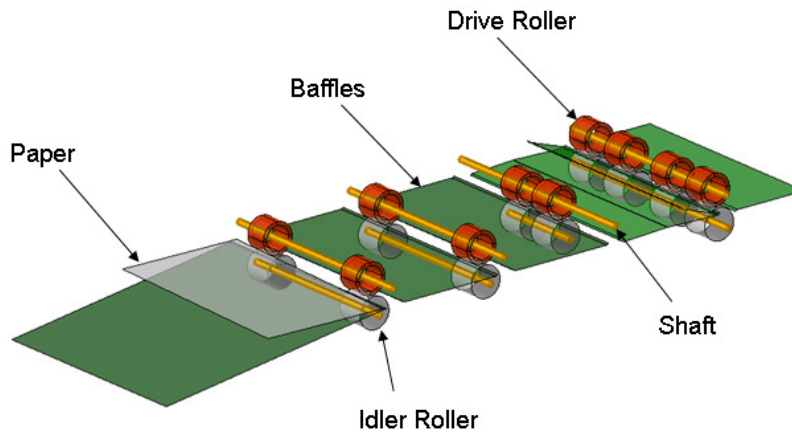


Figure 3: Typical flow path in 3D space

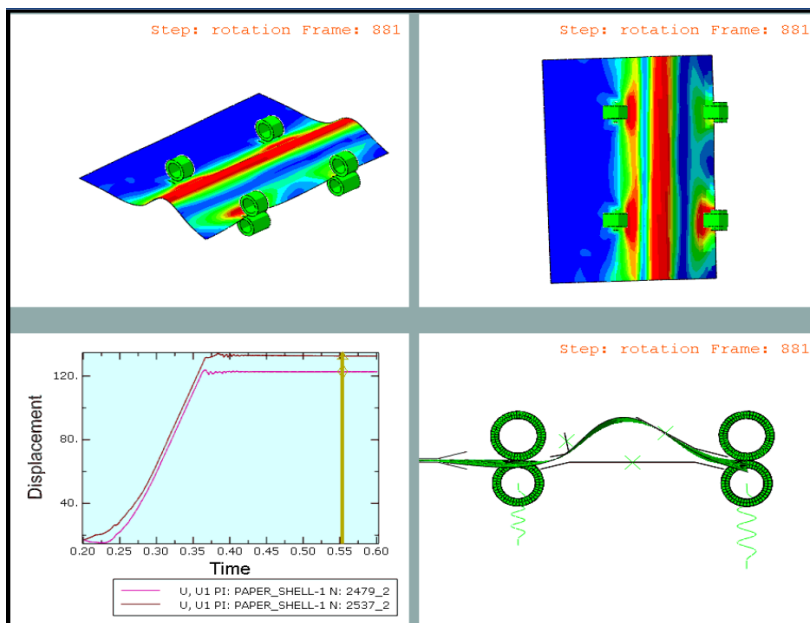


Figure 4: 3D Buckle Contours

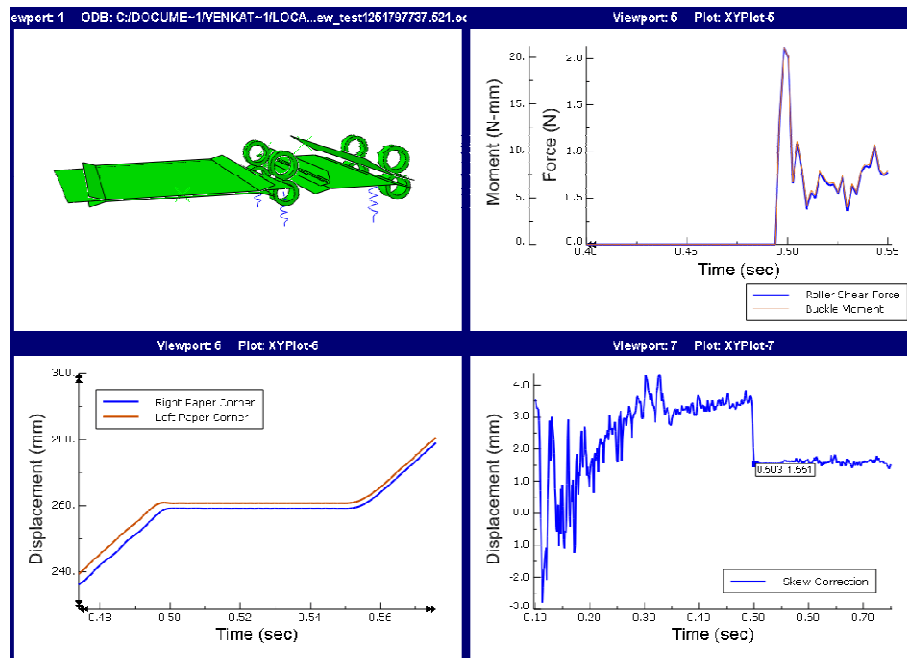


Figure 5: 3D skew measurement

Benefits Summary

Abaqus analyses can be used to simulate paper flow path design there by predicting the stubbing points at the early stage of design, further to this Choosing appropriate roller diameter. this simulation helps in Justifying the appropriateness of the guide path and the roller positioning. reducing the number of physical testing and improving the product design prior to prototype construction. Virtual simulation can be made more efficient in concurrent engineering of product design, which allows the creation of virtual models meeting the requirements of paper flow path simulation, and allows for the simultaneous creation of multiple models for simulation with different flow path configuration and different grades of papers as well for different types of substrates like photo film papers, OHP sheets, vinyl media etc. This helps the engineers and industry to meet the tight requirement like very short design cycle and manufacturers to cut costs in many ways. Recent developments in analysis tools and computer technology has minimized many of these and hereby made the simulation more useful. Both engineers and industry constantly seek to improve accuracy of the results, time to analysis results etc, to benefit most from simulation.

Challenges

With a constant drive for product innovation, cost and weight reduction, the hi-tech electronics industry is highly competitive with the challenge of continuously updating products in a very short design cycle. Reliable functionality is one of the major challenges for information technology and electro-mechanical products. Some of limitations of these techniques to mention are model size, modeling of complex features, computer performance, capability of the solver to handle contacts, initial penetration, convergence etc.

Future Plans

In addition to the current work, further challenges like;

- introducing the effect of electro static charges on the paper during the transport along the flow path.
- effect of environmental conditions like humidity and temperature can be studied.

Conclusions

In this paper, ABAQUS has been used to simulate the paper flow path design. From the results of the paper flow path simulation, we will be able to assess the feasibility of the proposed flow path design configurations. Early stage detection of stubbing points helps in improving the flow path design. The flow path simulation helps in predicting the roller slip and variation in substrate velocity there by deciding the roller positions. Fine tuning the roller rotation velocities helps in the designing the drive mechanisms and paper buckle height calculations directs us in fixing the design space for buckle chamber.

The work presented in this paper is the generic flow path configuration and further demand more detailed analyses with different complex flow path design to predict the exact paper behavior under different transport conditions.

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References

[1] Pulp & paper resources & information site <http://www.paperonweb.com>

[2] Newmark, N. M., 1959, "A Method of Computation for Structural Dynamics," ASCE Journal of the Engineering Mechanics Division, Vol. 85, pp.

[3] Ugural, A. C , 1981, Stresses in Plates and Shells, McGraw-Hill Incorporated, New York.

[4] Wang, C. Y., 1986, "A Critical Review of the Heavy Elastica," International Journal of Mechanical Sciences, Vol. 28, pp. 549-559.

[5] ABAQUS 6.8 Documentation

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