Pilot-Scale Recycling of HP-Indigo Printed Media and Mixed Office Waste

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Abstract

We show here that good recyclability of HP-Indigo printed media and mixed office waste can be achieved at pilot scale while using our environmentally benign near-neutral deinking chemistry (coded HPES). The pilot trials were performed in a fashion that closely depicts a standard production operation. Various key attributes, such as the optical brightness, dirt count, ERIC value, ash content, and pH, of the accepts and rejects were closely monitored at critical stages of the recycling process. Encouraging statistical data of these various key indicators, for mixed office waste with varying amounts of HP-Indigo printed media (from 0% to 100%), suggest a recovered pulp quality which closely matches that would achieve regularly in a commercial recycling mill. It is noteworthy to point out that good recyclability of HP-Indigo printed media can be accomplished irrespective of the ink coverage and media types.

Introduction

The current global print market is worth more than 600 billion dollars, and is expected to increase in the coming years [1]. Irrespective of the different printing materials and technologies, trillions of pages are printed per year. Accordingly, a significant amount of natural resources is consumed. Recycling of paper products for renewable resources is therefore important towards fulfilling both environmental sustainability and economical returns.

The global print market is undergoing an analog to digital transformation where more pages are printed digitally and digital inks, materials and digital printing technologies are being constantly introduced. It becomes inevitable that successful recycling of paper products will largely depend on the efficiency of the recycling ecosystems. In particular, advancements and breakthroughs on deinking chemistries and recycling technologies are needed to continue fueled growth of the print market.

Previously, we have demonstrated that by using an environmentally benign near-neutral deinking chemistry (coded HPES), a wide range of inks can be deinked satisfactorily at lab-scale [2]; see Figure 1. A significant challenge, from a deinking standpoint, is to innovate a deinking chemistry that can successfully remove various kinds of inks, including digital and traditional offset inks, from recycling furnish in a regular recycling process.

In this work, we investigate the recyclability of HP-Indigo LEP prints (with varying amounts) in mixed-office waste furnish at pilot scale using our HPES, while adopting a recycling process that closely mimics a standard recycling operation. Various key parameters such as the optical brightness, ash content of the pulps, and dirt count at strategically chosen processing stages were monitored to determine the efficacy of HPES and the quality of the recovered pulps.

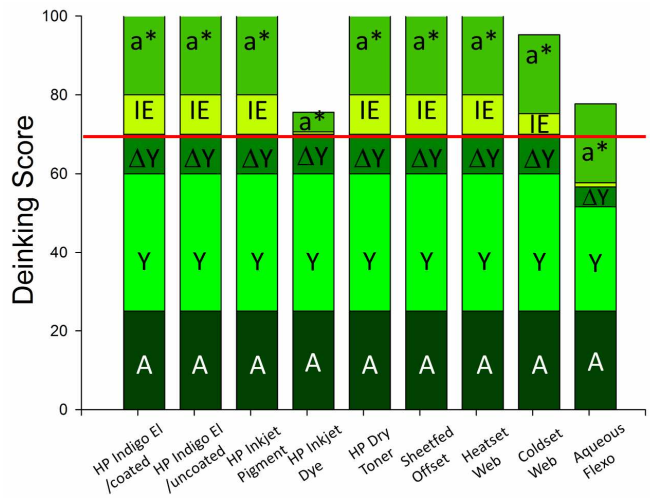

***Figure 1.** The total deinking scores of various digital and traditional offset inks, graded according to the ERPC's Deinking Scorecard [3]. EI = ElectroInk; A = dirt area, Y = luminosity, ΔY = filtrate darkening; IE = ink elimination; a* = color shade.*

Experimental

Furnish Configurations

Four different configurations were considered for the recyclability evaluation – A) 100% mixed-office waste (MOW) which was acquired from a major recycling mill; B) 20% HP-Indigo LEP prints (which were acquired from print service providers) in MOW; C) 50% HP-Indigo LEP prints in MOW and D) 100% HP-Indigo LEP prints. For the configuration C, a substantial amount of LEP prints with 100% ink coverage, including solid black, solid purple and solid red print patterns was used.

Recycling Process Steps & HPES

Figure 2 shows the general flow of a recycling process, which involved essentially 13 major stages. The pilot runs were conducted at the Recycling Pilot Plant at Western Michigan University, Kalamazoo. A total of 500lbs of furnish was used per run. Prior to the high consistency pulping, manual de-trashing was performed. The first chemical (nonionic surfactant, 0.5 – 0.7% loading) of the dual-chemical component HPES was added during the pulping. This was followed by the Johnson and coarse screening to remove undesirable large contaminants from the pulps. Metallic contaminants such as staples were removed by a strong magnet placed in one of the process chests. Prior to the first flotation, the second chemical component (anionic surfactant, 0.02 – 0.15%) of HPES was added. Flotation was performed for ~ 50 min. Next, additional cleaning was performed via a series of high-pressure fine screening, reverse-forward cleaning and Sidehill washing. Thickening of the pulps was conducted via a dewatering belt press and followed by a kneading step. Bleaching of the pulps was performed next and then continued on with a second flotation to further remove residual ink particulates. The entire recycling process was concluded with a hydrosieve washing step.

