Factors influencing polymeric granule-assisted dispersion of ultraviolet ink

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ABSTRACT: The objective of this research is to identify and evaluate the factors influencing polymeric granule-assisted dispersion of ultraviolet (UV) ink particles. First time, granule-assisted alternative dispersion was observed during adsorption deinking. By optimizing and combining this alternative dispersion process with pulping, we aim to minimize the energy consumption in the dispersion process and thus reduce the environmental impact of the paper recycling process on carbon footprint. For experimental confirmation, a combination of printed paper and polymeric granules was selected such that ink detached from the fibers would not be adsorbed onto the surface of polymeric granules. Factors that affect the mechanical dispersion process were chosen and varied for optimization of the newly developed dispersion method.

Results show that at 15% consistency, temperature 45°C, and mass ratio of oven dry pulp and granules of 1:1.5 (200 g pulp and 300 g granules), the granule-assisted dispersion process gives optimum results for reduction of specks size. All experiments were carried out at rotor speed 2 of Hobart pulper (INGEDE Method 11 "Assessment of print product recyclability–Deinkability test"). These optimized parameters are similar to the optimized parameters of adsorption deinking, which give a further option to combine both of the steps (adsorption deinking and granule-assisted dispersion) into one. We also demonstrated that the polymeric granule-assisted dispersion method is a viable replacement for the conventional dispersion process by assuring no alteration in fiber length, water retention value of pulp, and strength properties of the handsheets.

Application: This paper introduces an alternative method of dispersion for paper recycling that significantly reduces energy consumption. This dispersion process can be combined with adsorption deinking to further reduce energy and water consumption and improve the stock preparation process.

Paper recycling is challenging due to the ever changing nature of contaminants associated with various grades of recovered paper. One class of troublesome contaminants, called "stickies," affects paper machine operations and end-product quality. The other classes of concern and the ones addressed in this paper are inks and specks. The deinking technique in paper recycling serves the purpose of removing the printing inks and other contaminants that affect the papermaking process or final properties of paper. Deinking essentially involves the detachment of ink from fibers, removal of detached ink from the pulp suspension, and then the treatment of waste water for reuse and disposal of removed ink and contaminants. After detachment of ink particles from fiber surfaces, it is necessary to separate these detached ink particles from pulp slurry using any of the conventional methods — flotation, washing, screening, centrifugation, etc.

Continuous development has taken place to improve the efficiency of the existing deinking process. For example, to improve the efficiency of flotation deinking for papers containing xerographic toner ink particles, Quick et. al used an organic ester and a solid polymeric powder in repulped aqueous slurry to agglomerate the xerographic toner particles to larger size particles so that these larger particles remove easily and efficiently in the next separation step — flotation [1].

Muvundamina and Liu presented another breakthrough technology for deinking pulp, which demonstrated the use of plastics present in recycled pulp as ink collectors [2]. In this process, the plastic polymers present as contaminants in the recycled pulp served as scavengers for ink and other colloids. This was done by the exposure of discarded paper to pulping liquor containing mineral spirits and sodium silicate. Sodium silicate and spirit helps in alteration of the surface properties of the plastic material, making them suitable to extract ink and other colloidal contaminants from the pulp. Deinking will only take place when these ink-loaded plastics are separated from the fibers by screening. However, no implementation was found for this process at the industrial level.

Apart from detaching ink particles from fibers, dispersion also plays a critical role in producing good quality recycled pulp. For the production of high quality recycled pulp, dispersion must be included in the deinking process. Because deinked old newsprint (ONP) and old magazine paper require brightness above 60%, many deinking plants also include a dispersion step in their processes.

Dispersion is a multipurpose step included in the deinking process; it supports detachment of recalcitrant ink from fibers to disperse and fragment ink particles to a favorable size for downstream removal and to reduce particle specks below the visible detection limit of about 50 µm. Dispersion is particularly used for hard inks (e.g., linseed oil-based or ultraviolet [UV]-cured inks) that are present in an ONP deinking facility. These types of inks are strongly bonded to the fiber, and some quantity may remain attached to the fiber following the pulping stage [3]. These bonded ink particles can be detached from the fiber surfaces in a disperser by applying higher shear forces than can be imparted in a pulper.

The main applications of dispersion/kneading are to:

- Disperse the hot-melt contaminants, stickies, and residual ink below the visibility limit.
- Treat fibers thermally to increase bulk.
- Detach residual ink prior to post-deinking.
- Change fiber properties, depending on device used and operating conditions.

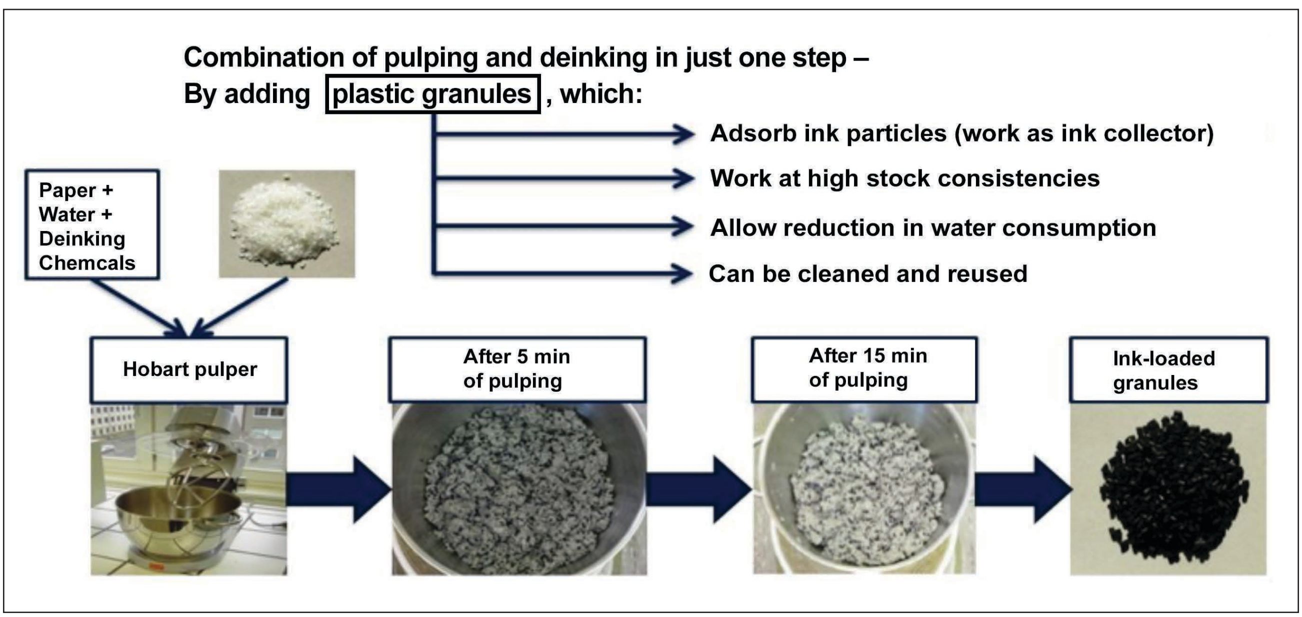
Dispersion of specks is one of the most energy intensive sub-processes in paper recycling [4], but this sub-process can possibly be combined into one step with pulping. In this study, we discuss a new alternative dispersion technique that we have designated as "granule-assisted dispersion."

