High Speed Printing with Polygon Scan Heads

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ABSTRACT

To reduce and in many cases eliminate the costs associated with high volume printing of consumer and industrial products, this paper investigates and validates the use of the new generation of high speed pulse on demand (POD) lasers in concert with high speed (HS) polygon scan heads (PSH). Associated costs include consumables such as printing ink and nozzles, provisioning labor, maintenance and repair expense as well as reduction of printing lines due to high through put. Targets that are applicable and investigated include direct printing on plastics, printing on paper/cardboard as well as printing on labels. Market segments would include consumer products (CPG), medical and pharmaceutical products, universal ID (UID), and industrial products. In regards to the POD lasers employed, the wavelengths include UV(355nm), Green (532nm) and IR (1064nm) operating within the repetition range of 180 to 250 KHz.

Keywords: Polygon Scan Head, PSH, High Speed Printing, POD Lasers, High Speed Lasers, High Volume Printing, CPG Printing, Universal ID, UID

1. INTRODUCTION

With the advent of Nanosecond and now the shorter pulse width Picosecond and Femtosecond lasers, opportunities to investigate new paradigms in traditional manufacturing processes have presented themselves. These areas include cutting, ablation, welding and engraving to name a few.

1.1 POD Lasers

The lasers that work well with a polygon scan head have the feature of Pulse on Demand. This is essentially a pulse picking option that allows the laser to output only when a pixel is required. Lasers that have a pulse equalizer mode in addition to POD are optimal. These lasers reliably output pulses of equal energy independent of the data stream prior to the current pulse. A third feature that allows for more accurate pixel placement when used with a polygon scan head is a higher frequency internal clock. An example of this is the Coherent Avia NX 355-20 that is used in this experiment. This laser has an 80 MHz internal clock that can align the pixels to a start of data trigger to a fraction of the 240 KHz operating frequency.

1.2 Wavelength Selection

The most common wavelengths used for marking plastics are 10.6 microns and 1064nm. The sources available at these wavelengths have become reliable and readily available and are reasonably priced for industrial and commercial applications. The mechanism involved in marking/printing with these wavelengths is thermal in nature, as detailed by Heller[1]. The laser energy is absorbed by the plastic and the local heating causes the mark by bleaching, carbonizing or ablating the material. UV lasers operating at 355 nm offer another type of solution. The 355nm interaction with the surface is a cold process rather than thermal. The UV energy passes through the surface and causes a photochemical reaction within the bulk material. The result is a smooth mark that does not have the rough texture of the thermal marks. In this application the UV laser was used as the application required a smooth mark.

2. METHODOLOGY

2.1 Test Methodology

All testing was carried out in a lab environment that was set up to model the characteristics and physical parameters of the

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actual production floor applications for printing either directly onto plastic containers or package materials. Figures 1 and 2 are an accurate representation of the test lab environment that was used. All testing was performed by Lincoln Laser in our corporate test lab facilities. The UV laser was mounted to the top of the frame as shown in Figure 1 below. This laser is capable of producing 30 nanosecond pulses at rep rates up to 250 KHz. The average power of the device is 20 watts. The repetition rate of the laser was varied to adjust the pulse energy to achieve the optimum contrast mark. Laser output is directed to the POLYtek™ high speed polygon scan head using two 90 degree fold mirrors. A beam expander is used between the second fold mirror and the scan head to increase the beam size entering the scan head.

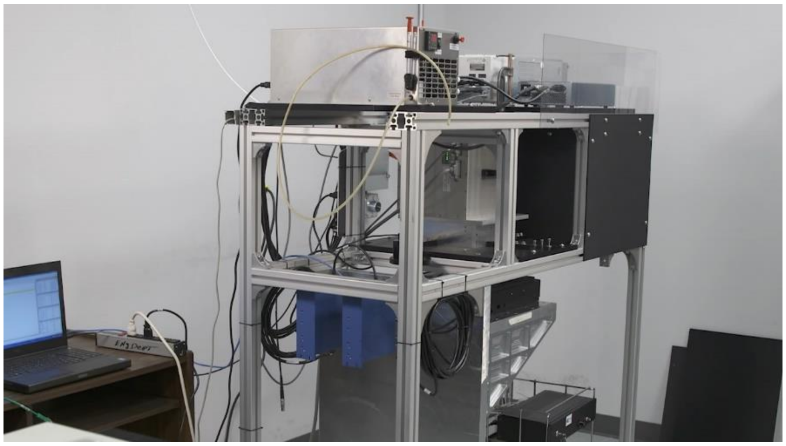

Figure 1. Typical test configuration in the Lincoln Laser test lab incorporating a UV 20 Watt laser. The test control panel for the validation OS is shown on the notebook computer on the table, with the laser components located on the top of the test frame.

