Flexographic Water-based Ink Use White Paper

I. Introduction

Flexographic water-based inks are widely used in food packaging, labels, corrugated cartons, and other fields due to their environmental friendliness (low VOCs emissions), safety, and printing adaptability. This white paper aims to provide operational guidance for technicians and systematically sort out common problems and solutions to ensure printing quality and production efficiency.

II. Basic Characteristics of Flexographic Water-based Inks

1. **Composition**: Water-soluble resin, pigments, additives (wetting agents, defoamers, leveling agents, etc.), deionized water.
2. **Core Advantages**: Environmental compliance, wide printing adaptability, easy cleaning, low odor.
3. **Suitable Substrates**: Paper, cardboard, some plastic films (requires pretreatment), aluminum foil, etc.

III. Common Problems and Solutions

1. Slow Ink Drying Speed

- **Causes**:
  - High printing environment humidity (>70% RH) or low temperature (<20°C).
  - High ink viscosity, slow water volatilization.
  - Poor water absorption of the substrate (e.g., plastic film).
- **Solutions**:
  - Increase oven temperature (recommended 50–80°C) or air volume.
  - Add 2%–5% ethanol or isopropanol to accelerate drying (test compatibility required).
  - Reduce ink viscosity (dilute with deionized water to 25–35 seconds/25°C, No. 4 viscosity cup).

2. Poor Printing Adhesion

- **Causes**:
  - Insufficient surface energy of the substrate (e.g., PE/PP film not corona-treated).
  - Ink formula incompatible with the substrate.
  - Incomplete drying leading to residual moisture affecting adhesion.
- **Solutions**:
  - Corona-treat plastic substrates (Dyne value ⩾38 mN/m).
  - Add 3%–5% adhesion promoters (e.g., polyurethane-based).
  - Optimize oven temperature curves to ensure complete ink drying.

3. Blurred Printing Dots or Edge Diffusion

- **Causes**:
  - Too low ink viscosity resulting in excessive leveling.
  - Improper selection of anilox roll line count (e.g., high-line anilox roll with high-viscosity ink).
  - Excessive printing pressure.
- **Solutions**:
  - Adjust ink viscosity to 30–40 seconds (No. 4 cup).
  - Match anilox roll line count (recommended: solid printing 400–600 LPI, fine graphics 800–1000 LPI).
  - Reduce printing pressure to 0.1–0.3 MPa.

4. Unstable Ink pH Value

- **Causes**:
  - Volatilization of amine neutralizers leading to pH drop (ideal pH 8.5–9.5).
  - Ink in the circulation system exposed to air for long periods.
- **Solutions**:
  - Test pH every 4 hours and replenish ammonia water or amine stabilizers (each addition ⩽1%).
  - Seal the ink circulation system to reduce volatilization.

5. Foam Generation

- **Causes**:
  - Excessive mechanical shear force during high-speed printing.
  - Insufficient defoamer addition or 失效 (ineffectiveness).
- **Solutions**:
  - Add 0.1%–0.5% silicone-based defoamer (pre-dispersion required).
  - Reduce pump speed or switch to a low-shear ink delivery system.

6. Ink Delamination or Sedimentation After Storage

- **Causes**:
  - High pigment density (e.g., titanium dioxide) leading to sedimentation.
  - Storage at too low a temperature (<5°C) or for too long (>6 months).
- **Solutions**:
  - Mechanically stir for more than 30 minutes before use.
  - Add 0.5%–1% anti-sediment agents (e.g., fumed silica).

7. Color Deviation or Batch Inconsistency

- **Causes**:

    - Uneven pigment dispersion or particle size differences between batches.
    - Insufficient stirring due to pigment sedimentation after long-term storage.
    - Color differences in printing substrates (e.g., varying paper whiteness).
- **Solutions**:
    - Pre-disperse ink with a high-shear disperser (recommended speed 2000–3000 rpm, time 15–30 minutes).
    - Perform Lab value testing for each batch (color difference ΔE ≤1.5 is qualified).
    - Pre-test substrates and adjust ink formulas to compensate for substrate background color effects.

8. Printing Plate Plugging (Anilox Roll or Plate Clogging)

- **Causes**:
    - Too fast ink drying, forming skin in the anilox cells.
    - Ink impurities (e.g., undispersed pigment particles or foreign matter).
    - Incomplete cleaning leading to residual ink curing.
- **Solutions**:
    - Add 1%–3% slow-drying agents (e.g., ethylene glycol butyl ether) to extend open time.
    - Filter ink with a 5–10μm filter before loading.
    - When 停机 (shutting down) for more than 30 minutes, cover the plate with pH-neutral fountain solution.