The process concept

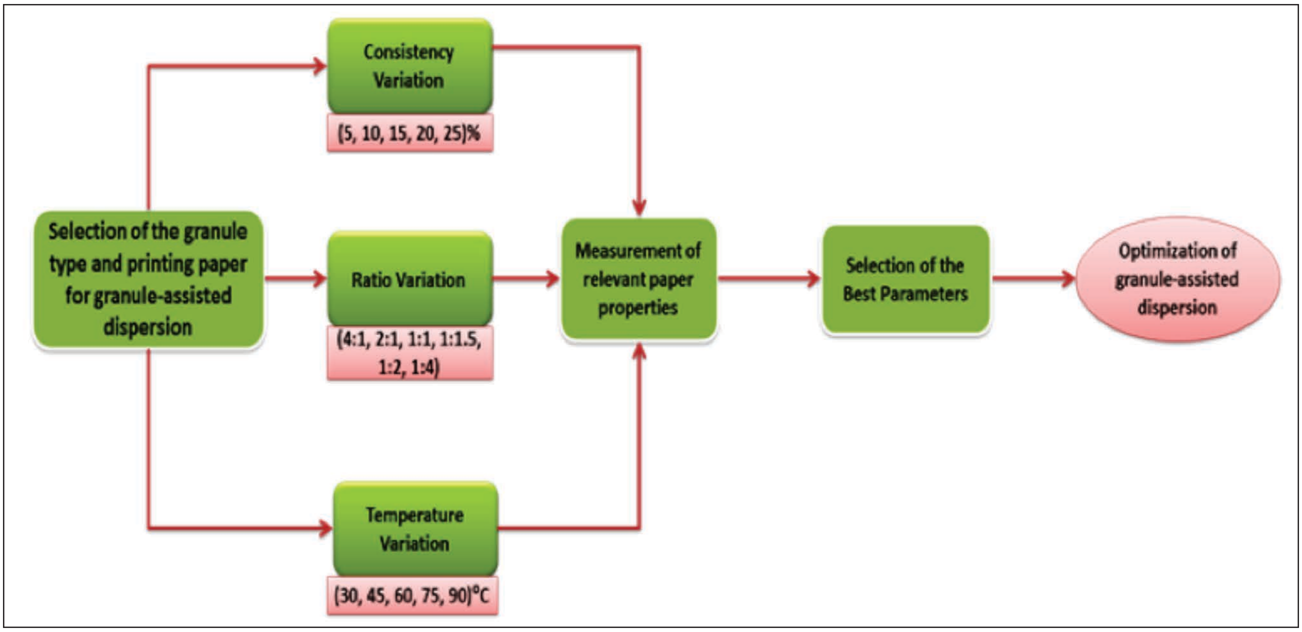
In contrast to conventional washing and flotation deinking methods, a new methodology was recently developed at Dresden University of Technology called "adsorption deinking." In this method of adsorption deinking, ink from the recycled pulp is separated within the pulping step [5]. **Figure 1** depicts how plastic granules were used in adsorption deinking to separate ink particles from the pulp. These plastic granules were added during the pulping process, eliminating the flotation/washing step for removing ink particles from the pulp. A similar study was also done by Muvundamina and Liu, but in their work, the plastic present in recycled pulp as a contaminant was modified by adding spirit and sodium silicate in the pulping liquor. This alteration modifies the surface of plastic such that it collects ink and other colloidal particles on its surface. These plastic particles are then separated from the pulp by screening method to attain deinking [2]. In contrast with the work of Muvundamina and Liu, adsorption deinking involves addition of characterized-plastic granules (surface and chemical properties of plastic material are known) in the pulper during the pulping process, where physical adsorption of ink and mineral oil particles over the surface of the granules takes place. Also in contrast the work of Muvundamina and Liu, no spirit or similar chemical was added during pulping to alter the surface of the plastic granules.

During experiments with adsorption deinking, it was recognized that dirt speck areas on the handsheets reduced drastically after adsorption deinking, but brightness was not reduced by the same significant value. These results lead us to conclude that along with the surface adsorption of the ink particles, adsorbent material in the pulping vessel also leads to mechanical rubbing action, which is similar to low speed dispersing (kneading) of ink particles [6]. Due to the relative motion between plastic granules and paper pulp, ink particles become dispersed and thus result in lower brightness.

Various tests indicate that adsorption deinking is an outcome of intensive mechanical interactions between the plas-



1. The adsorption deinking process [5].



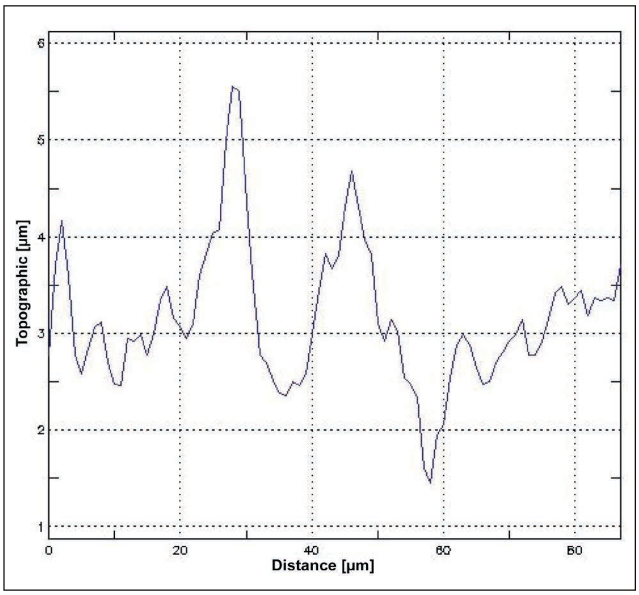
2. Layout of the tests carried out in order to assess the factors influencing "alternative dispersion."

tic granules and the pulp. This can lead to a substantial decrease in the high energy required in paper recycling by forgoing the existing practice of a separate mechanical dispersion. Consequently, it can reduce water consumption along with the benefit of simplifying the entire process chain [5].

The alternative dispersion process would require further studies and research aiming to find out the exact role of the type of granules and optimization of operating conditions like mass ratio between pulp and granules, specific energy consumption (speed of impellers of the pulper used), temperature, and stock consistency. However, the economic and technical viability of this approach would result in a significant development for recovered paper stock preparation, particularly because dispersion consumes the highest amount of energy in paper recycling processes.

EXPERIMENTAL

An experimental setup in **Fig. 2** shows a corresponding, though simplified, flow chart for most of the tests. With respect to the requirement mentioned previously, UV-cured printing products were used for these investigations. This is because UV ink particles are particularly suitable for optical image analysis, and it has also been found that UV ink particles do not attach to the surface of the polyamide granules chosen as the dispersant material. Apart from this experimental setup, two reference experiments were also carried out. In one experiment, recovered paper was conventionally pulped according to INGEDE Method 11 "Assessment of Print Product Recyclability–Deinkability Test." In a second experiment, the pulp was treated in a pilot disperser after defibrillation to compare alternative dispersion results with that of granule-assisted dispersion.



3. Roughness of polyamide granules used as dispersing material by profilometry.

Dispersant material

The main dispersing material discussed in this study is nylon 6-6 in the form of granules of non-symmetric cuboid shape (size was approximately 5 mm^3 x 2.5 mm^3 x 2.5 mm^3). By profilometry characterization of granules, roughness was found in the topography range of 0.55 µm to 5.5 µm. The profilometry graph in **Fig. 3** was taken along the longer face side of the cuboid. This roughness was not enough to make the nylon surface absorbable for UV ink particles at lower temperature (=< 75°C); however, it was sufficient to provide frictional force for dispersing the detached ink particles into smaller ones.

