Visualization study of flow stability between rigid and deformable rolls

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Introduction

Reverse roll coating is widely used to coat a thin liquid layer onto a moving substrate. The metered liquid layer is created within the gap between a pair of co-rotating rolls. When gap between rolls is small, one of the rolls will have a compliant polymer cover to avoid roll damage due to roll run-out, substrate caliper change or splice passage,. The existence of a deformable cover in the gap between metal roll and rubber roll creates a elastrohydrodynamic flow field in that region. As the liquid passes through the coverging-diverging section within the gap it generates pressure; this pressure can deform the elastic roll surface, which in turn, alters the geometry of the gap and the flow. Therefore the uniformity of coating is affected differently than what is observed for when only rigid rolls are used. In this study, visualizations of the flow emerging from the gap between a reverse deformable roll and solid stainless steel roll were done to determine how the uniformity of coating at the high roll speed region is affected by operating parameters: the speed ratio between the rolls, roll cover properties, and liquid properties. The

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wavelength of ribbing is investigated to verify the effect of speed ratio, wet coating thickness, and viscosity.

Experimental set-up

In order to determine the coating conditions necessary to produce a uniform coating, flow visualization experiments were performed. The experimental set-up is shown in Fig.1. The roll coating apparatus used in these experiments and located in the Coating Process and Visualization Laboratory at the University of Minnesota has 4 inch diameter rolls installed one above the other. A high-resolution digital camera was used for visualizations of the flow.

The ribbing wavelength was measured from images at various coating conditions.

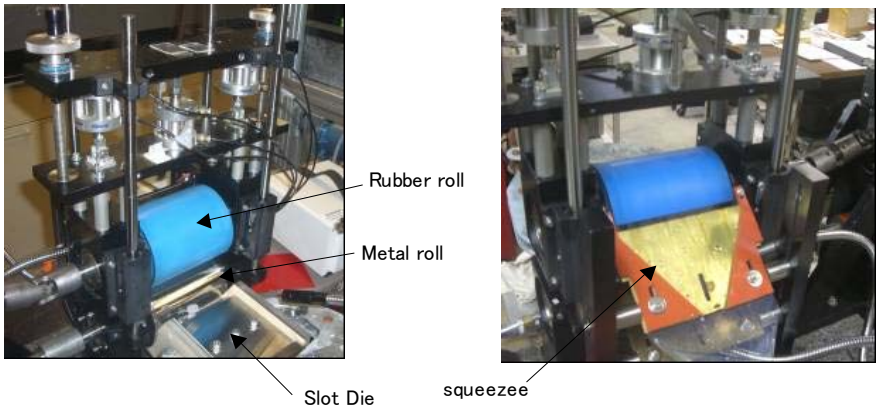

Fig.1 Experimental set-up

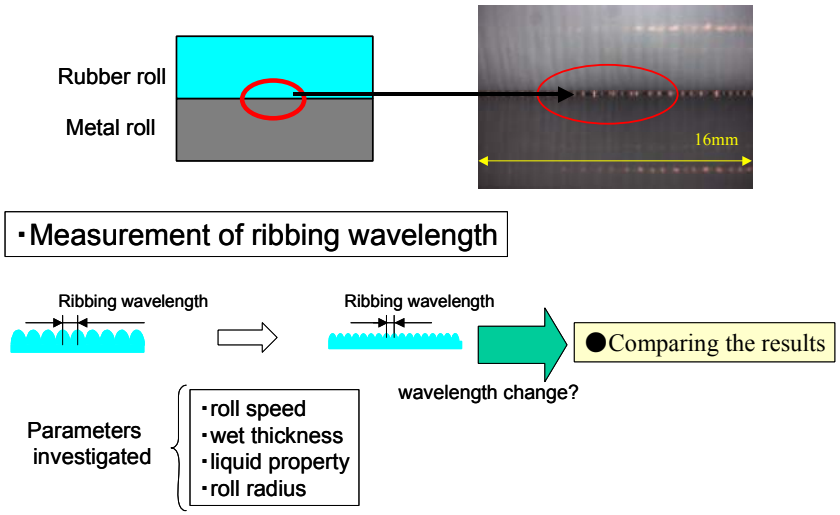

Fig.2 Example of roll coating visualization and data extracted from image

Results :

The effect of viscosity change on stability is shown in Fig.3. Stable uniform coating for coating liquid with 44 cps viscosity was observed at low speeds and at speed ratio between top and bottom rolls equal to 1.0. The stable region gradually expanded when viscosity decreased.

