Comparing Components of Flexography Printing for the Application of Oxygen Barrier Inks on Films

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> > by

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Abstract

The purpose of this study is to appraise typical components used in flexographic printing to provide more knowledge on the use of printing with functional inks on filmic substrates when printing packaged products inline. An oxygen barrier coating was applied using different plate-screening technologies and anilox rolls. Comparing two plate-screening technologies and three different anilox rolls using oxygen permeability tests helped to conclude the optimum plate and anilox roll solution that best apply the ink for proper functionality of the coating, with minimal ink application as to reduce waste.

Further knowledge of printing oxygen barrier coatings inline will yield results that benefit in both production and cost areas. Selecting the right combination of plate technology and anilox roll that achieves similar results of barrier properties available in pretreated films will allow companies to achieve maximum barrier assets in their packaging in a more cost effective manner.

The first print run comparing the different plate screening technologies, revealed that the capped plate technology provided much higher barrier properites than the cell patterned technology. As the capped plate technology was used with the second print run comparing the anilox rolls, optimum results disclose the combination of these two flexographic components for achieving maximum functionality of barrier inks. Using the 360 CPI, 6.53 BCM anilox roll with the capped plate technology provides barrier properties that are competitvely comparable with pretreated films. Benefits of inline printing versus pretreated films are found in both cost and production areas of the company.

Chapter One

Introduction

Today, a majority of packaging is printed with flexography and a fair amount of flexography is printed on filmic substrates. Filmic substrates include plastic films that often come as a large roll, for web printing. As the trend of using functional barrier properties on packaged food products becomes increasingly popular, having additional knowledge of functional barriers is both cost effective and production efficient. Functional barrier properties are the characteristics found among certain inks and coatings that serves to prevent one or more gasses or liquids from permeating the package.

Examples of smart packaging technologies include inks with barrier, sensor, and scavenging properties. These available techniques may control oxygen, carbon dioxide, ethylene, moisture, or odor, in order to help improve shelf life or product quality. While plastic films with precoated protective barrier properties can be purchased, having a tractable way of printing these functional inks inline may prove to be more cost effective. Printing inks inline refers to buying the barrier coating in ink form and applying it to the filmic substrate on press while printing the packaging graphics. When printing with functional inks it is critical that the application of ink meet the specified requirements to ensure the purpose of the "smart" and specific function.

In flexographic printing, the anilox cell volume and the printing plate used for the imagecarrier, are the primary controlling factors in ink transfer. Since there are several technologies used to enhance the ink transfer on printing plates, comparing these technologies will indicate the optimal plate technology for printing functional coatings onto films. Two plate-screening options for flexography printing were tested: plate cell

patterning and capped plate technologies. As the anilox roll is another controllable element of flexography printing, having an understanding of the characteristics of the cells and their impact on ink transfer is important for the application of barrier coatings and their functionality.

Background

With various smart packaging options available, adding protective properties to packaging products is guite broad. Three popular forms of intelligent packaging include sensors, scavengers and barriers. With a focus on barrier coatings, comparing different screening technologies reveals the best plate technology to optimize the functionality of these materials. The anilox roll selected for the print run is dependent on the printed product's characteristics and needs. Primary characteristics that need to be considered when deciding on which anilox roll to use for a flexographic print run include, the angle of the cells, the carrying capacity of the cell (cell volume), and the number of cells per linear inch (line screen) (Hamrick). In the case of printing functional inks with specific barrier properties, anilox roll selection becomes even more important because of the requirement of specific densities to ensure proper functionality of the ink. With so many properties to consider, the question becomes: What is the best combination of anilox roll characteristics, and plate technology to ensure the optimum application of functional inks, such as an oxygen barrier coating? While a high volume, anilox roll will provide a thick application of the coating, a combination of the capped plate technology and a medium volume anilox will apply the full functionality of the ink without excess material use.

Purpose of Study

The purpose of this study is to evaluate different components found in flexographic printing to provide more knowledge on the use of printing functional inks on filmic

substrates in packaged food products when printing inline. Comparing the application of the oxygen barrier coating using different plate-screening technologies and anilox rolls using oxygen permeability tests, will help determine the plate and anilox roll that best apply the ink for proper functionality of the coating. Further knowledge of printing with oxygen barrier coatings inline will provide results that benefit in both cost and production efficiency. Choosing the right combination of plate technology and anilox roll can achieve similar results of these barrier properties that are available in pretreated films, but can be applied in a more cost effective manner. From this research, further understanding will be gained on achieving similar results with cost and production efficient methods of barrier coating application.