Procedure

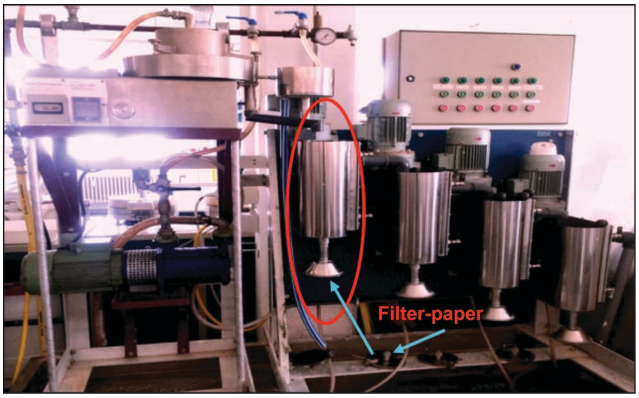
Granule-assisted dispersion

To perform the dispersion along with the pulping process, standard deinking chemicals were prepared according to INGEDE Method 11 "Assessment of print product recyclability–Deinkability test." For this, 6 g of sodium hydroxide, 8 g oleic acid, and 18 g sodium silicate solution were added in 2000 mL of water. Then, the chemical equivalent to the INGEDE Method 11 recipe was added into the pulping mixture so that the final mixture contained 0.6% sodium hydroxide, 0.8% oleic acid, 1.8% sodium silicate, and 0.7% hydrogen peroxide against the weight of paper to be recycled. Hydrogen peroxide was added in the pulping mixture at a concentration of 0.7%, and it was prepared just before the pulping started to avoid any loss due to volatilization. To make the procedure more generalized, UV printed papers containing equal amounts of UV printed ink from three different manufacturers (Stora Enso, SCA, and UPM) were used as a test sample and torn in the approximate size of 2 cm x 2 cm.

The test samples were added to the pulper along with deinking chemicals and dispersant granules. Duration of pulping was 20 min, and the Hobart pulper rotor speed was optimized for adsorption deinking at a speed level of 1.5–2 [6]. The pulping and dispersion process was started at approximately the 600 rpm level of the pulper.

Washing

For analyzing how effectively the UV ink detached from the fibers and dispersed into smaller particles, washing was carried out with a sieve/wire with a No. 50 mesh (50 mesh/in). INGEDE Method 5, "Evaluation of printing ink detachment by hyperwashing with the Haindl-McNett classifier," was used to remove the maximum possible ink particles (specifically, of lower size, ~<50µm) from the pulp. Washed pulp was analyzed for optical properties. Representative ink-dispersed pulp of weight 20 ± 0.05 g (oven dry) was taken, which was calculated according to the consistency of the pulp sample to be washed. As per requirement, only one chamber (primary) of the McNett cascade was used for washing purposes (**Fig. 4**); the remaining chambers were kept dormant and disengaged from the others.



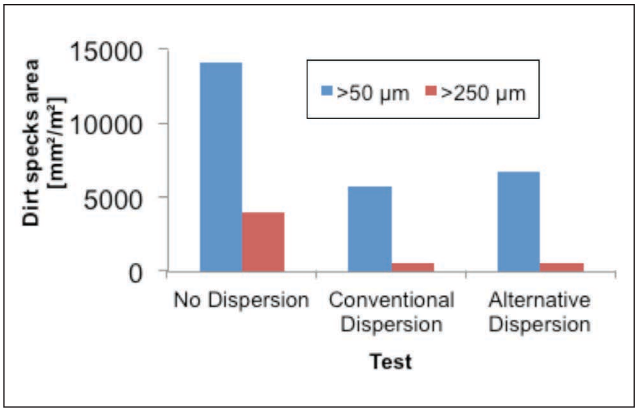
4. McNett cascade setup for hyperwashing.

Procedure details

1. UV printed sheets were shredded by hand to the size of 2 cm x 2 cm, weighed accordingly as per test, and placed in a Hobart pulper.
2. Deinking chemical solution, dilution water, hydrogen peroxide, and polyamide granules (if required) were also added into the pulper , and then the test sample was disintegrated at a Hobart pulper rotor speed level of 1.5–2 for 20 min at variable pulp consistency (required as per test). During the first 5–10 min, pulping was interrupted after each minute to scrape off the pulp sticking to the sides of pulper.
3. A suspension of 20 g o.d. pulp in 2 L water was prepared from the previously described test and added to the first screening chamber of the McNett cascade, fitted with mesh No. 50. The introduced pulp was washed for 20 min with the water flow rate at 10 L/min and vacuum was applied to collect the pulp on the filter paper fitted below the first screening chamber.
4. Next, 5 g o.d. pulp was added in 500 mL of water, and polyamide granules that settled on the bottom of the vessel were separated from the suspension. The suspension was thickened by passing through the filter-pad preparation apparatus. Thickened pulp was centrifuged in a sieve containing centrifuged tubes for 15 min at 5000 rpm; pulp without polyamide sample was used directly for centrifugation. After 15 min, the thickened pulp pad was taken from the centrifuge and dried to a constant weight. Finally, the water retention value (WRV) was calculated according to the following equation, where W_a = weight of centrifuged pulp brick prior drying and W_b = weight of pulp brick after drying:

$$\text{WRV} = \frac{W_a - W_b}{W_b}$$

5. A 2 g oven dry pulp sample was taken just after pulping, and a pulp suspension of volume 500 mL was prepared. This suspension was decanted into another vessel to remove polyamide granules. A 1000 mL pulp suspension of 2 g o.d. pulp at temperature 20°C was poured in the top vessel of the Schopper-Riegler freeness equipment. We noted the reading from the top on the vessel, which was kept under the lateral opening.
6. 0.01 g dry pulp was transferred to the analyzer cup of a kajaaniFiberLab fiber analyzer (Metso Automation; Helsinki, Finland) containing 500 mL of water and then manually disintegrated. A concentration of 0.01 g dry pulp/500 mL ensures that kajaaniFiberLab will automat-



5. Dispersion effect of polyamide granules on newsprint ink at 15% consistency and 45°C temperature [6].

ically dilute the pulp sample until the desired consistency is attained (0.015%–0.025%) to obtain a fiber count of 40-100 fibers/s. Analysis was then conducted with the kajaaniFiberLab.