The optimization of the dual-component HPES was performed at lab-scale [4]. Optimum chemical loading of respective components and entry points at specific stages of the recycling process were determined at the pilot plant during a pretrial with process conditions mimicking a standard operation.

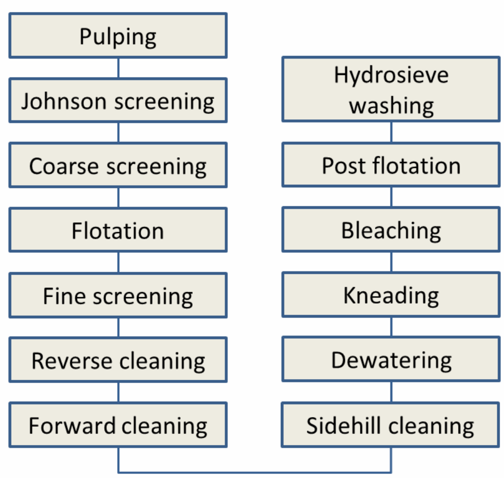

Figure 2*. The key stages of the recycling process adopted in the present study.*

Key Monitoring Parameters and Methods

Evolution of the optical brightness, ash content, dirt count of the pulps and pH were monitored at selected interim stages. Effective residual ink contents (ERIC) were measured for the four different furnish configurations. TAPPI method T-452 om-92 (Technidyne Brightimeter Micro S-5), TAPPI method T-413/T-211 om-93 (drying oven, muffle furnace), TAPPI method T-567 pm-97, and Verity IA (Epson Perfection 4490 Photo scanner, Verity IA Light & Dark Dirt v2.1.0) were used respectively to determine the optical brightness, ash contents (900/525C), ERIC values and dirt counts.

Results and Discussion

Figure 3 shows the evolution of ink speck contaminations for each different furnish configurations while Figure 4 shows examples of handsheets made from pulps recovered at specific stages of the recycling process. Major ink removal was observed to occur during the first flotation stage, assisted by various screening stages. Interestingly, we observed spontaneous attachment of large ink specks (in particular for furnishes with the LEP prints) to the foams during the first flotation. Figure 5 shows a representative photograph of the observed phenomenon.

It is noteworthy to point out that the dirt counts for respective runs are brought to the same order of magnitude after the first flotation, and to the same impressively low level after the second flotation, irrespective of the variations in the amount of LEP prints and ink coverages. The positive effect of kneading and the effectiveness of the second flotation on ink removal for all furnish configurations can be clearly seen by the step-wise reduction in dirt count between the dewatering step and after the second flotation.

Leveraging the present HPES deinking chemistry, we observe a high average ink removal rate of 96%, suggesting a high likelihood of achieving acceptable ink removal in an industrial recycling mill adopting a similar process flow and conditions.

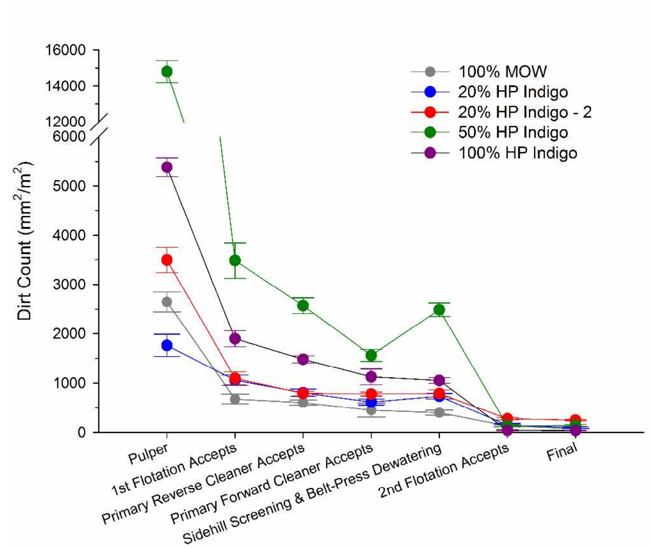

Figure 3*. Evolution of dirt counts with respect to selected monitoring stages of the recycling process. Each data point represents an average of data from 10 handsheets.*

Next, we investigated the optical brightness of the recovered pulps which plays an important role in determining the quality of the new paper products. In particular, a high brightness is generally necessary for making high-grade office writing and printing papers. Figure 6 shows evidently the effectiveness of HPES and the adopted recycling process to obtain high luminosity of the recovered pulps for all four furnish configurations.