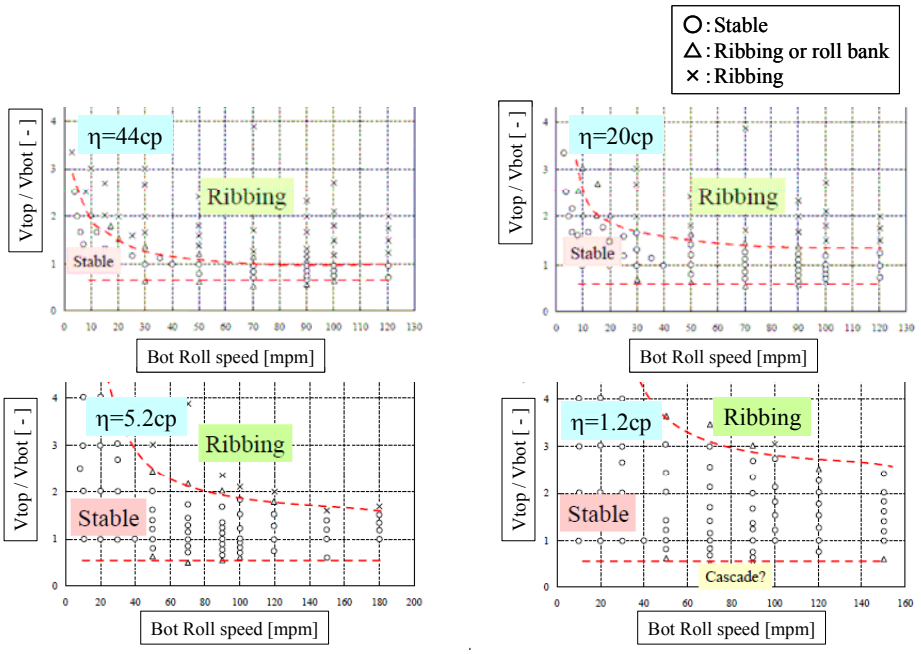

Fig.3 Stability diagram

The effect of roll speed, wet thickness and viscosity on ribbing wavelength is demonstrated in Fig.4. The ribbing wavelength narrowed when the roll speed and the viscosity increased.

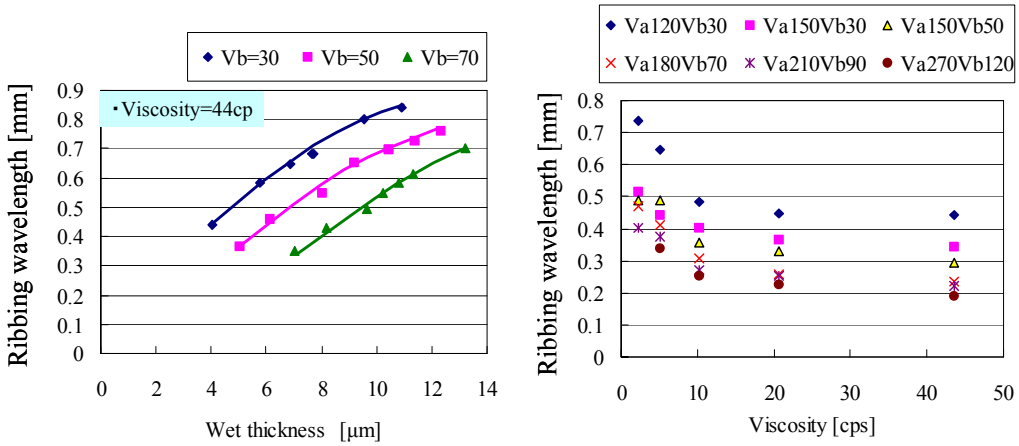

Fig.4 Ribbing wavelength

Conclusion

The results from experiments show that low viscosity helps to expand the stable region of coating in reverse roll coating with deformable rolls. The results from the measurements of show that the ribbing wavelength narrowed when the roll speed and the viscosity increased.

References

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