Chapter Two

There are several components of flexographic printing that are controlled before or during a pressrun in order to fulfill the scope of the printed project. When it comes to printing specialty inks – inks that serve a particular function – it is important that these specifications be met in order for the proper functionality of such inks. Two of these controlled components include the image-carrier, or printing plate, and anilox roll. While the plate serves as the image carrier for the ink lay-down between the ink metering system and substrate, the anilox roll is designed to consistently supply a uniform volume of ink onto the plate. With so many plate and anilox roll options, having an understanding of their variables will help in choosing what plate or roller will maximize the functionality when printing with specialty inks.

Intelligent packaging has come a long way to ensure customer satisfaction. With ways of controlling oxygen, carbon dioxide, ethylene, moisture, odor and temperature, smart packaging is available for many possible packaging problems. While intelligent packaging devices are narrowed down to the capability of sensing and providing information about the properties of the packaged food, active packaging includes components of packaging systems that have been deliberately included in or on the packaging material to enhance the performance of the package system (Kerry). Prior to deciding on the oxygen barrier ink as the focus for this research project, other intelligent packaging options were researched and considered. These include sensors and scavengers.

A sensor is a device that detects or measures a physical property and records, indicates or otherwise responds to it (Kerry). An example of using sensors in smart packaging is the AgeLess Eye by Mitsubishi Gas Company. The AgeLess Eye is a colorimetrix redox

dye-based indicator, in tablet form, placed inside a package to indicate the presence of oxygen in one glance (Mitsubishi). When exposed to oxygen, it turns blue, returning to its original pink appearance as soon as the oxygen is eliminated.

A scavenger, in chemistry, is a substance added to a mixture in order to react with, or otherwise interact and remove impurities or unwanted reaction products (ChemiCool). An example of this absorber in packaging is an oxygen scavenger in the form of a sachet. The mixture of chemicals found in the sachet, mainly salt and iron, react with the water and oxygen for elimination. Therefore the contents of the bag can sift through the oxygen in the packaging and moisture from the food to chemically create rust inside the bag; hence removing the oxygen from the package (Kaufman). Another example of a scavenger comes in the form of a film. For an ethylene film, the ethylene absorption agent is bound to films through polymer processing and then placed inside the packaging, as a liner or sheet. This liner/sheet then absorbs the ethylene gas as it is emitted inside the package (Research Gate).

A third functional component of smart packaging is a barrier. The barrier works as a limit or boundary to restrain or keep out anything unwanted, designed to be impervious to gas migration (Sargeant). An example of this is a film that resists oxygen permeation. The film is usually multi-layer with the outer top layer being a strong plastic, the inner layer being a thin layer of gas barrier material, and the inside or bottom layer is almost always a soft, low-density polyethylene (Sargeant). An alternative of using a composite material is to coat a plastic with a barrier coating.

Printing plates act as the image-carrier and a main component in controlling the print quality in flexographic printing. As there are many ways of treating a substrate in order to adjust ink acceptance, there are many ways of altering a flexographic printing plate

to change the ink acceptance properties. One of these techniques is to add a screening technology to the plate. In plate cell patterning, screening engines place cells in the solid areas of the plate by imaging them on an imagesetter, or directly onto the plate unit (Nexus). The cells found in the solid areas serve a similar function to the cells found in anilox rolls, providing more uniform ink. The results include lower ink consumption, less pressure required during the printing process, improved solids and finer positive images (Nexus).

Capped plates are considered another kind of plate technology. Capped plates have a micro-rough cap layer covering the entire plate which helps produce excellent ink transfer for both solid coverage and fine dot reproduction (MacDermid). In the printing of specialty inks it is advantageous to use a method to increase ink lay-down in order to achieve the ink thickness required with minimum waste.