We have noted two interesting observations while following the evolution of the optical brightness. First, initial starting brightness appears to be increased with increasing amount of LEP prints in the MOW, likely to be attributable to the higher quality of the commercial substrates used in HP-Indigo LEP printing. The increased amount of LEP prints apparently has a positive impact on the final optical brightness. Remarkably, an impressively high luminosity of > 90% was obtained for the 100% HP-Indigo LEP run. In all cases, the final luminosity is above 80%. Second, the bleaching of processed pulps provides a noticeable step-wise increase in the optical brightness, regardless of the furnish configurations. A consistent incremental increase in luminosity is also noted for both flotation stages. While taking into consideration the corresponding decrease in dirt counts, we conclude the inertness of the present deinking chemistry and its robustness towards process variations in pH. The nominal average pH for all runs is ~ 7.8, except during the bleaching stage.

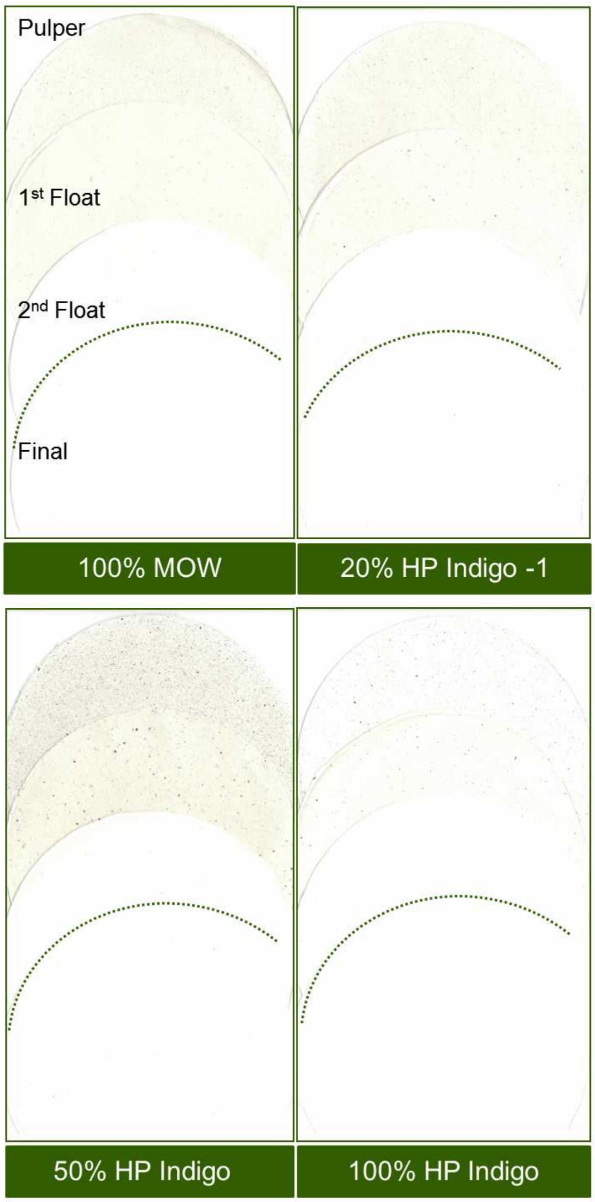

Figure 4. *Images of representative handsheets made from recovered pulps at specific stages of the recycling process.*

Figure 5. *A photograph showing visual attachment of ink specks on skimmed-off foams during the first flotation stage for furnish with LEP prints.*

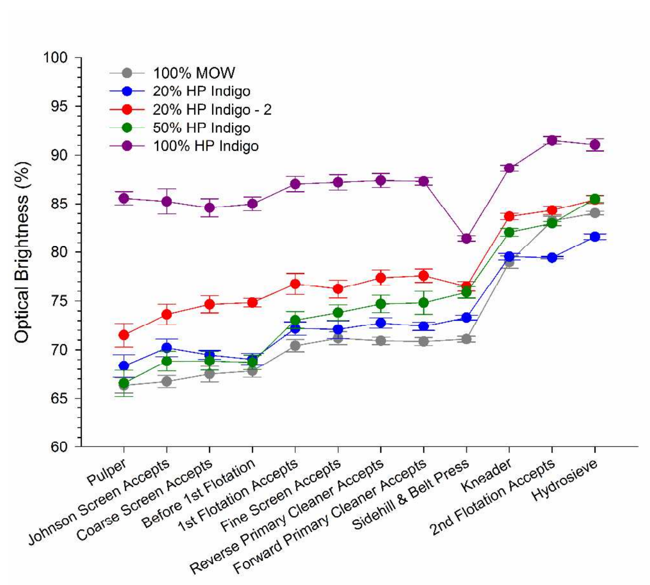

Figure 6. *Evolution of optical brightness of recovered pulps with progress of the recycling process for the four different furnish configurations.*