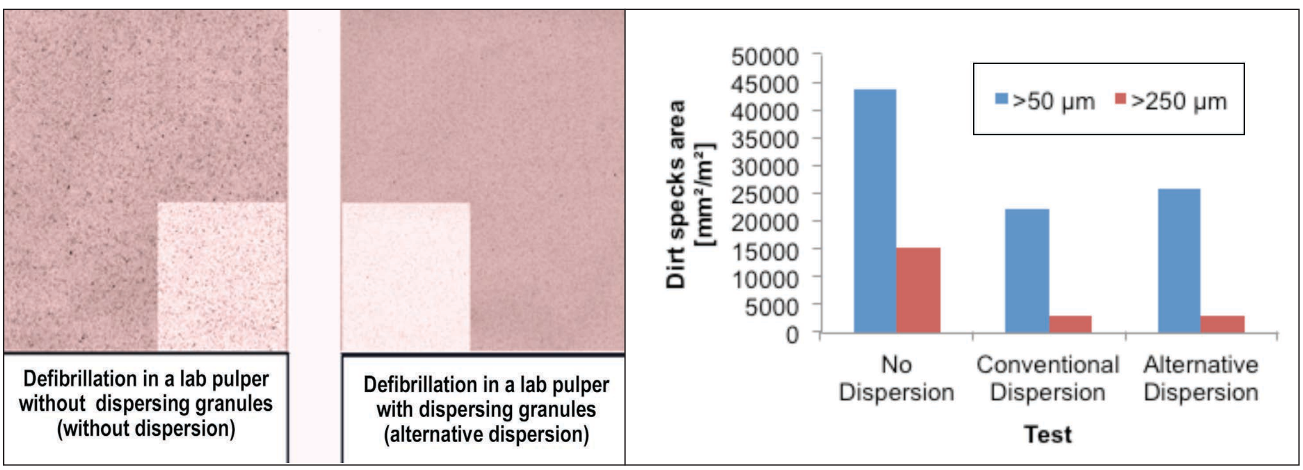
7. Five standard handsheets of 2.4 ± .05 g and three handsheets of 1.35 ± .05 g were made in a Rapid-Köthen (RK) handsheet maker from both washed and unwashed pulp and stored in a conditioning room for optical and mechanical properties analyses.
8. The 1.35 g handsheets were tested for dirt speck counts and the 2.4 g sheets were checked for ISO brightness and other mechanical properties. The PTS-DOMAS system (Papiertechnische Stiftung; Munich, Germany) was used to measure dirt specks area. The area to be measured on each handsheet was set to 99.81 cm^2 in the system, and sheets were scanned with 8-bit grey modus, 600 dpi (reflective light), and a threshold of 180, which was optimized to get the best results for dirt specks measurement. ISO brightness was performed on a Datacolor ELREPHO spectrophotometer (Datacolor; Lawrenceville, NJ, USA) in accordance with the ISO Standard 2470-1(2009) "Paper, board and pulps - Measurement of diffuse blue reflectance factor," and R∞ at a wavelength of 457 nm was measured.
9. Standard handsheets of weight 2.4 ±0.05 g were cut into 18 mm wide strips with a minimum length of 100 mm. Tensile strength was measured with a Lorentzen & Wettre tensile tester (Lorentzen & Wettre; Kista, Sweden). The 2.4 g test sheets were cut in dimensions of 50 mm x 50 mm and used for testing the tear strength of the paper.

RESULTS & DISCUSSION

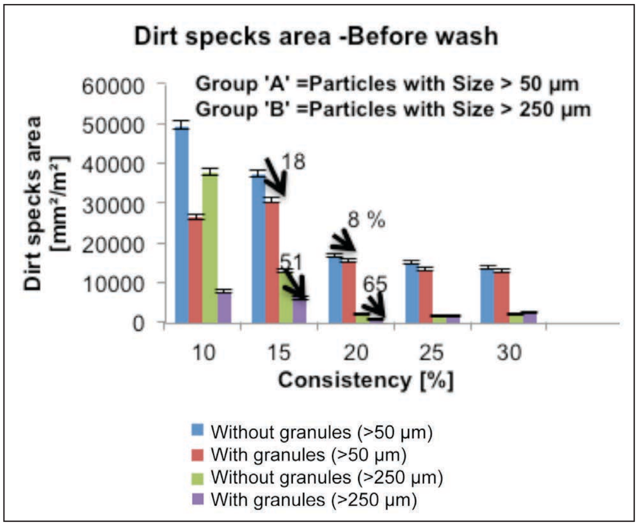
As far as dispersion is concerned, granule-assisted alternative dispersion shows significant effect on ink particle (**Fig. 5**) size reduction for ONP. Before drawing any conclusions, we tried to exhaust the full optimization potential of the process. To optimize the process, we identified that polyamide is the best possible adsorbent material to give desirable results for alternative dispersion (**Fig. 6**). The following discussion confirms this conclusion.

Effect of consistency

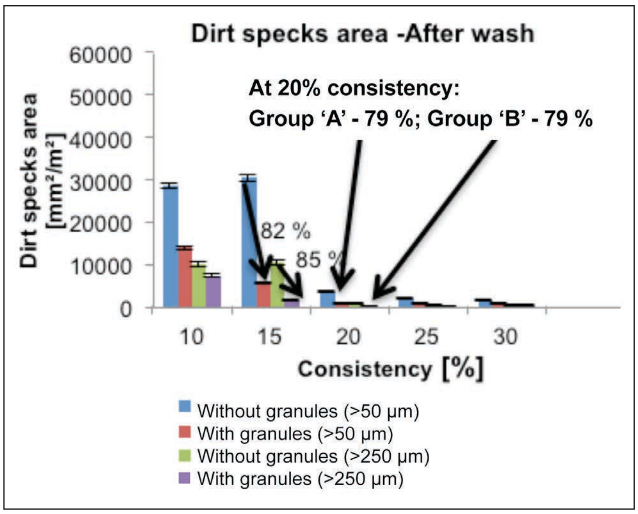
To evaluate the effectiveness of granule-assisted dispersion, dirt specks counted with the DOMAS system were divided into two groups: Group A containing particles of size >50 µm (all countable specks particles), and Group B containing specks >250 µm. Particles <50 µm are not monitored by DOMAS and are not visible to the human eye. **Figure 7** shows that the specific dirt specks area analyzed for particles from both groups was lowest at 30% pulp consistency and highest at 10% pulp consistency with alternative dispersion. However there is no significant difference in the specks area of pulp with and without alternative dispersion. On the other hand, at 15% (optimized consistency for adsorption deinking) and 20% consistency, a clear difference in dirt specks area of particles was observed. Before washing, the dirt specks area reduced by 18% for Group A and 51% for Group B (Fig. 7). After washing at 15% pulp consistency, a decrease in the dirt specks area of the pulp was observed at 82%



6. Dispersion effect of polyamide granules on ultraviolet (UV) ink at 15% consistency and 45°C temperature with a pulp-to-granules mass ratio of 1:1.



7. Dirt specks area (mm²/m²) distribution at different consistencies (before wash).



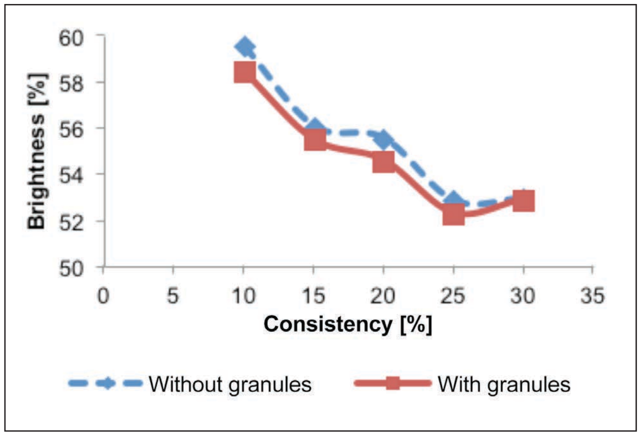
8. Dirt specks area (mm²/m²) distribution at different consistencies (after wash).

for Group A and 85% for Group B (**Fig. 8**). This is a significant difference, and a clear improvement can be observed in the sheet quality (Fig. 6).

