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# Effect of pressure of photopolymer plate to the ground on the compression resistance of transport containers made from tri-layer corrugated board during inline flexographic printing.

TOMASZ NOWAK, IZABELA MODZELEWSKA

Poznan University of Life Sciences, Institute of Chemical Wood Technology

**Abstract.** In the following article, an attempt was made to empirically determine an impact of technological errors on compression resistance of corrugated fiberboard transport containers during inline flexographic printing on industrial slotted – printing – gluing and folding machine. Investigation proves that the printing process has an influence on packaging resistance. It has been shown how important press photopolymer printing plates are to corrugated board adjustment by a machine operator and a correct production technology preparation. Adjusted high pressure due to male/female creasing occurred, caused resistance loss by 13%.

*Key words:* photopolymer pressure, BCT, compression resistance, RSC, transport containers

## INTRODUCTION

Manufacturing corrugated fiberboard transport containers is still an important and intensively developing industry of a wood converting sector. Continuous economic optimization is focused on increasing durability of packaging products simultaneously reducing expenses for resources. Good manufacturing practices can increase quality of finished products without superfluous interference into the material. Effects of work depend on a human factor resulting from knowledge, experience of machines operators and technological factors depended on converting machines' specifications and processes in which boxes are treated.

The aim of this study is empirical determination of technological errors during inline flexography printing on industrial slotting – printing – folding and gluing machines influence on compression resistance of corrugated fiberboard transport containers.

## MATERIALS AND METHODS

The analyzed product was made in industrial environment. Boxes were produced on MARTIN 924 NT line, equipped in 60º screened cylinder (anilox) 12 $cm^3/m^2$ volume and 100 lpc linature, and chambered doctor blades. As ink transferring medium was used 5 mm thickness DuPont Cyrel DPC photopolymer printing plates with duromater 35 SR A. Ready boxes were tested for compression resistance according to PN-EN ISO 12048:2002 on 25CTBOX Box Compression Tester. In investigation three-layer corrugated board in C profile was used. Board contained following paper: Testliner white 140 g/sqm as an external layer, Wellenstoff 120 g/sqm as a medium one and Testliner3 135 g/sqm as an internal layer. Additionally, board contained cross male/female creasing lines made on corrugator. The subject of the study was Regular Slotted Container signed as 0201 according to FEFCO standards, with 270 mm x 200 mm x 260 mm internal dimensions.

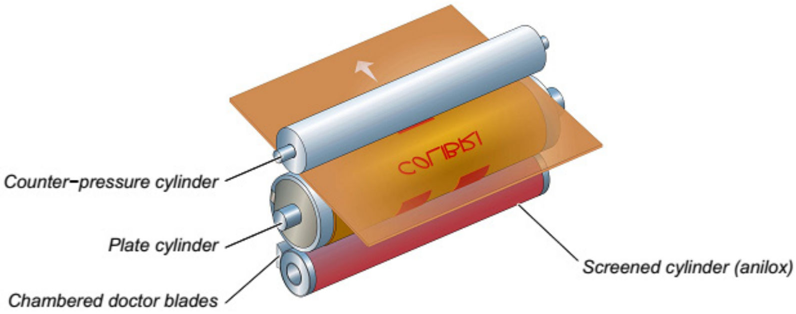


***Figure 1.*** *MARTIN 924 NT Printing section*

RESEARCH RESULTS

MARTIN 924 NT, is equipped with an adjustable gap between photopolymer plate and counter – pressure cylinder (Figure 1), which allows for printing with gap graded at 0,1 mm. Percentage gap width was expressed as

$$St\ [\%] = \frac{Sm\ [mm]}{Gt\ [mm]} \times 100, \qquad where$$

*Sm – gap between printing surface and counter - pressure cylinder, Gt – board thickness before pass through printing section*

A printing effect was assessed visually, where only full ink covered was recognized as correct. The test was performed for range of gap from Sm = 3,98 St =105 % to Sm =0,86, St = 23%.
Relative compression resistance expressed as:

$$Ww\ [\%] = \frac{W\ [N]}{Wr\ [N]} \times 100, \qquad where$$

*W – Compression resistance, Wr – compression resistance of reference sample Sm=3,98 St=105%*

***Table 1.*** *shows the relation between compression resistance of tested samples according to PN-ISO 12048, and the gap between printing surface and counter - pressure cylinder*