Figure 2. Side view of the typical test configuration in the Lincoln Laser lab. The Lincoln Laser POLYtek™ high speed polygon scan head is shown placed in the middle section of the test frame. An f-theta lens is facing downward toward the test bed table which is located directly below it. The target is lying on the test bed below.

The laser pulse energy versus rep rate of the Coherent Avia NX 355-20 follows the curve shown in Figure 3 below.

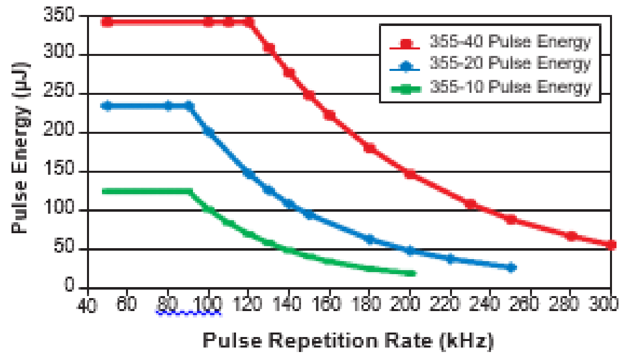

Figure 3. Laser pulse energy versus rep rate.

The content to be printed on the typical PTFE plastic targets, which were flat plastic sheets as well as thermoformed containers, included the typical font size and information for CPG packaged goods on a 1.75 inch by 1.75 inch area.

In addition, to be comparable to an existing ink jet printed image, a 1D bar code was required as well. The following photos represent an example of the content that was uploaded into the sample OS program of the POLYtek™ high speed polygon scan head in a bitmap .bmp file format based on a 300 dpi resolution. The goal was to print this complete image shown below in Figure 4 in under 1.5 seconds.

Figure 4. Image of the typical test content as loaded into the Lincoln Laser POLYtek™ high speed polygon scan head test program. The content was converted into a bitmap file and then loaded into the program via the user control panel.

3. COMPONENT DETAIL

3.1 Data Detail

The Lincoln Laser POLYtek™ high speed polygon scan head is a general purpose configurable scan head. It has been designed to work with a controller and marking software similar to conventional Galvanometer scan heads. The POLYtek™ consists of a high speed multi-faceted polygonal mirror that spins at a high rate of speed providing for a laser line scan of multiple lines for each revolution. Spacing for adjacent lines is provided by using either an optional galvanometer which is incorporated into the scan head or a translation device such as a moving stage.

With integrated Winlase marking software, the data is output in a raster mode based on timing signals driven by the Polygon scan head in coordination with an incorporated start of scan subsystem to synchronize the data stream with the position of the Polygon mirror. A high performance motion controller provides for the velocity stability as well as low jitter in the fast scan axis.

The Lincoln Laser POLYtek™ high speed polygon scan head was fitted with a 150mm focal length scan lens which produced a 25 micron 1/e2 spot size on the target. The POLYtek™ scan head is configurable with polygons ranging from 10 to 14 facets based on the application requirements, with this application using a 10 facet polygon mirror. Operating in a line scan mode, an Aerotech translation stage was used in concert with the POLYtek™ scan head to provide the slow axis movement. Figure 5 depicts the internal view of the POLYtek™ high speed scan head.