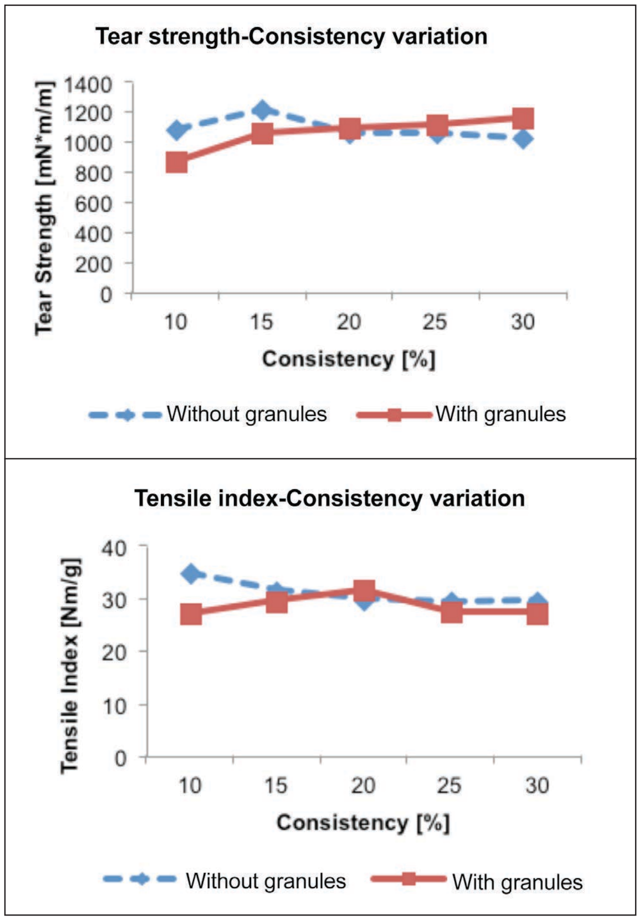
When a particle comminutes into smaller pieces, then surface area increases. However, here we consider only those particles that are >50 µm. Therefore, these specks particles after dispersion (before wash) are reduced in size to <50 µm and thus not counted by the DOMAS analysis system. After washing, all these particles (<50 µm) are removed from the pulp, resulting in higher losses.

Further confirmation of the results can be obtained after measuring brightness. If ink particles in the paper are dispersed or comminuted into smaller particles, then reflection of light will be lowered due to an increase of specks surface area throughout the pulp.

Brightness of pulp with alternative dispersion is always lower than that of pulp without any dispersion (**Fig. 9**),

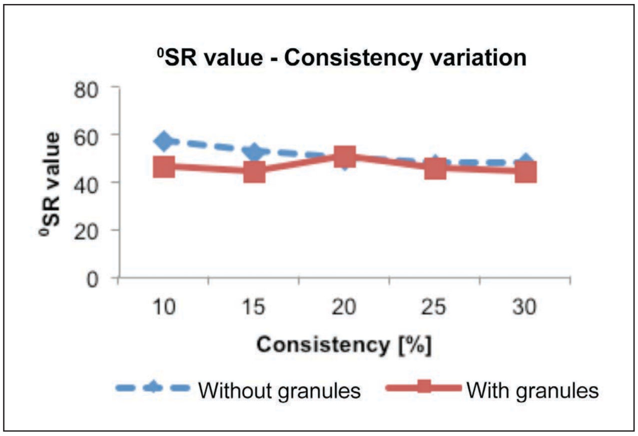


9. Brightness comparison of granule-assisted dispersion.

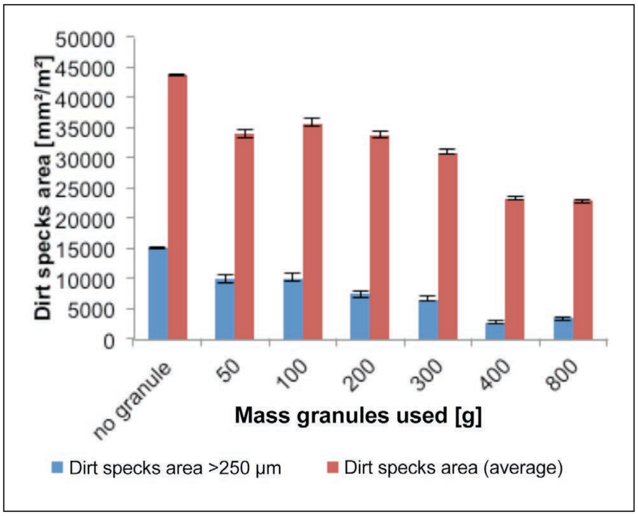


10. Effect of granule-assisted dispersion on tear strength and tensile strength.

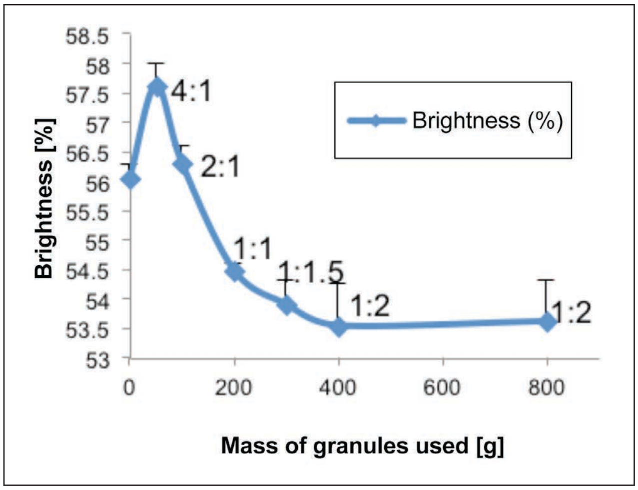
which confirms that surface areas of ink/speck particles have increased due to comminuting bigger particles into smaller ones. Following the same pattern of specks area, brightness should have reduced at 15% consistency; however, at 15% consistency, the adsorption factor predominates, which results in no significant reduction in brightness [5]. Apart from dirt specks and brightness, conventional dispersion also leads to a loss in fiber length that further results in lower tensile and



11. *Effect of granule-assisted dispersion on °SR.*



12. *Effect of increasing surface area of dispersing granules on dispersion effect.*



13. *Brightness as a function of mass of granules used for granule-assisted dispersion.*

tear strength. However, granule assisted dispersion does not harshly impact fibers; it gently comminutes the ink particle, and therefore disperses ink uniformly (**Fig. 10**). At 10% consistency, tear strength was found to be lower than at all other consistencies tested. As we know, tear strength depends on interfiber bonding, which further depends on the intensity of fibrillation. In the Hobart pulper that we used at 10% pulp consistency, fiber-fiber shear is much less due to lower fiber density in pulp. In addition to this, the frequency of mechanical impact of impellers on fibers is also much less due to low fiber density in the pulper, resulting in poor fiber bonding during sheet formation.

Apart from mechanical properties, freeness, water retention properties, and fiber length distribution remained almost similar with alternative dispersion. The degree of Schopper-Riegler freeness (°SR)and water retention value of the pulp remained similar with or without granules. Since °SR depends on the fibrillation of the fibers, this indicates granules do not have much impact on fibers, even at different consistencies varied in the range 15 %–30 % (**Fig. 11**). However, at 10% consistency, addition of polyamide granules improves fiber fibrillation, which results in higher °SR and, consequently, higher tensile and tear properties [7].