Comparing a control plate with two different printing plates reveals the plate technology that attains maximum functionality and conservation, when printing with specialty inks. This is possible by measuring the oxygen transmission rate (OTR). Using an OTR test is beneficial in this study because it reveals the amount of oxygen that passes through the coated film, revealing its permeability. Permeability is how easily an element transfers through a solid substrate. A low value reveals a large resistance to the unwanted component, while a high value reveals a low resistance. The OTR inspection assesses the polypropylene film that is printed with the oxygen barrier coating, providing a quantitative measure of oxygen passing through the film in a cm3/m2/24hrs format. The smaller the number, the less oxygen that passes through the film.

Anilox rolls are the metering roll designed to consistently supply a uniform volume of ink onto the plate, or image carrier (Kenny). While there are three main characteristics that

make up the discreet differences from roll to roll, two of these components have a more prominent effect when printing with specialty inks. These characteristics however are the key to matching specifications that differ immensely from ink to ink. The three parts include the engraving angle of the cells, the cell volume and line-count.

In the case of printing with oxygen barrier ink and the large solid area coverage, having control of the engraved cell angle and the cell volume assist in the functionality of the ink. The engraving angle determines the shape of the cells and usually is provided in three angles: 30 degrees, 45 degrees and 60 degrees (Lanska, January). While the 45 degree cut provides a diamond shaped cell, the 30 and 60-degree angle yield hexagonal shaped cells. The shape of these cells is critical because the hexagonal shape produces 15 percent more cells per square inch of surface area than the diamond shape (Lanska, January). Now while the cell count is more critical in higher resolution printing or finer-line reproduction, it does come into play with the oxygen barrier coating in terms of waste. When applying an oxygen barrier coating, the functionality of the ink will be increased as the ink film is increased. However, once a critical thickness has been achieved, getting a thicker ink application is wasteful. While large cells have low numbered cell counts for more volume, balancing cell size ensures a more beneficial use of the ink by only applying the thickness required for its functionality.

The cell volume is the second and more critical component in having control of ink application in flexographic printing. The cell volume, which refers to the ink capacity of the cells, tells how much ink each cell can hold (Shawn). The common unit of measurement is billion cubic microns per square inch (BCM). The cell volume is essential to the process because it gives the best inclination of the amount of ink that will actually be delivered to the plate, and then to the film. The amount of ink that is

transferred to the plate from the anilox roll is often referred to as the delivered volume. While the cell volume tells us how much ink the cells are capable of holding, the delivered volume tells us how much ink actually transfers out of the cells. Since printing with specialty inks requires a precise thickness of ink application, it is crucial that the cell volume is delivering the correct amount of ink. With various factors impacting the delivered volume, such as the viscosity of the ink, doctoring method system used, and surface tension of the plate and substrate, it is vital that the delivered volume is predictable (Lanska, January).

Chapter Three

Purpose of Study

There are several variables considered in the process of applying an oxygen barrier coating inline. Components including anilox roll specification, plate characteristics and doctor blade condition are controllable in the sense that they can be adjusted or replaced in order to accommodate certain printing requirements. Requirements such as attaining a specific ink film thickness during the printing process are essential. While it is important to reach a specific ink thickness in order for the proper functionality of the coating, applying more ink than necessary is wasteful.

The purpose of this study is to evaluate two different variables found in flexographic printing to provide knowledge of these components when printing with functional inks. Comparing the application of the oxygen barrier coating through the use of different printing plate technologies and anilox rolls results in the best combination of roll and plate that can achieve comparable results to a pretreated, barrier film. Further knowledge of printing with an oxygen barrier coating inline produces results that benefit in the realm of cost and production.

Research Method

While there are several research options available, the scientific method is the most appropriate method for this study. The scientific method is a process of experimentation that searches for cause and effect relationships. Experiments are designed so that changes to one variable cause another variable to alter in a predictable way (Science Buddies). The scientific method is a suitable method for this study because the change in printing plates and anilox is expected to alter the oxygen barrier effect in a predictable manner.