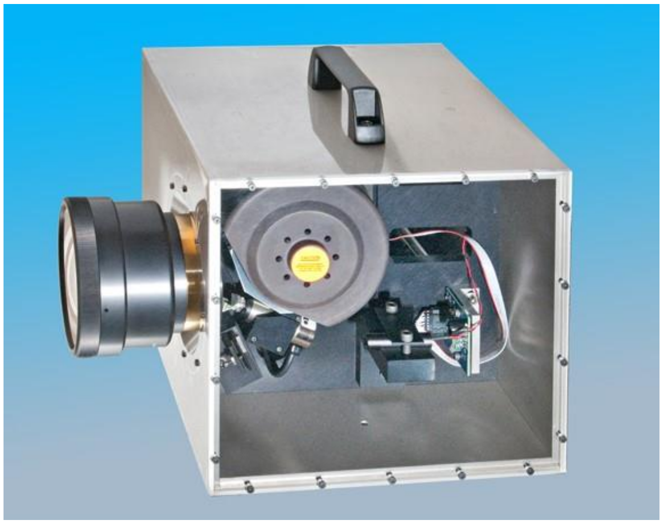

Figure 5. Image of the Lincoln Laser POLYtek™ high speed polygon scan head.

This particular POLYtek™ scan head was designed with the following specifications.

Table 1. POLYtek™ Scan Head Data.

SPECIFICATIONS	
Input Aperture	**15mm**
Standard Wavelengths	**355nm, 532nm, 1064nm**
Scan Speed	**150—1600 lines per second** **0—1600 lines per second optional**
Galvanometer Analog Communication	**+/- 10 volts**
Input Power	**+/- 15 volts DC @ 7 amps maximum**
Line Placement Repeatability—Y axis	**+/- 48 microrad**
Pixel Placement Repeatability—X axis	**0.10 microrad**
Output Scan Angle	**Maximum +/- 16 degrees for X and Y**
Dimensions (excluding handles & scan lens)	**10 inches x 12 inches x 12 inches**
Operating Temperature	**25 +/- 10 degrees C**
Start of Line Sensor	**YES**
Port for CDA purge	**YES**
Control Card	**YES, included with software interface**
Provides fastest X axis scans over targets. With Galvo option provides fastest X—Y	

Figure 6 provides a detailed representation of the internal components of the POLYtek™ scan head. As shown in the detailed representation, the scan head is available with an optional integrated galvanometer to provide for line spacing placement.

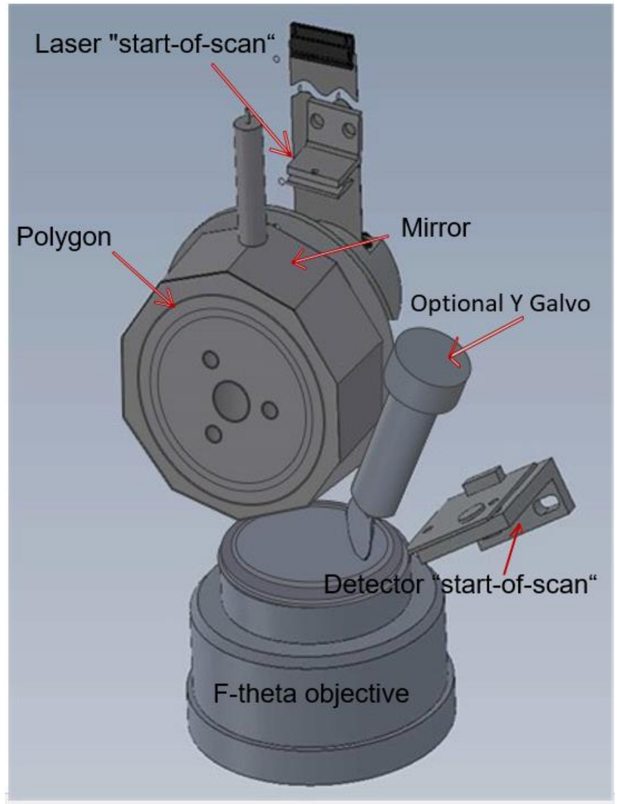

Figure 6. Image of the internal components of the Lincoln Laser POLYtek™ high speed polygon scan head.

4. RESULTS

4.1 Test Results

After several iterative trial passes where the repetition rates and laser power levels were adjusted, a final suitable printed image was successfully attained. The primary criteria for a successful printed image were twofold; one, that the image was readable by the naked eye from a distance of 12 inches away and two, that the 1D bar code could be read by a typical hand held bar code reading application.