Effect of mass-ratio/surface area

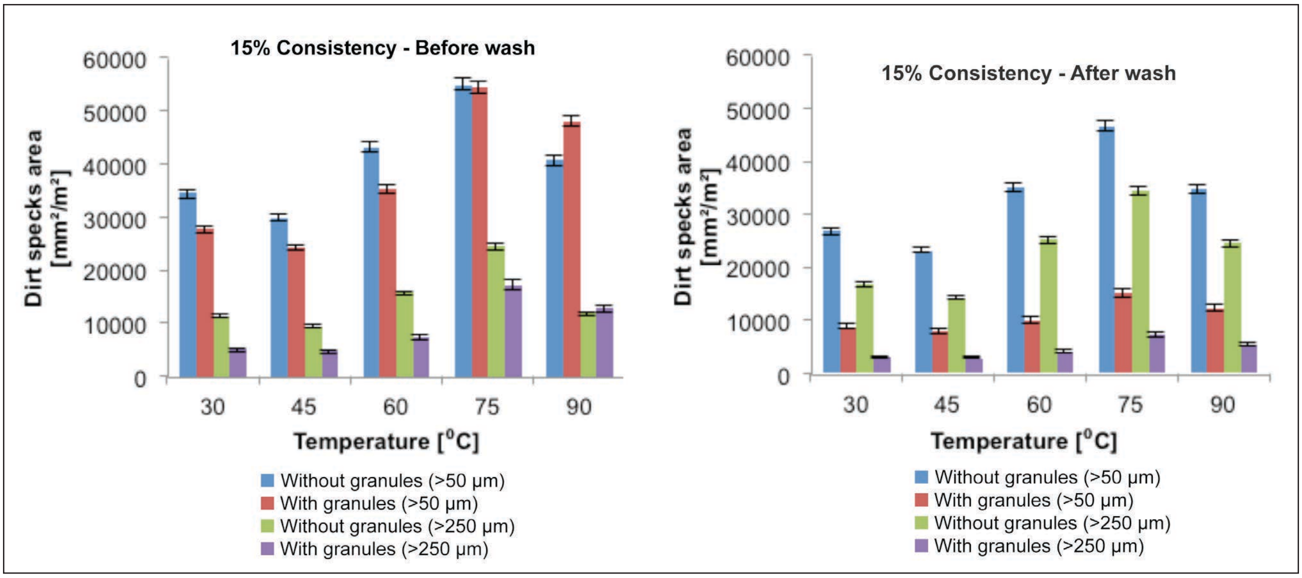
Manually measuring surface area of non-geometrical granules is a difficult and tedious process. To correlate the effect of mechanical impact due to an increase in surface area of granules on dirt specks, we took the mass of the granules as a promising factor. The mass of granules (of same density and size) can linearly be correlated with surface area. By estimating, 1 g of polyamide granules of size 5 mm³ x 2.5 mm³ x 2.5 mm³ (average size of granules used in experiment) will have surface area equivalent to 15.65 cm². If the mass of granules is increased due to a linear increase in surface area, rubbing action between granules and pulp increases and, therefore, dispersion should increase.

Figure 12 shows the effect of increasing mass of granules (50–800 g) while keeping the mass of paper constant (200 g). The specks area decreases almost linearly with an increase in the mass of granules, but after the paper-to-granules ratio of 1:2 (i.e., 400 g of granules, equivalent to a surface of 6260 cm²) in 200 g of pulp, there is no increase in dispersion of ink particles.

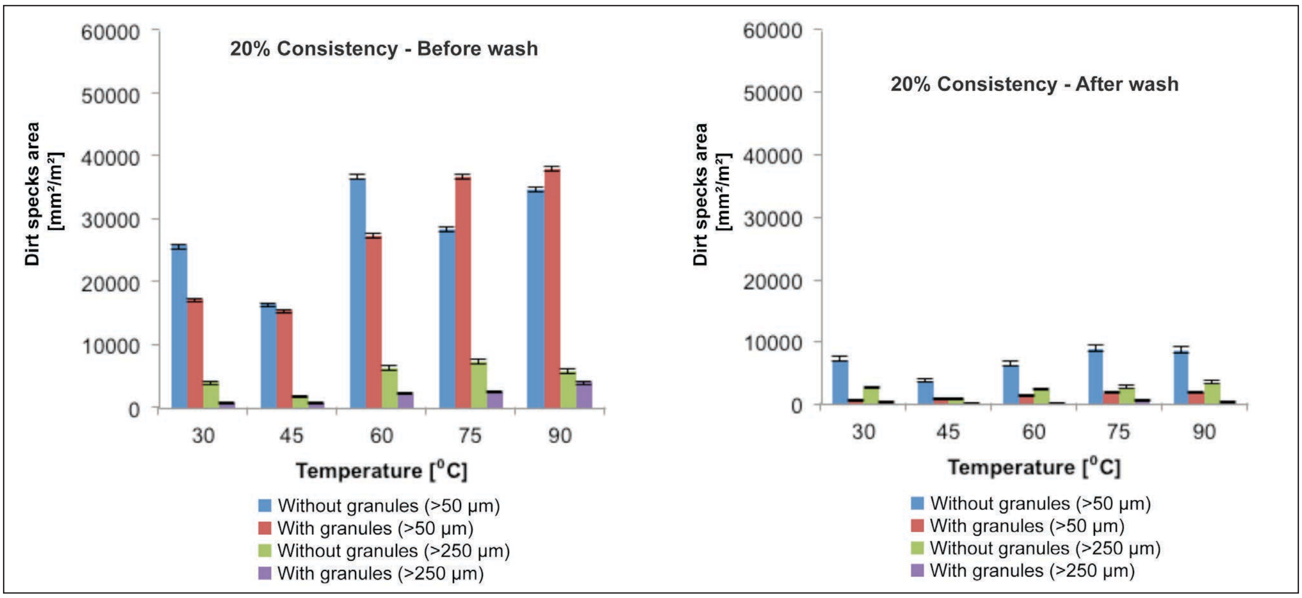
Regarding the brightness results, we found that brightness decreases with an increase in the mass of the granules. It also becomes constant after the use of 400 g of granules (pulp:granules =1:2), following a similar trend to dirt specks area (**Fig. 13**). Mechanical strength and fiber-related properties were monitored for the pulp and found to be similar to those without dispersion.

Effect of temperature

In the conventional high speed dispersion method, reduction of ink particles increases with an increase in temperature, and optimum temperature for high speed dispersion is 80°C– 95°C



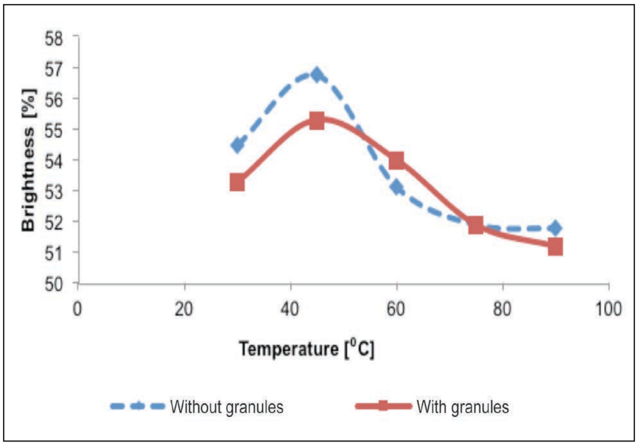
14. Dirt specks area as a function of pulping temperature (test carried out at 15% consistency).