| Sm [mm] | St [%] | W [N] | Ww [%] | Sm [mm] | St [%] | W [N] | Ww [%] | Sm [mm] | St [%] | W [N] | Ww[%] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D 3,98 | 105 | 1827 | 100 | 2,95 | 78 | 1725 | 94 | 1,87 | 49 | 1620 | 88 |
| 3,89 | 102 | 1817 | 99 | 2,89 | 76 | 1680 | 92 | 1,84 | 48 | 1635 | 89 |
| C 3,80 | 100 | 1773 | 97 | 2,80 | 74 | 1699 | 93 | 1,75 | 46 | 1645 | 90 |
| B 3,68 | 97 | 1780 | 97 | 2,72 | 72 | 1685 | 92 | 1,69 | 44 | 1625 | 89 |
| 3,60 | 95 | 1740 | 95 | 2,63 | 69 | 1670 | 91 | E 1,60 | 42 | 1595 | 87 |
| 3,51 | 92 | 1780 | 97 | 2,54 | 67 | 1640 | 89 | 1,49 | 39 | 1580 | 86 |
| 3,48 | 92 | 1750 | 95 | 2,45 | 64 | 1650 | 90 | 1,40 | 37 | 1539 | 84 |
| A/F 3,39 | 89 | 1710 | 93 | 2,39 | 63 | 1690 | 92 | 1,28 | 34 | 1511 | 82 |
| 3,30 | 87 | 1725 | 94 | 2,22 | 58 | 1665 | 91 | 1,19 | 31 | 1539 | 84 |
| 3,21 | 84 | 1720 | 94 | 2,13 | 56 | 1680 | 92 | 1,08 | 28 | 1443 | 79 |
| 3,13 | 82 | 1690 | 92 | 2,04 | 54 | 1701 | 93 | 1,02 | 27 | 1508 | 82 |
| 3,04 | 80 | 1686 | 92 | 1,96 | 52 | 1698 | 92 | 0,93 | 24 | 1487 | 81 |
| | | | | | | | | 0,86 | 23 | 1412 | 77 |

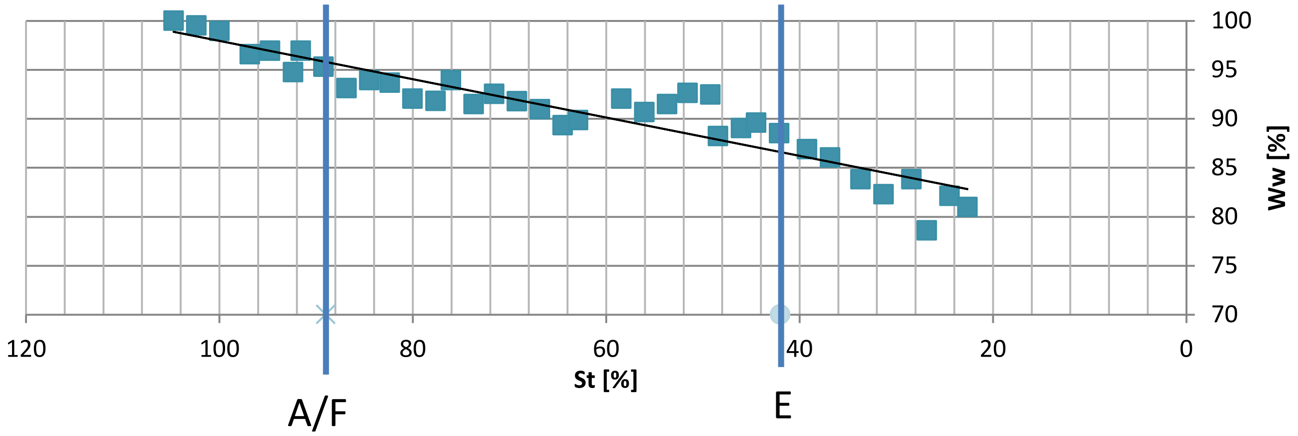


***Figure. 2.*** *Shows relations between compression resistances BCT expressed as percentage relation to reference box and gap expressed as percentage relation gap width to board thickness.*

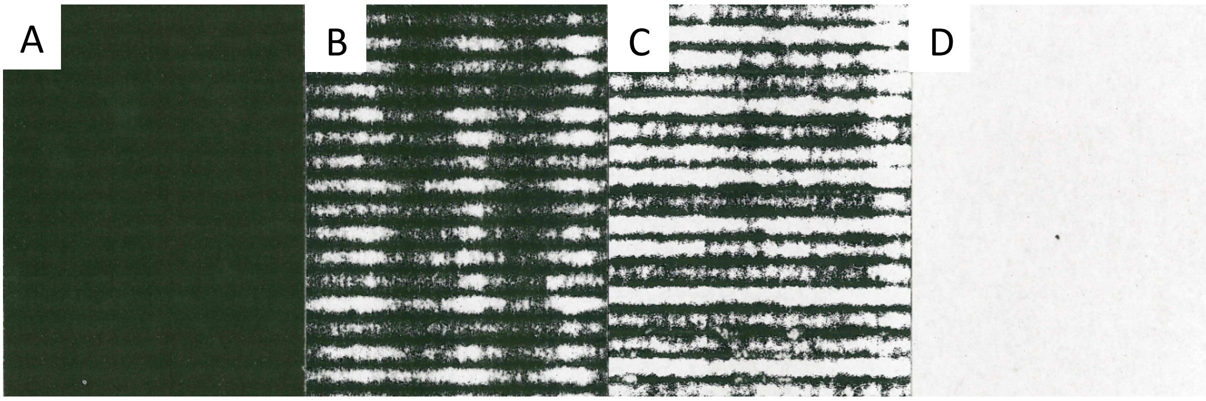


***Figure. 3.*** *Photos show results of printing in different gap width*

*A – Optimal surface coverage where gap was 89% of material thickness, B,C – insufficient coverage where gap was equal to board thickness 97%,100%, D – reference sample where gap were larger than material thickness 105%*