The scientific method begins with identifying and defining the problem. As printing with specialty inks becomes increasingly popular, the need for specifications of printing with these inks is apparent. When printing with a functional coating inline, several concerns may arise in considering which aniox roll and printing plate to use. The next step is to formulate a hypothesis, followed by collecting, organizing and analyzing the data by actually performing the experiment. Through a series of print runs testing different anilox rolls and plate technologies on a Mark Andy 2200 flexographic press, an oxygen barrier coating is applied to the film and then tested to compare how much oxygen can pass through the film. After formulating the conclusion, it is important to communicate your results through verifiable and repeatable research (Science Buddies).

Materials and Methods

Various materials were used to conduct the press run and tests necessary to determine the results. Materials and equipment used for the flexographic print run included a flexographic printing press, printing plates, oxygen barrier ink, anilox rolls, and a filmic substrate. The printing press used for the press run was Cal Poly's Mark Andy 2200 Flexographic Press. The first printing plate tested was a DuPont Cyrel DFQ plate. This plate acted as the control plate since there was no screening technology added. The second plate tested was a MacDermid Epic capped plate provided by MacDermid. The third plate was a DuPont Cyrel DFQ plate that was screened with cell-patterned technology using EskoArtwork's plate cell patterning technology.

The specialty ink that was tested was SunBar 1.1 from SunChemical, one of the largest ink corporations nationwide. This two-part oxygen barrier coating prevents the penetration of certain gases that jeopardize the shelf life of a packaged product.

A second variable was also introduced. Three different anilox rolls were tested. The first was a 360 CPI, 6.53 BCM anilox roll. The second a 440 CPI, 3.33 BCM and the third anilox roll a 600 CPI 2.05 BCM.

The filmic substrate evaluated was a 2 mil oriented Clear Polypropylene 5000 from Multi-Plastics Inc. It is critical that the film tested was non-heat sealable because that indicates the film is not pretreated with any coating. Other machinery that was used included an Oxygen Transmission Rate (OTR) Analyzer Model 8001 (Illinois Instruments).

The film was printed using the first anilox roll of 360 CPI, 6.53 BCM, to print the three plate technologies with the same specialty ink per run. A second print run was then performed to compare three different anilox rolls printing the same ink, using the capped plate. Once the film was treated with the barrier coating, it was separated into seven rolls and each roll then cut into two two-inch squares (4 inches 2). These squares were then placed in the OTR machine to see how much oxygen passed through the film. Each film was measured at a sampling rate of 30 minutes.

Chapter Four

Results

There were two print runs conducted on a Mark Andy 2200 Flexographic printing press. The first print run was comparing the effect of different plate technologies by printing with one conventional plate method and two plate-treatment technologies. One screening technology consisted of plate-cell patterning, while the second technology utilized the capped plate method.

A second print run was performed using the capped plate comparing the effect of different anilox rolls by printing with three rolls. The first roll had a cell count of 360 with a cell volume of 6.53 BCM and was the anilox roll used for the first print runs comparing the different plate technologies. The second anilox roll had a cell count of 440, and a volume of 3.33 BCM. The third roll used had the highest cell count of 600, with the lowest cell volume of 2.05 BCM. Using anilox rolls that increased in cell count, and decreased in the cell volume, allowed the comparison at lower ink coverages. Once the samples were printed, they were tested in an oxygen transmission rate machine to see which film had the lowest oxygen permeability. The film was separated into seven trolls: film with no treatment, film with control treatment (conventional plate), film with treatment 1 (plate cell patterned plate), film with treatment 2 (capped plate), film with anilox 1 (360 CPI, 6.53 BCM), film with anilox 2 (440 CPI, 3.33 BCM), and film with anilox 3 (600 CPI, 2.05 BCM). Each film was cut into two, 2-inch squares (4 inches2) to be placed in the Oxygen Transmission Rate (OTR) Analyzer Model 8001 (Illinois Instruments). The OTR was measured for each 2-inch square, per film, until it reached a final result and automatically stopped at 1% convergence with a bypass time of 30 minutes, and a sampling rate of 30 minutes. The temperature was 23° C with RH at 0.0%. The results of the permeability for both tests run is found in Table 1 and Table 2.