15. Dirt specks area as a function of pulping temperature (test carried out at 20% consistency).

(at a peripheral speed 50-100 m/s). On the other hand, optimum temperature for low speed kneading is 40°C–85°C (with a peripheral speed range of 5–15 m/s) [3]. The effect of temperature on granule-assisted dispersion was evaluated by varying temperature in the range of 30°C–90°C to obtain optimum dispersion results. In **Fig. 14**, the dirt specks area vs. temperature graph depicts that, without washing of the pulp, the minimum dirt specks area was observed at 45°C and the maximum at 75°C. At 45°C temperature, the dirt specks area after granule-assisted dispersion is reduced by 18% for Group A (all particles >50µm) and 50% for Group B (particles >250µm). It can be seen from the graph that the dirt specks area starts increasing more after the temperature increases beyond 60°C and experiences a slight fall at 90°C. After washing the pulp, at temperature 45°C the dirt specks area is reduced by 65% for Group A and by 80 % for Group B due to removal of all smaller specks particles (<50µm).

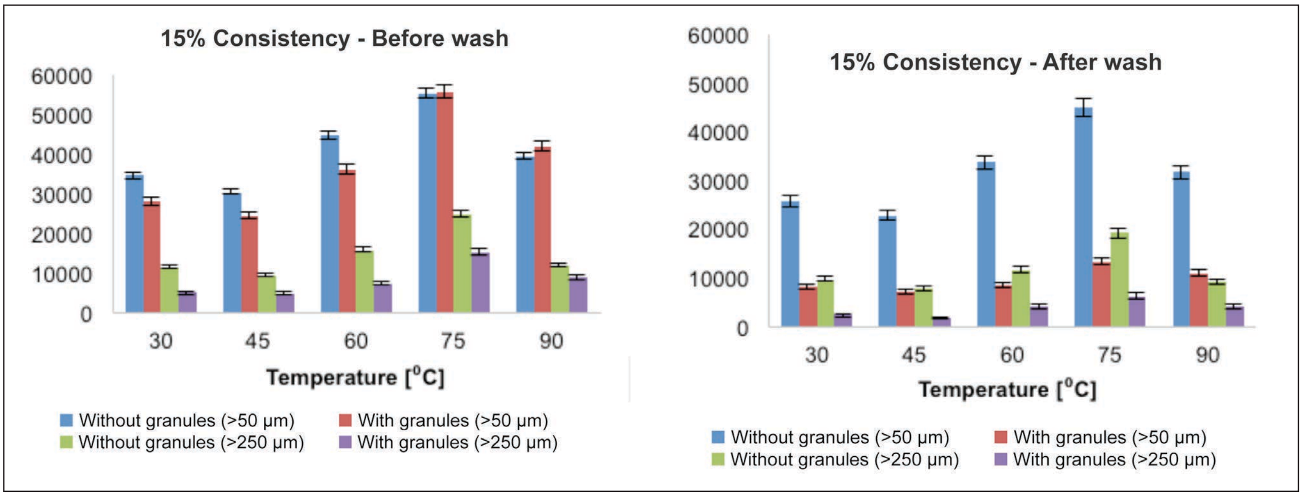
At temperature 90°C, the trend was reversed; dirt specks area was found more for pulp with alternative dispersion than without dispersion. The results were confirmed by repeating the test at 20% consistency and measuring the dirt specks area (**Fig. 15**) and ISO brightness (**Fig. 16**). However, after washing the pulp, a normal dispersion trend was observed. Importantly, washing reduces the number of particles in the range of ~0–200 µm. In Fig. 15 (after washing), the dirt specks area for particles of Group B increased for pulp without alternative dispersion at all temperatures. However, with alternative dispersion, the specks area reduces after washing, even for Group B particles.



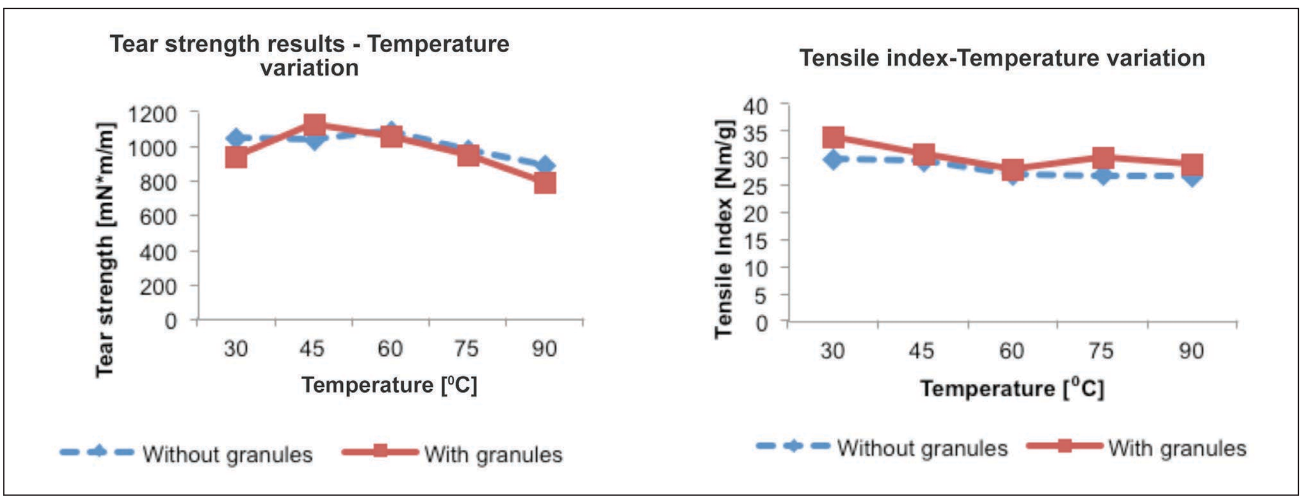
16. Brightness variation against temperature (pulping carried out at 20% consistency).

When hot pulp (45°C–90°C) is brought to lower temperature (15°C–20°C) at highly reduced consistency (~1%) during sheet formation, the particles tend to coalesce into larger specks. However, polyamide granules hinder this size increase. The reason for an increasing dirt specks area after washing for Group B can be explained by the same theory. During washing, which is carried out at a consistency of 1%–2%, UV ink particles in pulp get more space and prolonged time to aggregate smaller particles into larger ones. However, we may reduce this side effect by preventing any sudden cooling effect at lower consistencies. After pulping at a specified temperature, pulp was reduced to room temperature without disturbing the pulping consistency (15% and 20%, in this case) and then washing was continued. As shown in **Fig. 17**, if pulp consistency is not suddenly lowered just after pulping at higher temperature, then the specks area of UV ink particles that are of elastic nature will decrease predictably.

