New Directions in Print Head Construction

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Abstract

The market presentation of the DESKJET 855 introduced 600 dpi "single pass" printing for your desktop. This paper presents a short historical evolution of HP Thermal Inkjet pens, introduces the "Oriflex" concept and describes some of the engineering considerations in the development of a new platform.

Introduction

Hewlett Packard's traditional line of thermal injet cartridges has shown a progression to more nozzles and a narrower form factor with integrated drive electronics. Although the black pen for the Deskjet 1200 and Deskjet 855 appear similar, a new direction in print head construction has been unveiled with new materials and new processes that open a new horizon in Hewlett Packard technology... *600 dpi single pass printing and a 12 mm print swath.*

Originally printed in *Proc. of IS&T's Eleventh International Congress on Advances in Non-Impact Printing Technologies*, October 29-November 3, 1995 in Hilton Head, South Carolina.

Evolution of Design

The TIJ Famity Portrait (Figure 1) shows the evolution of appearance from the 1984 to 1995. Our first products were aimed directly at the 9 wire market and were 12 nozzle systems(at 92 dpi). The next products at 180 dpi aimed at the graphics market (Paintjet). The big advancement was 300 dpi "laser-like" printing of the early Deskjet product line. From Paintjet through the Deskjet 600 Series, all pens were passively driven and the nozzle plates, gold plated electroformed nickel. This series is designated TIJ2. TIJ2.5 arrived with the narrower pen body and integrated drive electronics of the 1200C products. Swath width increased to 1/3" and the throughput increased to 6 ppm for black . The step to 600 dpi, 1/2" swath and nozzles in the flexcircuit marked the beginning of TIJ 3 design. Several factors were involved in the push to TIJ 3. The strongest factors being: materials design freedom for the ink chemists, residual stress reduction during assembly and increased through-put with quality. The features of each print head are shown in Table 1.

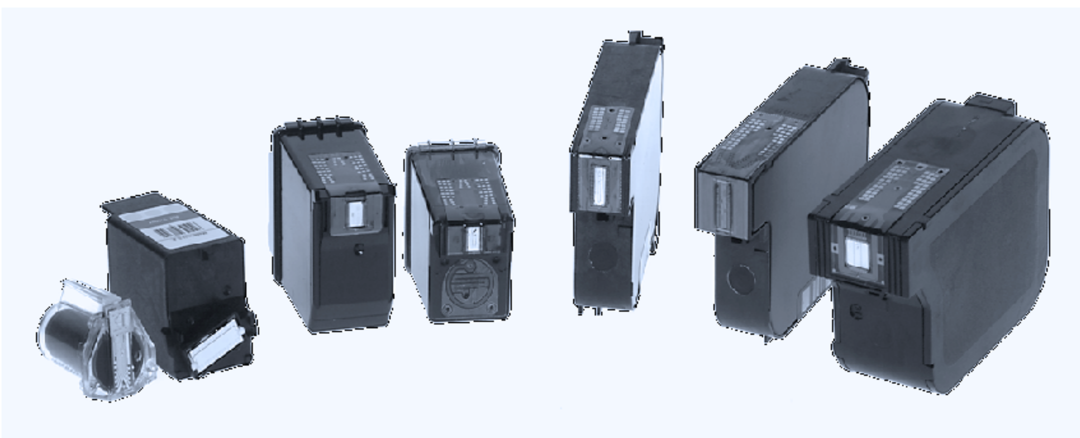

Figure 1. Hewlett Packard Thermal Inkjet Family Potrait

"Oriflex" ... Nozzle and Interconnect

During development of the first product we tested several methods of making nozzles, unfortunately we did not possess the technology to achieve a robust seal to the pen

Table 1. Print Head Feature Comparison.