The ash content of the recovered pulps was monitored as well. Its progression for each furnish configuration is shown in Figure 7. The positive influences of both flotation and screening stages are clearly seen from the corresponding noticeable reduction in the ash contents. In particular, a combination of first flotation, high-pressure screening and cleaning/washing has facilitated a significant reduction for furnish with high LEP print contents. A mean ash content of 2% was obtained for the various furnish configurations, comparable to lab-scale results, and suggests that the final recovered pulps are more than appropriate for making paper products, including tissue paper. Such a low ash content will provide several advantages towards tissue manufacturing – 1) ~ 10% increase in machine speed; 2) reduction in creping blade wear; 3) increase in felt and wire life and 4) reduction in dust level [5].

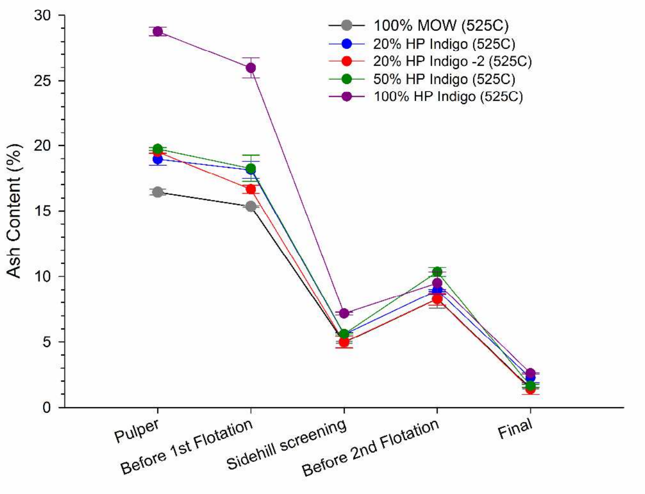

***Figure 7**. Evolution of ash contents with progress of the recycling process.*

Due to the non-continuous nature of the pilot runs, no attempt was made to quantify the exact fiber yields. However, visual inspection and consistency measurement of the flotation accepts/rejects were monitored which collectively suggest a very low loss of less than 8% fibrous pulps.

The ERIC values were measured for all runs and are shown in Table 1. It is clearly evident that the present HPES deinking chemistry and process flow deliver consistently low ERIC values, regardless of the furnish configurations and variations in LEP ink coverages. Interestingly, the lowest number was obtained for the highest amount of LEP print contents.

Furnish	ERIC Value
100% MOW	13.3
20% HP Indigo	14.5
20% HP Indigo -2	12.4
50% HP Indigo	12.9
100% HP Indigo	10.3

***Table 1**. ERIC values with respect to the four different furnish configurations.*

Conclusion

In summary, we have successfully demonstrated, at pilot scale, good recyclability of HP-Indigo LEP prints with varied amounts in MOW. High quality recovered pulps can be obtained, at pilot scale, employing HPES. Through the pilot trials, we conclude that HPES can serve as a good environmentally benign near-neutral deinking chemistry to effectively remove LEP ElectroInks, digital inks and traditional offset inks in a recycling process that closely mimics a standard production operation.

References

[1] S. Smyth, The Future of Global Printing (Pira International Ltd., Surrey, UK, 2009).

[2] H.T. Ng, M.K. Bhattacharyya, L. Mittelstadt, E.G. Hanson, 'Deinking of HP Digital Commercial Prints: Effect of Chemicals and Their Loadings on Deinkability' Proc. NIP 25, p. 173 (2009).

[3] http://www.wrr.icodat.com/resources/reports/erpc%20deinkability%20scorecard.pdf.

[4] M.K. Bhattacharyya, H.T. Ng, L. Mittelstadt, E.G. Hanson, 'Effect of Surfactant Chemistry on deinkability' Proc. NIP 26 (2010).

[5] R.W.J. McKinney, Technology of Paper Recycling (Blackie Academic & Professional, Chapman & Hall, Suffolk, UK, 1995).

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Eric Hanson is the Director of the Commercial Print Engine Laboratory of Hewlett Packard Laboratories, in Palo Alto, California, where he has managed research investigating advanced digital printing since 1984. He is currently the Immediate Past President of IS&T, the Society for Imaging Science and Technology. He received a Ph.D. in physics in 1976 from the University of California at Berkeley and has been awarded 18 US patents.