The Examination of The Impact of Humidity on Cardboard Endurance in The Offset Printed and Laminated Packages

Dogan TUTAK
Cem ÖZAKHUN
Ahmet AKGUL

Marmara University Technical Education Faculty Printing Department
Istanbul / Turkey

Keyword: humidity, laminating, paper, packaging, offset printing

Abstract

The essential function of packaging is to conserve the product that the package contains. In the course of this conservation, packaging is affected by many physical and chemical factors, the major one of which is moisture absorbed in the cardboard. The package gets in a relationship with humidity in the air from the time of its production up until its last user. It picks up most of the moisture it has during the processes of offset printing and lamination.

This study examines both the procedures run before and after the manufacture of packages produced in the packaging sector, and the interplay between the package and the environments in which it is placed during these procedures. In this research, the combination of 225 gram/m² cardboard, 112 gram/m² test-liner and 125 gram/m² kraft-liner was used. The cardboard that were set to different values of moisture and were brought to optimum condition in the conditioning room were printed successively on the offset printing machine under the same conditions.

The printed cardboards were laminated after they were left for 24 hours in the environment in which the lamination process was to be carried out. The lamination was followed by the procedure of cutting and box-folding lines. Afterwards such tests as ECT (Edge Crush Test), FCT (Flat Crush Test), BCT

(Box Compression Test) were applied to the corrugated cardboards produced after lamination. Finally, suggestions were offered as to which moisture values the corrugated cardboards are more durable at during and after manufacturing.

Introduction

Cardboard Package

This is a packaging material that is used most in the market and formed by two external papers called liners and one in-between paper called wave/flute. The combination of these papers is called the corrugated cardboard. This type of cardboard is the main material in the production of cardboard package. It is the package that provides appeal for the product it contains, and also preserves the product and help market it easily.

Corrugated Cardboard

Corrugated cardboard, according to DIN 55405, is defined as the "cardboard made up of one or more flute papers that are glued to one or more papers." In a way, it is a multi-layered cardboard. The basic corrugated cardboard is produced by gluing in the corrugated cardboard machine a liner paper onto the bottom, top or both sides of the in-between undulated layer which has been sinusoidalized. Corrugated cardboards are classified according to the number of undulated (wavy) layers and are named according to their types of flute (undulation) and wave heights.

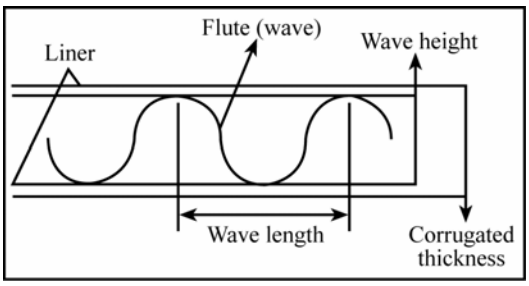


Figure 1. Corrugated cardboard layer and its characteristics

Humidity

Humidity is the amount of water vapor in air. In humidity measurements, absolute humidity, relative humidity and specific humidity are calculated. The English word "moisture" is the amount of fluid that is present in a solid material. It has no exact counterpart in Turkish and may be called dampness.

Paper and Climate

The air's absorption capacity of water vapor, which is always present in the atmosphere, is limited and depends on its temperature. The warmer the air is, the more capacity of absorption it has. Every temperature has its own maximum humidity, which is the maximum amount of water vapor that the air can absorb under a certain temperature. If the maximum humidity is passed, then dew forms or it becomes rain. The relative humidity indicates the ratio of the water vapor's maximum amount which is contained in the air. For example, 50 % relative humidity tells us that the air contains half of the humidity that it can absorb under a given temperature.

The following table shows how vapors in the air rise to the maximum amounts.

Table 1. Temperature and humidity values in the air

Temperature °C	**Amount of Humidity g/m²**
10°	9,3 (±3)
15°	12,8 (±3)
20°	17,3 (±3)
25°	23,0 (±3)
30°	30,4 (±3)

For a relative humidity value, every paper has a balanced humidity value. This means that, when it is balanced, it does not take water from the air, nor does it emit. This is the ideal condition of paper. Paper has the relative humidity around it and the amount of water that is in balance. The expression of 'the relative humidity of paper' is not accurate. 'The relative stacking humidity' is more accurate. The air in the paper is always in balance with the humidity of paper. By balancing the relative stacking humidity and the relative humidity of the air, one can find out how the paper would behave in the factory. If the two rates are close to each other, the paper neither loses nor absorbs humidity. If the relative stacking humidity is lower than the relative humidity of the air in the storage room, then the paper takes in the humidity from the air and extends. The temperature in the factory's finish and conservation rooms are set to the post-print climate.