Pen	Thinkjet	Paintjet	Deskjet 560 Color	Deskjet 560 Black	Deskjet 1200 C	Deskjet 855 Black	Deskjet 855 Color
Interconnet	Direct	Direct	TAB Flex	TAB Flex	TAB Flex	Oriflex	TAB Flex
Drive	Direct	Direct	Direct	Direct	Integrated	Integrated	Intergrated
Dpi	92	180	300	300	300	600	300
Nozzles	12	30	48 / 3 Color	50	200	300	300 / 3 Color

body, or to control bore defects. Electroformed nickel provided economical solutions to most of the probems. As the drive for higher throughput increased, the need for more nozzles increased. More nozzles required space and the die length increased. The addition of integrated drive electonics on the print head reduced the interconnect allowing for more and closer heaters, but also increased the manufacturing sensitivity to the number of operations and yield. Extending the nickel nozzle plate beyond the edge provided a solid surface to bond to the pen body, a rigid member to support the silicon, and flat surface for the service station. On the down side the difference in CTE between the nickel and the silicon, the high modulus of nickel, and the high temperature cycles involved in our type of assembly caused significant die distortion (potential yield loss). Designing a system that included the nozzle in a polymeric material that was thermally stable, resistant to ink swelling, and lower modulus reduced the distortion, and provided an avenue to high volume assembly. Table 2 shows the calculated (FEA) deflection and hoop stess of sytems with nickel and Kapton® orifice plates after a 225°C attachment cycle. Low modulus and adequate adhesion allowed stress reduction without nozzle to heater misalignment.

Oriflex Description

Coupling excimer laser ablated nozzles with the reel to reel handling capability of the flexible circuit system addressed the issues of nozzle precision, stress reduction, engineerable materials, part count reduction and high volume manufacturability. Working with the Excimer Laser Lab in HPLABS, Corvallis began building chambers and nozzles for testing in 1987 - 1988. Between 1990 and 1994, Corvallis operations produced over 200,000 nozzle sets to prepare for the production of of the Deskjet 855C Black pen. The complete concept of "Oriflex" is described in U.S.Patents 5,291,226 Schantz et al. and 5,305,015 Schantz et al., and shown in Figures 2 and 3.

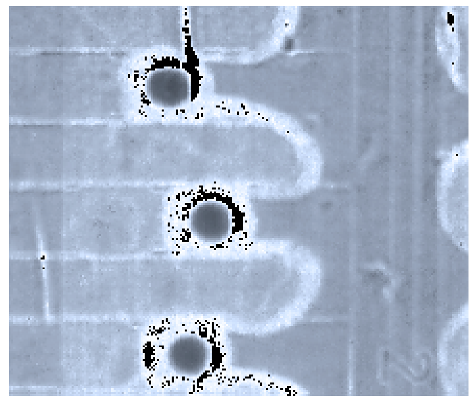

Figure 2. Image of Orifex pen through the Kapton® Flexible Circuit

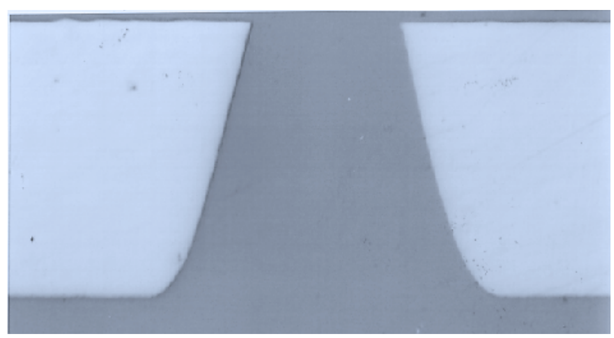

Figure 3. Excimer ablated nozzle in Kapton®

Kapton® Registered Trademark of
The Dupont Corporation, Wilmington Delaware.

Table 2. The Effect of Die Length On Deformation and Stress Distribution By FEA Modeling.

Assembly Length (mm)	Deflection for Nickel (mm)	Deflection for Kapton® (mm)	Hoop Stress for Nickel (ksi)	Hoop Stress for Kapton® (ksi)
2	4.3	2.9	13.2 / 33.6	2.2 /3
4	16	3.7	25.6 /59.1	2.3 / 3
8	69.4	6.9	34.7 /64.5	2.33 /3
16	282.8	20	39.4 / 64.4	2.35 /3