9. Poor Print Water Resistance

- **Causes**:
    - Insufficient water resistance of the water-based resin (e.g., uncrosslinked acrylic resin).
    - Incomplete drying leading to residual hydrophilic additives (e.g., wetting agents).
- **Solutions**:
    - Replace with water-resistant resins (e.g., polyurethane-acrylic composite systems).
    - Add 2%–5% crosslinking agents (e.g., aziridine-based) to improve water resistance.
    - Increase drying temperature to 80–100°C to thoroughly remove moisture.

10. Insufficient Ink Gloss

- **Causes**:
  - Poor ink leveling, rough film surface.
  - Excessive pigment content or low resin proportion.
  - Fast ink absorption by the substrate causing surface collapse.
- **Solutions**:
  - Add 0.5%–1.5% leveling agents (e.g., silicone-modified acrylic esters).
  - Adjust the resin-to-pigment ratio to 4:1–5:1 (resin accounts for 60%–70%).
  - Pre-coat the substrate or choose low-absorbency substrates.

11. Large Ink Viscosity Fluctuations During Printing

- **Causes**:
  - Unstable water volatilization rate due to changes in environmental temperature and humidity (e.g., rapid volatilization at temperatures >30°C).
  - Poor circulation system sealing, causing solvent volatilization or water absorption.
- **Solutions**:
  - Install temperature and humidity control equipment (recommended temperature 23±2°C, humidity 50%–60%).
  - Use closed doctor blade systems and ink barrels to reduce air contact.
  - Employ automatic viscosity controllers (e.g., ultrasonic viscometers) for real-time adjustment.

12. Printing Adhesion (Post-print Stacking Sticking)

- **Causes**:
  - Incomplete ink drying, residual moisture or additives.
  - Excessive stacking pressure or high environmental humidity.
- **Solutions**:
  - Extend drying time or increase the temperature of the cooling roller before winding (to 40–50°C).
  - Add 0.3%–0.8% anti-sticking agents (e.g., wax emulsions or silica powders).
  - Control stacking height ⩽1 meter and use separator paper.

13. Poor Ink Transfer (Unreal Printing or Missing Prints)

- **Causes**:
  - Worn anilox roll or improper line count selection, resulting in insufficient ink loading.

    - Too low ink viscosity or poor wettability, failing to adhere to the plate effectively.
    - Excessive substrate surface roughness (e.g., coarse corrugated paper).
- **Solutions**:
    - Inspect anilox roll wear and replace or repair (replace if ink loading loss >15%).
    - Increase ink viscosity to 35–45 seconds (No. 4 cup) and add 0.1%–0.3% wetting agents .
    - Switch to highly elastic plates (e.g., hardness 60–70 Shore A) to adapt to rough substrates.

14. Poor Print Rub Resistance

- **Causes**:
    - Insufficient hardness of the ink film (low resin glass transition temperature Tg).
    - Weak bonding force between pigments and resin, prone to shedding.
    - Lack of or insufficient anti-wear additives.
- **Solutions**:
    - Select high-Tg resins (e.g., acrylic-polyurethane composite resins with Tg > 50°C).
    - Add 2%–4% nano-silica or ceramic microspheres to enhance surface hardness.
    - Coat water-based varnish after printing (dry film thickness 1–2μm) to improve wear resistance.

15. Ink Skinning (Surface Film Formation)

- **Causes**:
    - Ink exposed to air for extended periods, causing surface curing due to water volatilization.
    - Excessive defoamer or too fast self-crosslinking rate of the resin.
- **Solutions**:
    - Seal the ink tank with a moist cover film during shutdown to reduce air contact.
    - Adjust defoamer dosage to 0.1%–0.3% to avoid excessive inhibition of surface activity.
    - Add 0.5%–1% propylene glycol as a humectant to delay drying.

16. Print Yellowing or Discoloration

- **Causes**:

    - Poor light/heat stability of resins or additives (e.g., oxidation of amine neutralizers).
    - Pigment degradation due to UV exposure or high-temperature storage.
- **Solutions**:
    - Use yellowing-resistant resins (e.g., aliphatic polyurethane) and antioxidants (e.g., BHT).
    - Add 0.5%–1% UV absorbers (e.g., benzotriazole types).
    - Control storage conditions (avoid light, temperature <30°C).