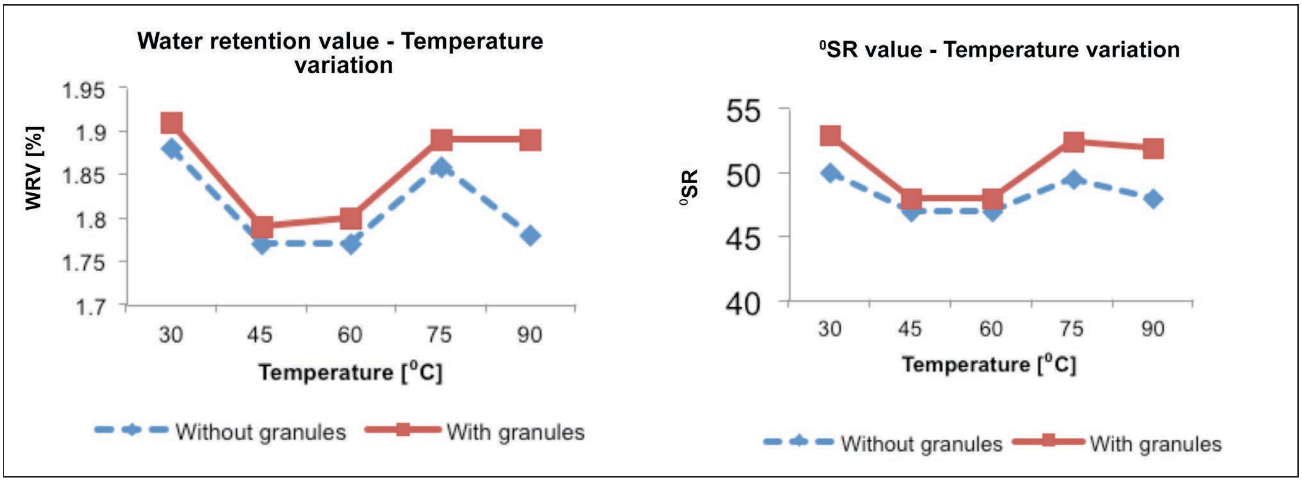
There is a slight decrease in tear as well as tensile strength with an increase in temperature. However, pulp with alternative dispersion follows the same path (**Fig. 18**), ensuring prevention of harmful effects from polyamide granules on wood fibers at a given temperature range.



17. Dirt specks area of the pulp after dispersion at temperature range of 30º–90ºC without any sudden cooling effect.



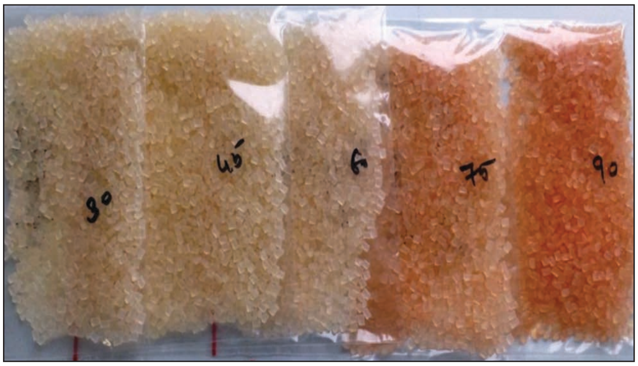
18. Effect of granule-assisted dispersion on tensile strength with variation of temperature (20% consistency).



19. Wet strength and water carryover capacity of fiber.

Water retention value ends up constant for the temperature range 45°C–60°C and increased slightly by 1% when pulping was carried out at a temperature of 75°C (with polyamide granules). **Fig. 19** shows that °SR of pulp at 30°C, 75°C, and 90°C is higher by two points than the pulp at 45°C and 60°C. There is no significant difference in °SR values of these two different types of pulp (pulping in presence/absence of polyamide granules).

Apart from dispersion, temperature variation demonstrated another positive side effect of physical adsorption, shown in **Fig. 20**. UV ink was adsorbed on the surface of polyamide granules, predominantly at temperature 90°C. This result must be explored in further detail, but due to the limitations of this work, it is not included in this manuscript.



20. Polyamide granules after granule-assisted dispersion at 20% consistency with temperature from 30°– 90°C.

CONCLUSION

Substantial research has been conducted in the field of deinking, yet further work continues on reducing carbon footprint/energy consumption without affecting product quality. Adsorption deinking of recovered paper uses appropriate plastic granules to act as both adsorption material for ink removal and as a dispersing material to comminute the ink particles during the pulping process. It is a real alternative to the energy intensive sub-processes of conventional deinking and the dispersion method. Similar to conventional dispersion/kneading, the trials conducted in our research show that granule-assisted dispersion depends on parameters like consistency, temperature, and surface area.

A maximum and predominant effect of granules for dispersion was observed at 15% pulp consistency. The remainder of the tests were carried out at 15% consistency so that any alteration in optical properties could easily be studied. By adding the plastic granules (with appropriate roughness) to the pulper, pulping, deinking, and dispersing can be combined in just one process step at the same high consistency (15%). It can be concluded from the experiments that appropriate granules used in pulping of recycling paper can work as both ink collectors and as dispersing granulates. Such a combined process — if technically and commercially feasible — would undoubtedly represent major progress in stock preparation, if not a breakthrough.

Adsorption deinking and granulate-assisted dispersion can provide valuable contributions towards achieving the ambitious goals of the CEPI Roadmap 2050 [8]. Even if these concepts do not evolve into breakthrough technologies, they at least represent a first attempt to leave beaten tracks — a necessary step, in most cases, for opening new horizons. At Dresden University of Technology, we believe in this strategy and are highly motivated to continue our work to identify new solutions, which could make our industry more energy efficient. **TJ**

ACKNOWLEDGEMENTS

Dresden University of Technology funded this research. The results reported in this paper were obtained in the framework of a number of research projects supported by the Association of the German Paper Industry (VDP-INFOR) and INGEDE (The International Association of the Deinking Industry). Support from Papiertechnische Stiftung (PTS) for the conventional dispersion process is gratefully acknowledged. Author Tyagi especially acknowledges DAAD for their personal support in Dresden.

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ABOUT THE AUTHORS

As paper technologists, we at Dresden University of Technology always look for new solutions and alternative methods for papermaking industries to minimize energy consumption as a means to reduce carbon footprint. Minimization of energy consumption in the paper recycling process is why we chose to research polymeric granule-assisted dispersion.

Prior to the research in this paper, we at Dresden University of Technology were working on adsorption deinking instead of dispersion. The idea of alternative dispersion came from some unexpected results in adsorption deinking that resulted in energy minimization for paper recycling.

Selection of the combination of granules material and paper type was a difficult task for this research work, because offset ink has a tendency to adsorb over the surface of most of the granules. This may lead to undetected results because, for verification of dispersion results, ink particles should remain in the pulp so that dispersion can be measured with DOMAS. If ink had been adsorbed on the surface of granules, we could not measure the dispersion effect of the polymeric granules.

An interesting discovery in this research was that in pulping at higher temperature (>75°C), granules started absorbing ink particles from the pulp. To confirm this result, we repeated the trials but obtained similar results every time.

The results from this research provide a basic idea of how to use this alternative dispersion method to disperse ink particles and eliminate one of the highest energy consuming processes (conventional dispersion) in the paper recycling industry. The results in this paper also show that, by using this method of dispersion, we can combine pulping, deinking (adsorption deinking), and dispersion in just one process.

Separation of used granules from the stock (ink-dispersed and deinked pulp) is the most crucial part that is now left unanswered. Before bringing this breakthrough technology to the real world paper industry, we must find an economical and feasible method requiring the least energy to separate these granules from the pulp stock after use.

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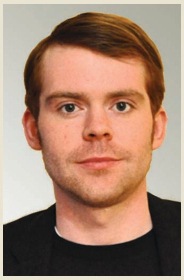
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