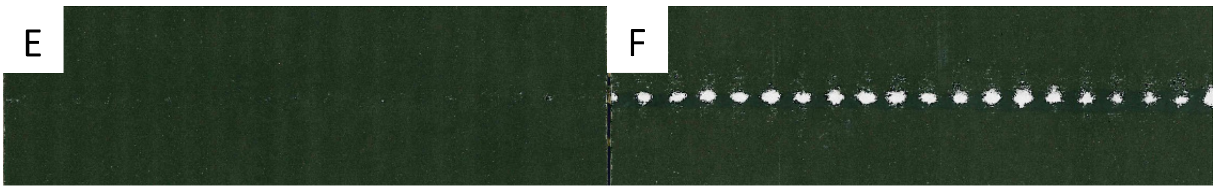


***Figure. 4.*** *Photos shows the part of samples where creasing line occurred*
F – Sample printed in gap 89%, optimal coverage on flat surface, on part where creasing line occur *insufficient ink coverage,*
*E* - Sample printed in gap 42%, optimal coverage also on part where creasing line occur

The tested corrugated board has the highest flute profile from commonly used in Europe –C. Theoretical compression resistance of boxes is closely correlated with corrugated board thickness according to $BCT = a \times ECT\ [kN/m] \times \sqrt{Gt\ [m]} \times \sqrt{Ob[m]}$ formula where Ob is box circuit and ECT is Edge Crush Test (McKee 1963). Therefore after flattening due to printing plate press, the most significant resistant decrease should be expected using the highest profiles. The most difficult in a printing process should be deemed to the highest profile owing to washboarding effect. Male/female creasing on corrugator was intentionally used (just as commonly manufacturers do) which can cause serious problems during printing.

Table 1 presents results of analyses compression resistance according to gap width. Graph 1 presents relative resistance according to a gap exposed as percentage of corrugated board thickness. The investigation proves that with increasing pressure of photopolymer plates to material, box resistance decreases. Reference sample, that has not had contact with printing plate had BCT on level of 1827 N, ink coverage equal to zero (Figure 3 D) confirms non-contact pass through printing section. When the gap reached the board thickness, the ink occurred on tops of flute ridges (Figure. 3 C), at this moment box resistance did not change. Acceptable ink coverage on flat surface (Figure. 3 A) obtained when the gap was 89% at this moment compression resistant decreased to 93%. Pressure did not provide the ink coverage on places where the creasing line occurred (Figure. 4 F). Acceptable coverage on creasing lines was obtained where the gap reached level 42% of material thickness, which caused resistance decrease to 87% (Figure 4 E). Investigation was stopped when the gap reached 23%, at that moment box compression resistance was on 77% related to reference sample.

## CONCLUSIONS

The investigation proves that inline flexographic printing process has an impact on compression resistance of corrugated fiberboard transport containers. Results show how important an optimal pressure printing plate to material adjustment is during machine setup and proper production technology. Adjusted high pressure due to male/female creasing occurred, caused resistance loss by 13%. It is indicated that in order to avoid putting printing elements on the creases during preparing graphical project, it is better to cut the artwork approx. 10 mm before the crease. Another option is to choose the “V” on flat creasing type on corrugator if it is possible or make a crease on rotary cutting the board, when this process is available on a machine because it is localized after the printing section. If above good practice was applied it would be achievable to print with acceptable quality with compression resistance loss by 7%. It should be noted that in extremely wrong machine adjustment, the parameters loss can reach 23%, which can cause serious consequences during the transport of packaged goods.

## REFERENCES

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STRESZCZENIE. *Wpływ docisku kliszy fotopolimerowej, do podłoża podczas druku metodą flexograficzną, na wytrzymałość opakowań z tektury falistej.* W niniejszym artykule podjęto próbę empirycznego sprawdzenie wpływu błędów technologicznych podczas druku metodą flexograficzną inline na przemysłowej maszynie slotująco – drukująco – klejącej na wytrzymałość na nacisk statyczny opakowań transportowych. Badania dowiodły, iż proces druku inline metodą flexograficzą ma wpływ na wytrzymałość opakowań. Wykazano również jak ważne jest optymalne ustawienie docisków kliszy do tektury przez drukarza oraz poprawne ustawienie technologii produkcji. Bigowanie obustronne wymusiło docisk powodujący spadek wytrzymałości rzędu 13%.

Corresponding author:

mgr inż. Tomasz Nowak
Research and Development Manager in United Packaging S.A. Packaging Plant Skarbimierz ul. Opakpowaniowa 2, 49-318 Skarbimierz-Osiedle, tomasz.nowak@unitedpackaging.pl
dr hab. inż. Izabela Modzelewska
Uniwersytet Przyrodniczy w Poznaniu, Instytut Chemicznej Technologii Drewna,
Zakład Technologii Celulozy i Papieru
ul. Wojska Polskiego 38/42, 60-036 Poznań, Poland
e-mail: izabelajanicka@poczta.fm