17. Chemical Reaction Between Ink and Substrate

- **Causes**:
    - Acidic/alkaline substances in the substrate coating (e.g., antistatic agents in some PE films).
    - Excessively high ink pH (>9.5) or corrosive components.
- **Solutions**:
    - Pre-test substrate-ink compatibility (48-hour immersion test).
    - Adjust ink pH to 8.0–9.0 and avoid strong alkaline amine neutralizers.
    - Switch to inert substrates or add barrier coatings (e.g., water-based primer).

18. Print Edge Jaggedness (Fringing)

- **Causes**:
    - Insufficient plate resolution or low platemaking precision (e.g., digital plates vs. traditional plates).
    - Poor ink leveling, unable to evenly fill plate edges.
    - Uneven printing pressure or equipment vibration.
- **Solutions**:
    - Use high-definition digital platemaking technology (resolution ≥4000 dpi).
    - Add 0.2%–0.5% leveling agent to improve ink spreading.
    - Calibrate printing pressure and check equipment drive system stability.

19. Abnormal Ink Performance After Low-Temperature Storage

- **Causes**:
    - Low temperature (<5°C) causing crystallization of water-based resins or drastic viscosity increase, losing fluidity.
    - Insufficient antifreeze (e.g., propylene glycol) leading to water freezing and emulsion system damage.

- **Solutions**:
    - Add 3%–5% antifreeze (propylene glycol or glycerin) and ensure storage temperature ⩾5°C.
    - Slowly rewarm to 20–25°C before use, avoiding direct heating to prevent component separation.

20. Poor Print Chemical Resistance (e.g., Alcohol/Grease Wipe-off)

- **Causes**:
    - Low resin crosslinking density, unable to resist solvent erosion.
    - Incompletely encapsulated pigments, with exposed parts prone to dissolution.
- **Solutions**:
    - Use two-component water-based inks and add 3%–5% water-based isocyanate crosslinkers.
    - Optimize the grinding process (particle size ⩽5μm) to ensure pigments are fully wrapped by resin.

21. Ink Splashing During Printing (Ink Spray Contaminating Equipment)

- **Causes**:
    - High printing speed (>200 m/min) leading to excessive ink centrifugal force.
    - Too low ink viscosity (<25 seconds) or insufficient surface tension.
- **Solutions**:
    - Control printing speed ⩽150 m/min or use a closed doctor blade system.
    - Increase ink viscosity to 30–35 seconds and add 0.1%–0.2% thickeners (e.g., polyurethane types).

22. Insufficient Antistatic Performance (Plastic Substrates Attracting Dust)

- **Causes**:
    - Uneliminated static electricity on the substrate surface (e.g., BOPP film without antistatic treatment).
    - Lack of antistatic function in the ink itself.
- **Solutions**:
    - Add 0.5%–1.5% ionic antistatic agents (e.g., quaternary ammonium salts) to the ink.
    - Treat the substrate with antistatic treatment before printing (Dyne value ⩾40 mN/m).

23. Unstable Ink Rheology (Shear Thinning or Thickening)

- **Causes**:
    - Wide resin molecular weight distribution, causing structural

breakdown under shear.
    - Uneven dispersion of thixotropic agents (e.g., fumed silica).
- **Solutions**:
    - Select resins with narrow molecular weight distribution (PDI <1.5).
    - Add 0.3%–0.8% organically modified bentonite to enhance thixotropy.

24. Post-Print Blocking (Re-sticking After Drying)

- **Causes**:
    - Residual hydrophilic groups in the resin, softening after moisture absorption.
    - High environmental humidity (>70% RH) or large temperature fluctuations.
- **Solutions**:
    - Use hydrophobic modified resins (e.g., silicone acrylate).
    - Add 0.5%–1% anti-blocking wax emulsion and control warehouse humidity ⩽60%.

IV. Operation and Maintenance Recommendations

1. **Printing Parameter Optimization**:
    - **Viscosity Control**: Test every 2 hours, with a fluctuation range of ±2 seconds.
    - **Anilox Roll Cleaning**: Use special cleaning agents (pH-neutral) daily to prevent clogging.
2. **Storage Conditions**:
    - Store at 5–30°C in a dark, sealed environment.
    - Use opened ink within 7 days; seal and store unused ink.

V. Safety and Environmental Protection

1. Dispose of waste ink in accordance with local environmental regulations; do not discharge directly.
2. Wear protective gloves and goggles during operation to avoid skin contact.

VI. Conclusion

The performance of flexographic water-based inks is affected by multiple factors such as environment, equipment, and operation. By scientifically controlling viscosity, pH, and drying conditions, and using additives targetedly, printing quality and efficiency can be significantly improved. It is recommended to

establish standardized operating procedures (SOPs) and provide regular training for technicians.

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