Table 2. The physical state of paper under humidity changes

Humidity Rate (%)		Result
Room	Paper	
30	50	Convexity
80	50	Undulation
50	30	Undulation
50	80	Convexity

Storage Conditions and Relation Between Climate and Cardboard

With regard to the climate in the print room, we often hear about the following characteristics: heat, humidity, relative humidity, absolute humidity, dew point temperature, humidity balance. When there is an interaction between climate and paper, we talk about humidity. Paper fibers react to humidity in a way in which they become varied in size. The widths of paper fibers increase three times their heights. All suggestions should be taken into consideration and the paper should be on an appropriate humidity rate. Paper fibers do not change their sizes in these environments.

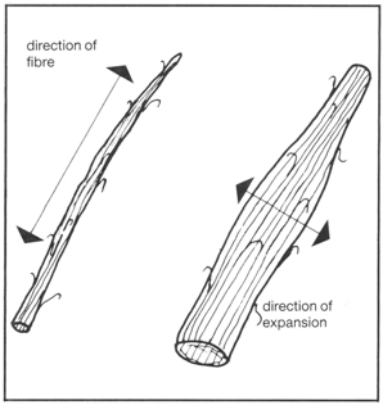


Figure 2. A normal fiber and a water-saturated fiber

The heat in a printing environment is as important as humidity in that environment. Heat and humidity are inversely proportional –as the heat increases, the humidity of the environment decreases. This is accounted for by drying of the water vapor and its leaving the environment due to the increase of the heat in the environment. In a printing environment, the heat should be between 20-22 °C and the humidity value should be between 50-55 percent. If the heat and humidity values vary in a printing room, we will encounter the problems of concave and wavy surface on the paper.

The Effect of Reservoir Water on Cardboard in Offset Printing

As is known, the offset printing system is based on the principle of water thrusting the oily ink. This is because water and oil meet at the same time on the plate before printing. In the next phase, the plate whose surface is water-saturated transfers the ink on its surface and some of the water onto the blanket with help of certain level of force. During the transfer of image, the ink and the water on the blanket transfer onto the cardboard. In the course of this transfer, the humidity in the blanket penetrates the cardboard and increases the humidity rate of the paper, which causes changes in its physical characteristics.

This change is the opening in the cardboard fibers. The cardboard fibers takes in the water and swell. As a result of this swelling, cardboard fibers lose their firm structures and this in turn weakens the endurance of the cardboard.

The Effect on the Pre-printing and Pre-lamination Cardboard of its Environment

The humidity and heat values in the print and lamination room where the cardboard is printed and laminated are as significant as the storage conditions. The adaptation of the print room where the cardboard to be printed is placed and that of the lamination shop where it is to be laminated to the climate conditions makes the print and the lamination more robust.

The cardboard to be printed or laminated must be brought to the print or lamination room 24 hours in advance and be made adapted to the environment. Otherwise the cardboard that has different humidity and heat values will be affected more during the print and lamination and will cause it to have openings in the cardboard and to expand.

The Effects of the Wavy Layer and Glues Used in Lamination

The first job done during the lamination is the making of waves/flutes. The wave paper coming form the bobbin is conditioned in the conditioning section under high pressure and heat with the help of large cylinders. Here the humidity level of the wave/flute should be kept at 8-9 % so that the flute easily sticks. After the conditioning cylinders, the flute papers are transferred to the upper flute valve. Going around the upper flute valve, it will come between two flute valves, where the paper takes the wave/flute shape with the help of pressure. Glue is applied, by means of the glue valve, on the elevation tips of the flutes upon coming out of the cylinders. As a result of all these applications, the corrugated cardboard layer encounters a large amount of humidity during the process of conditioning, the formation of the flute and the application of the adhesive. The greater part of this humidity penetrates the corrugated cardboard and causes it to have a humid structure.

Experimental Part

MEASUREMENTS AND TESTS CONDUCTED

In this part of the study, during the production in the packaging factory, the heat and humidity were measured in every phase and the values that turned out were measured. It has been found out in this investigation that with respect to the paper and cardboards that were used in each phase of the production, the climatic conditions, the offset printing system that is used, the application of lac after printing and finally the whole procedure of laminating the corrugated cardboard affect the humidity value of the cardboard and the durability of the box.

