The White Paper

STEP-UP™ Program

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Table of Contents

Introduction .....................................................................................................................................1
  Purpose
  Scope

Background Information ............................................................................................................ 2-4
  The Echochek™ Audit
    • Purpose of the Echochek Audit
    • Use of Microscopes
  The Echotopography™ (ET) Audit
    • Advantages of the ET System
    • Disadvantages of the ET System
  Comparison of Echochek vs. ET System

Research Conducted ......................................................................................................................5
  The Study
  Test Parameters
  Objective
  Process Used
  Manufacturing Tolerance Levels

Conclusions and Recommendations ....................................................................................... 6-7
Introduction

In the past, Harper Corporation offered two types of anilox roll audits:
   (1) Echochek™ audit
   (2) Echotopography™ or ET audit

Both audit systems offered flexographers the ability to view the microscopic engravings of their anilox roll surfaces. However, in early-2002, Harper Corporation began investigating alternate anilox auditing methods with the goal of improving the process, getting more accurate results, and saving the customer time and money. This report describes the feasibility of the STEP-UP™ program, Harper’s new Systematic Technical Evaluation Process for Unlimited Potential, developed specifically to accomplish these tasks.

Purpose

The purpose of this study and report is to determine the feasibility of Harper’s new STEP-UP program, which combines the efficiency of a Harper Echochek audit with the digital accuracy of Harper’s ET audit.

Scope

This report, completed for Harper by a third party, describes the advantages, disadvantages, and a comparison between the Echochek audit and the ET audit. In pursuit of additional resources that might help improve the success of this study, several Harper Corporation experts were appointed to assist with this study in analyzing data, drawing conclusions and making recommendations. These individuals were asked to complete specified tasks, assist with research, and report on the technical challenges that are encountered in the current system.

To determine the feasibility of the STEP-UP program, test parameters were established, performed and recorded. The data was then analyzed and proved that the new process works.
Background Information

Echochek Audit

The Echochek is a small piece of foil used to make an impression of an anilox roll engraving. It consists of 2 mil mylar with a thin layer of polymer plastic coating. A coating of indium goes over the top to act as a reflective surface to light. Echochek evaluations can be performed on-site, allowing a technician to evaluate a customer's anilox rolls without removing them from the customer's facility.

The Echochek is placed on the anilox roll and pressed into the surface. The foil takes the shape of the engraving and can easily be sent to Harper's technical laboratory to be manually examined and photographed under a microscope. Echochecks are very small and easy to use. They provide us with a practical tool to determine anilox engraving information without taking highly sophisticated, and expensive instrumentation into the customer's facility or shipping the rolls to the anilox manufacturers facility. However, the limits of the use of the Echochek should be understood.

Purpose of the Echochek Audit

The primary purpose of the Echochek audit is to view the condition of the anilox engraving to determine:

- Quality of the Anilox Engraving
- Condition of the Anilox Roll (Is it worn out? Does it need cleaning?)
- Appropriateness of the Engraving for the Work Being Done

Use of Microscopes

Microscopes are used in Harper's technical laboratory to primarily evaluate results of the Echochek imprint, which is not viewable by the human eye. Under a microscope, the Echochek shows:

- Line Screen
- Cell wall size
- Cell shape
- Wear or Damage
- Consistency of engraving
While the primary objective is to view cell engravings under a microscope, the Echochek also allows a technician to calculate cell volume within +/-10% accuracy. A technician examining the anilox cells measures the cell opening size, and the cell depth using the microscope. Therefore, measurement by microscope is subjective and not intended to represent absolute values. Human factors must be considered such as:

- Steadiness of hands using the dials on the scope
- Individual eye depth perception
- Accuracy of Echochek impression

After measurement, the technician uses a mathematical formula to calculate the volume based on these measurements. The formula for determining volume is accurate for a very small range of cell shapes; therefore the accuracy of "calculated volumes" is approximate at best due to the formula and the human factors involved.

Anilox volumes are measured in BCM’s (Billions of Cubic Microns). These are very small measurements and every micron is critical. How big is a micron? A human hair is approximately 70 microns in diameter.

**The Echotopography (ET) Audit**

If the objective of the anilox evaluation is to determine the exact BCM (or volume), tools other than the microscope should be used. The ET system scans the anilox roll to produce accurate and repeatable three-dimensional profiles of anilox cells. A high-speed computer program analyzes thousands of data points and produces dimensional and volume measurements within 10 nanometers accuracy. The ET system removes human elements and assumptions from the measurements. This advanced technology allows Harper Corporation to maintain the tightest manufacturing tolerances in the industry.

![3-D Profile of Anilox Cells Produced by Echotopography](image)

**Advantages of the ET System**

- Correlates to press performance
- Standardized volume specifications
- Precise cell volume measurement
- Repeatable cell volume measurement
- Non-subjective analysis
- Reduced measurement error
- Statistically valid measurement process
- Used for production of all Harper rolls
Disadvantages of the ET System

- Extremely expensive
- Requires a vibration free environment
- Requires advanced planning and preparation
- Typically must be used at the customer's facility for auditing purposes

When a Harper technician travels to a customer's facility to perform an ET Audit, the technician must set the system up and measure each roll in the customer's facility. Additionally, he or she also takes an Echochek impression of each roll for visual reference.

The following factors make it difficult to use the ET system in a customer's facility:
- Calibration of the equipment may be off due to travel conditions
- Vibration in the facility from presses, running equipment and air currents
- The ability to find a controlled environment to perform the evaluation

A controlled environment is critical for accurate results, and unfortunately this is not always feasible in a customer's facility. These factors, along with the equipment condition, can create inaccurate data and cause the measurement of the anilox roll to be incorrect. Much better results can be obtained by utilizing the ET system in the controlled environment of the Harper technical lab, but we cannot ask our customers to ship all of their rolls to us for evaluation.