It was determined that the optimum spot size on the plastic was approximately 25 microns 1/e squared. There was internal blooming of the spot which increased the apparent size to about 40 microns. In order to achieve the desired contrast on the plastic without additives, it was found that a pulse energy of approximately 100 micro joules was required. In some applications, additives can be added to the plastic which can reduce the energy required to produce an equivalent contrast. The reduction in required laser energy can result in higher marking speeds as described by Sabreen[2].

In regards to the print speed parameter, the application user that was printing onto the containers stated that less than or equal to 1.5 seconds of total print time per target would be a substantial ROI improvement over the currently employed application of ink jet printing onto the plastic container target

It is important to note that the parameters and adjustments required to attain these printing parameters may require consideration in regards to spot size, focal length, and polygon mirror specifics as well as optimization of the content file and parameter specifications of the laser being employed. Based on these parameters as stated above, in this particular test scenario it was determined that a UV laser of 40 Watts power at 250 KHz would provide the contrast and speed that would be necessary to produce an acceptable image directly applied to the plastic. The results are shown in Figures 7-9.

The pixel placement accuracy error for this image is 10 microns in the fast scan axis and less than 5 microns in the slow scan axis. The achieved line scan accuracy is related to the laser. The laser's high speed internal 80 MHz timing clock was used to match the start of line signal from the POLYtek™ scan head and accurately synch up to the 250 KHz pulses from the laser.

Figure 7. Image of the printed content directly applied to the plastic container, including a 1D readable bar code. All font sizes were readable as well.

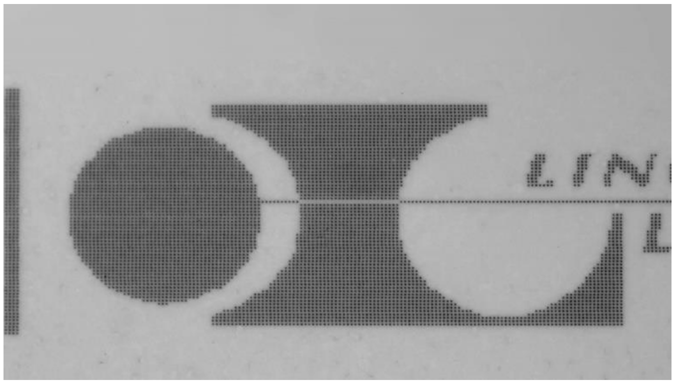

Figure 8. Close up image of the printed content.

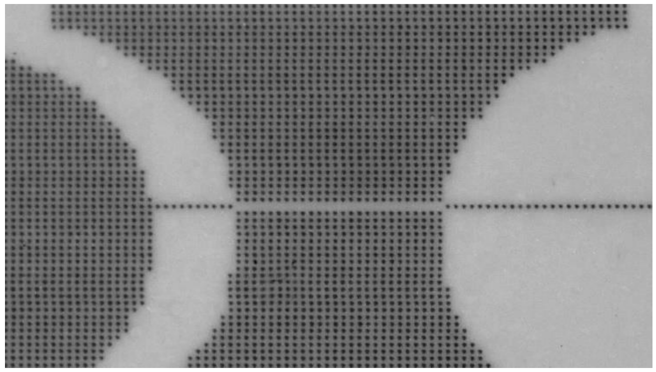

Figure 9. Close up image of the printed content pixels.

5. CONCLUSION

5.1 ROI Analysis

Based on the target parameters and specifications of this test, using a 40 Watt or greater UV laser in combination with a POLYtek™ high speed polygon scan head, the return on investment when compared to the comparable through put of a traditional ink jet printing line is adequate. Due to the greater speed provided by this laser based scan head solution, as well as the elimination of consumables, fewer lines are needed requiring less labor and down time. Flexibility is another key application consideration for marking and printing with lasers as discussed by Belfore[3]. With the POLYtek™ high speed polygon scan head in combination with a suitable laser, the solution provides print speeds that allow for in-line and on-demand printing of variable information, either directly onto the target or onto labels.

A video on demand of this test can be viewed at the following:

Video 1. Click the logo to be directed to the url page to view the project video http://dx.doi.org/doi.number.goes.here

REFERENCES

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