Heat and Humidity Measurement Values of Carton and Corrugated Cardboard in The Production Phases

Three main cartons were taken up in the measurements. These are X, Y, and Z cartons used in production. The heat and humidity measurements of these X, Y, and Z cartons were taken in the production phases of the corrugated cardboard, the condition they were in, in the printing room and the environment, and finally the lamination room and after the lamination. Such tests as the burst test, the edge crush test (ECT), flat crush test (FCT), and box compression test (BCT) were applied to the corrugated cardboard produced. The values that turned out in this application are shown on the table below. At the end of these tests, the humidity durability of the corrugated cardboard has appeared.

Table 3. Heat and humidity values measured for “225 g X” carton

	Storage	Bobbin	After cutting	Print shop	Before printing	After printing	Lamination shop	Before Lamination	After Lamination
Heat (°C)	21,3		20,7	23,8	21,9	35,6	21,4	29,7	27,4
Humidity (%)	44,7	64,7	63,8	49,1	61,2	68,9	44,6	67,6	81,3

Graphic 1. Heat and humidity graphic for “225 g X” carton

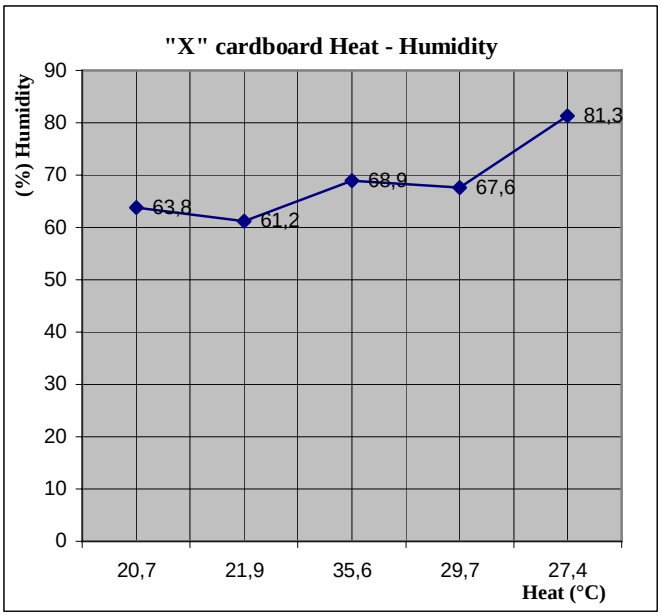


Table 4. Heat and humidity values measured for “225 g Y” carton

	Storage	Bobbin	After cutting	Print Shop	Before Printing	After Printing	Lamination shop	Before Lamination	After Lamination
Heat (°C)	20,9		22,3	21,7	22,1	33,5	20.6	27,8	26,2
Humidity (%)	45,4	46,8	46,8	47,2	47,6	57,3	47,1	56,9	62,4