Comparison of Echochek vs. ET System

<table>
<thead>
<tr>
<th>Echochek Audit</th>
<th>ET Audit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify cell quality</td>
<td>Identify volume (BCM)</td>
</tr>
<tr>
<td>Takes approximate measurements</td>
<td>Takes precise measurements</td>
</tr>
<tr>
<td>Inexpensive to use (1/8 the cost of ET system)</td>
<td>Expensive to use</td>
</tr>
<tr>
<td>Easy to use</td>
<td>Sophisticated training necessary</td>
</tr>
<tr>
<td>Results examined in Harper's laboratory</td>
<td>Results examined at the customer facility</td>
</tr>
<tr>
<td>Very little risk of damage to equipment</td>
<td>Fragile, risk of damage in transportation</td>
</tr>
</tbody>
</table>
Research Conducted

The Study

As noted previously, the ET system is the most precise way to measure anilox volume and line screen, when utilized in a controlled environment. Our goal was to create a program that would improve the process, offer more accurate results, and save the customer time and money. To do so, we tested a new possible process vs. taking the ET system into a customer’s facility.

The test included taking an Echochek impression of an anilox roll at a customer's facility, and then reading the impression using the ET system in Harper's controlled technical laboratory. This system, if proven accurate, will be called the STEP-UP program.

The STEP-UP program would potentially eliminate the possibility of the ET system breaking down due to travel, would allow for a controlled environment in the Harper Corporation laboratory, and would provide the most precise readings to the customer. Following as the testing procedure.

Test Parameters

1. Use one ET system to read an anilox roll and an Echochek taken from the same anilox roll.
2. Test with ET systems 1 and 2.
3. Include the manufacturing tolerance in the test results.
4. Test a variety of line screens.
5. Test 100 rolls.

Objective

Use the ET system to measure the BCM from the Echochek impression and from the anilox roll, and compare the differences to determine if the new STEP-UP program gives acceptable results.

Process Used

1. The technician takes a reading of the anilox roll using the ET system and records the data. This can be done in the customer's facility or in Harper's manufacturing facility.
2. Once the reading has been taken and recorded successfully, the technician takes an Echochek impression on the same anilox roll.
3. The technician sets up the ET system in a controlled environment at Harper Corporation.
4. After the set up is completed, the technician reads the Echochek with the ET system and records the data.
5. The results from both readings are combined into a spreadsheet to use to analyze.

Manufacturing Tolerance Levels

Manufacturing tolerance levels were established as a guide to determine an acceptable range of variance:

- Line Screen of 200-599 is +/- 5%
- Line Screen of 600+ is +/- 4%
Conclusions and Results

The technician performed the tests and recorded the data. The raw data was compiled and analyzed as the following:

1. 91 data samples were taken to analyze and evaluate (100 Tests performed; 9 bad impressions)

2. The number of tests per line screen are shown below.

<table>
<thead>
<tr>
<th>Line Screen</th>
<th>Number of tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>120-220</td>
<td>8</td>
</tr>
<tr>
<td>300-360</td>
<td>20</td>
</tr>
<tr>
<td>400-440</td>
<td>7</td>
</tr>
<tr>
<td>500-550</td>
<td>8</td>
</tr>
<tr>
<td>600-660</td>
<td>20</td>
</tr>
<tr>
<td>700-750</td>
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<tr>
<td>800</td>
<td>6</td>
</tr>
<tr>
<td>900</td>
<td>5</td>
</tr>
<tr>
<td>1000</td>
<td>6</td>
</tr>
<tr>
<td>1200</td>
<td>3</td>
</tr>
</tbody>
</table>

3. A BCM tolerance was calculated using the ET BCM reading to show the acceptable range of variance.

4. A BCM difference was calculated by comparing the ET reading to the Echochek

5. The BCM difference was compared against the BCM tolerance. If the BCM difference was below the calculated tolerance, the test was considered to be a pass. If the BCM difference was above the calculated tolerance, the test was considered to be a fail.

Following is a summary of conclusions that can be drawn from this study:

1. A greater number of tests passed than failed. This suggests that the new STEP-UP process does work.

2. Data with an extreme percentage difference of 10%-34.7% suggests that some piece of the test was not performed properly.

The following results came out of this study:

The primary goal of the study was to determine the viability of the STEP-UP program, which includes using the ET system to read the volume from an Echochek impression. We discovered that some of Echocheks were inconsistent and a portion of them were unreadable making it difficult and at times impossible for the ET to read the impressions. It’s important to note that a Harper Lab Technician performed all Echocheks, revealing the unpredictability of taking Echocheks. For that reason, Harper developed the Accuchek™ instrument, shown below.
The Accuchek tool provides consistent pressure, compensates for width, and discontinues double impressions. Harper customized the tip of the punch to deliver a wide circular impression. The automated instrument administers a repeatable and fixed burst of pressure every time an Echocheck is taken.

Testing was conducted on the accuracy the ET provides when using the new Echocheck tool to take impressions. With the human factors of error eliminated, all bad impressions that were present in the feasibility study conducted in May 2002 have been eliminated. Analysis of the test results showed a marked improvement in volume accuracy when the ET read the Echocheks taken using the Accuchek. Line screens 100 to 600 produced results similar to the feasibility study, but absent of frequent bad impression. Using the Accuchek tool the pass rate on line screens from 700-800 was 92.5%.