Plate	Oxygen Permeability Test 1 (cm³/m²/24hrs)	Oxygen Permeability Test 2 (cm³/m²/24hrs)	Mean (cm ³ /m ² /24hrs)
Control (untreated)	896	938	917
Conventional	202	131	166.5
Plate Cell patterened	142	190	166
Capped	111	83.7	97.35
Table for ec anilo	e 1. Shows the average ach test of plate techn x roll 360 CPI, 6.53 BC	e Oxygen Transmission ology method used wi M.	Rate th

Anilox Roll	Oxygen Permeability Test 1 (cm³/m²/24hrs)	Oxygen Permeability Test 2 (cm³/m²/24hrs)	Mean (cm ³ /m ² /24hrs)
Film : Anilox 1 360 срі 6.53 всм	111	83.7	97.35
Film : Anilox 2 440 срі 3.33 всм	252	285	268.5
Film : Anilox 3 600 срі 2.05всм	333	370	351.5
Table Rate plate	e 2. Shows the average for each test of anilox e technology.	e Oxygen Transmission roll used with the cap	ped

The results in Table 3 compare the averages of each film tested, to the oxygen permeability of the Mobile treated film already deposited with an oxygen barrier coating (pretreated film). This table shows a direct comparison of the different anilox rolls and screening technology to the pretreated film. These results reveal a significant difference between the untreated film and treated films, while the variation between the treated films and pretreated films varies greatly.

Plate	Mean (cm ³ /m ² /24hrs)
Control	917
Conventional Anilox 1	166.5
Plate Cell pattern Anilox 1	166
Capped Anilox 1	97.35
Anilox 1 360 срі 6.53 всм	97.35
Anilox 2 440 срі 3.33 всм	268.5
Anilox 3 600 срі 2.05 всм	351.5
Mobile (pretreated)	70

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Capped plate was used for the anilox tests.

Chapter Five

Conclusion

The results concluded from this experiment provided beneficial information in terms of both cost and production efficiencies of specialty packaging and printing. As the data in Table 3 are compared, it becomes obvious that coating the film with the barrier ink, in general, substantially lowered the oxygen transmission rate with a decrease from 917 OTR for the untreated film to 166.5 OTR for the conventional plate technology and anilox 1. The lack of increased barrier property for treatment 1 may be a result of how the plate cell treatment coating impacts ink uniformity. Further investigation is needed to determine why little substantial benefit occurred from the plate-cell patterned plate.

However, when the results between the plate cell pattern and capped plates are compared, there is another large reduction in oxygen permeability. While the plate cell patterned plate had an average OTR of 166, only 0.5 below the conventional plate, the capped plate had an OTR of 97.35. Both samples of the 2-inch squares from the capped plate had a much lower OTR than either of the squares tested from the plate cell pattern. While comparing these results with the specifications of the permeability of the pretreated film, a 2.1 mil oriented polypropylene film with excellent oxygen barrier properties, the capped plate offers a competitive option with its average OTR slightly higher.

When the results from the use of different anilox rolls are compared, the permeability of the film decreases as the cell volume increases, resulting in greater ink-film thickness. The first anilox roll used had the lowest cell count by almost half of what the third roll used, with a cell volume at over three times as high as the third roll used, resulting in an oxygen permeability almost four times lower. As the first anilox roll was also used to

print the different screening technologies, it is highly likely that the screening technology results would have been higher had they been printed using either of the other anilox rolls tested.

Printing an oxygen barrier coating inline offers some unique benefits. The substrate cost is lower and similar results can be achieved using a more cost-effective coating method. However, it is noted that it may be difficult to get the exact oxygen transmission rates achieved by other coating and extruding methods.

This study confirmed that with the right plate technology and anilox roll, similar oxygen barrier properties may be achieved in a more cost effective manner than purchasing pretreated films.

The results of the study concluded a combination of plate technology and anilox roll to achieve optimum functionality of the barrier coating. As the capped plate provided better barrier properties than the cell patterned plate and was used for the print run with each anilox roll, results reveal the prime combination. The anilox roll that provided the best barrier property was the first anilox roll, 360 CPI, 6.53 BCM. As the cell count increased, and the cell volume decreased, the permeability of the coating increased dramatically between each anilox roll. In the case of printing with an oxygen barrier coating, the most functional combination of flexographic components includes capped plate technology with a 360 CPI, 6.53 BCM. In comparison to the pretreated film, this combination provides a competitive alternative that gives packaging companies the option of printing with barrier properties inline using a more cost and production efficient method.

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