Graphic 2. Heat and humidity graphic for “225 g Y” carton

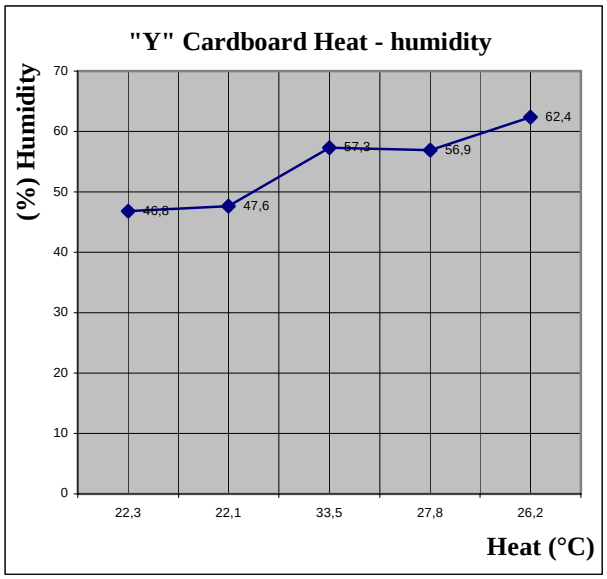
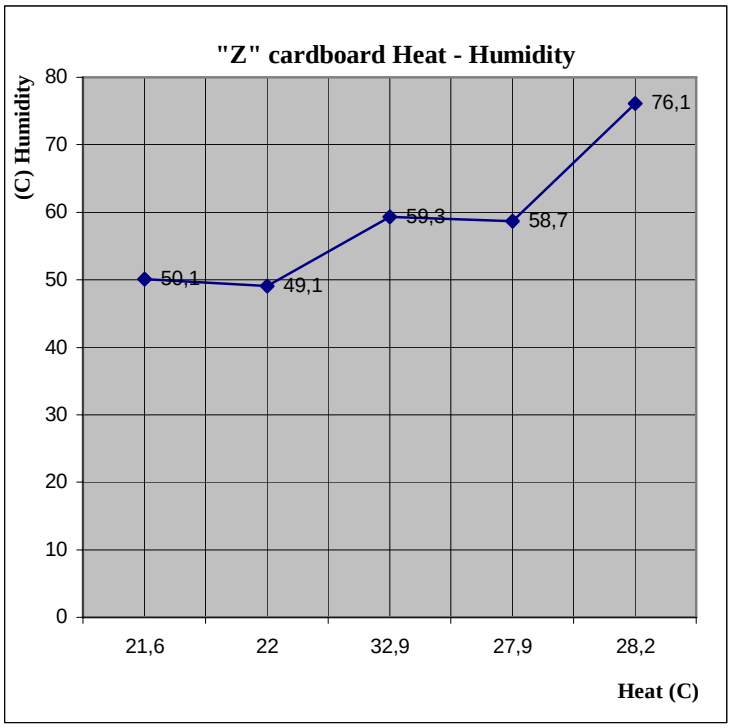


Table 5. Heat and humidity values measured for “225 g Y” Carton “225 g Z” Carton

Table 5. Heat and humidity values measured for “225 g Y” Carton “225 g Z” Carton	Storage	Bobbin	After cutting	Printing shop	Before Printing	After Printing	Lamination shop	Before Lamination	After Lamination
Heat (°C)	21,7		21,6	22,4	22,0	32,9	20.6	27,9	28.2
Humidity (%)	49,3	50,6	50,1	48,8	49,1	59,3	46,7	58,7	76,1

Graphic 3. Heat and humidity graphic for “Z” carton



Results of the Experiment and Measurement

Immediately after lamination, four samples were taken one after another. (For B wave) For the testing methods that would show the durability characteristic of the laminated sheets, their samples were cut. These samples were kept under 45 °C in an owen for 24 hours. Afterwards the sheets were conditioned for 4 hours with the environment humidity values of 85 %, 70 %, 50% and 40 % and their measurements were taken. (The measurements have been taken in accordance with TAPPI standards; the burst test: TAPPI T-810, ECT: TAPPI T-811, FCT: TAPPI T-825, BCT: TAPPI T-804).

The results are shown on the table below.

Table 6. Results of the tests conducted

	Combination : 225g Carton + 112g kraft + 125g Testliner					
	B - Wave		Humidity Values			
			85%	70%	50%	40%
Tests	ECT	kN/m	4,3	4,6	4,7	5,3
	FCT	kPa	157	163	176	208
	Burst	kPa	689	742	782	845
	BCT	kN	1,76	1,96	2,2	2,46

In the measurements taken according to TAPPI standards, considering the values on the table 6, as a result of the tests applied to the corrugated cardboard, ECT compression endurance, FCT compression endurance and the burst compression endurance, it has been found out that it had the highest degree in the environment of 40 % relative humidity. It has also been found out, however, that there occurred bursts on the folding-lines during the cutting operation because of the fact that as the humidity decreases, the fragility of the corrugated cardboard that has with the humidity value of 40 % increases. At the end of the ECT, FCT, and the burst testing, for the performance of the best corrugated cardboard, 70 % humidity value is its ideal value.

REFERENCES

[1]- Markström, H.:"Testing Methods and Instruments For Corrugated Board", Sweden

[2]-MALTENFORT, George G.,"Corrugated Shipping Containers: An Engineering Approach", A.B.D.-Illinois

[3]-Horn, H., Eichorn T., Keller, W., "Lectures And Worksheets For Ofset Priniting, MAN Raland druckmaschinen AG, Offenbach /Deutschland

[4]-Tutak, D.,"The Impact Of Relative And Absolute Humudity On Resistance In Offset-Printed Laminated Packaging " Msc Thesis Marmara University, Istanbul /TURKEY