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A STUDY TO INVESTIGATE THE NEW COST SAVING & ENVIRONMENTALLY SAFE UV-LED LAMPS IN PRINTING INDUSTRY

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Abstract: All that you needed to think about UV lamp. UV restoring innovation is seeing expanded use in the Printing Industry, essentially for inks and coatings. UV lamps are an elite part of the drying framework. Appropriate upkeep just as looking for sources can assist you with taking full advantage of these frameworks. The Photo Polymerization through safe and cost effective UV LED lamps. And to know the advantages and disadvantages of conventional UV lamps v/s LED UV lamps photo polymerization process etc. In accumulation to that it is possible to attain the added advantages such time saving, cost saving, ink saving, press stability, superior colour gamut with the effective use of plates.
Keywords: printing, printing industry, UV lamps, UV-LED lamps, cost saving UV-LED lamps, Environment safe UV - LED lamps

INTRODUCTION

The growing use of polymer in printing and packaging industries has lead to new challenges for the ink manufacturers. Transparent Packaging material and coatings, Such as Cellophane, Polypropylene, Polyester, Polyethylene, Polyurethane, poly-Acrylates, UV-Coatings and UV-Ink etc. Inks and coatings employ polymers in the form of vehicle resins which enable the mechanism of oxidation polymerization and drying, with ultraviolet and electron beam curing to be exploited. Printing rollers, blankets, flexographic plates, nonmetal polyester plate bases, and the photopolymer coating that give the printing image surfaces, adhesives, laminating materials, photographic film bases, high gloss UV-coatings.

The state of UV-LED Curing, Light emitting diode for ultraviolet-curing application so the green and cost effective solution is UV-LEDs, it has been industrially accessible for most recent 05 years, Due to its novel yield attributes, and require for recently defined UV science so as to exploit UV-LEDs. This talks about the characters of UV light and the correlation of ordinary UV and LED-UV regarding security/time and the advantages to end clients business utilizations of UV-LEDs and future anticipated turns of events.

PHOTOPOLYMERS IN DIFFERENT KIND OF PRINTING & COATING APPLICATIONS WITH SAFE AND COST EFFECTIVE UV LED CURING

- UV LED curing technology continues to win over many users in the printing world, replacing traditional methods. To utilize the advances in technology from UV LED light sources, there has also been growth in high-performance, UV LED energy curing inks and coatings. UV LED curing is now in the forefront, because it provides many benefits, including increased production speed, lower cost of ownership and less waste, while also providing an enhanced visual appearance and packaging
- UV LED curing is now an accepted tool in the printing industry. It allows for advanced capability on challenging applications for industrial printers. Printers can offer media versatility and can now run thinner materials through the machine without warping or wrinkling. UV LED technology offers the ability to print on uncommon substrates. As a side benefit, these thinner substrates also reduce shipping costs, both of the raw materials and the finished product, providing further economic benefit to end users and their customers.
- UV LED curing technology is now rapidly growing inside the UV printing market with compelling advantages of better economics, system capabilities, and environmental benefits.

DATA COLLECTION

— LED-UV lamp

We have to use different kind of UV lamps as per our requirement, e.g.:

- Mercury vapor lamp (Hg) H-Type has range between 220 to 320 nm.
- Mercury vapor lamp with Iron added substances; D-Type has extended between 350 to 400 nm.
- Mercury vapor lamp with Gallium added substance, V-Type has range between 400 to 450 nm.

All these lamps have capable to emit the different spectrum of radiation.

It is considerably more costly yet it's last up to multiple times longer and can be cycled on/off every now and again as they required. And this makes help in the selection of UV lamps for different type of pigments inks and adhesives and coatings.

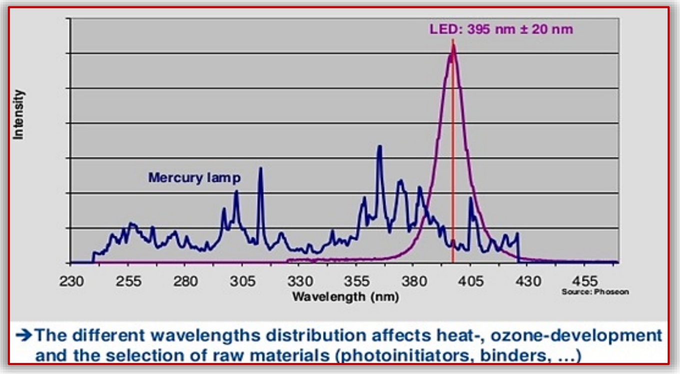

Figure 1. Comparison between conventional UV and LED-UV lamps

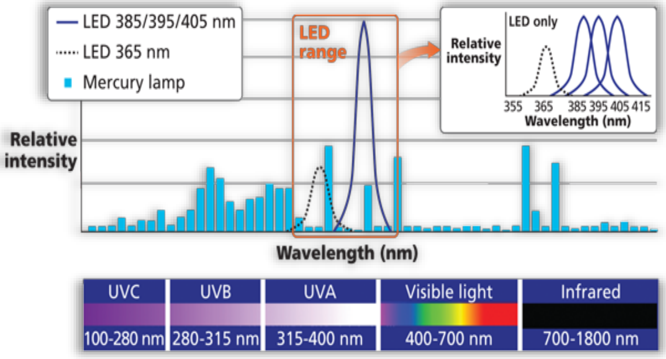

Figure 2. Wave length wise output comparison between mercury-arc UV lamp and UV-LED lamps

As per this Figure.2 we have to categorized the UV wave length in three stages

Stages UVC (100-280nm), UVB (280-315nm), UVA (315-400nm)

— The curing procedure

This drying procedure (regularly requiring a stove) requires significant investment, produces VOCs and the dried film thickness is not exactly initially applied. UV relieving happens a lot quicker (commonly not exactly a second), doesn't create VOCs and the film thickness applied is the thing that remaining parts as a solid (essential for certain end-use applications).

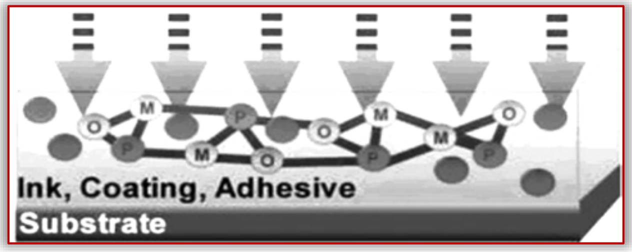

Figure 3.Curing procedure

It shows the spooky maintenance for different PIs and the recurrence yield for mercury-twist UV lamps. Many existing UV subtleties made for easing with a run of the mill mercury-arc light (showed up as H-bulb) use a wide range PI. While there is normally some ingestion inside the UV-LED yield run, it is evident to see that an extraordinary piece of the PI absorption go is wasted.

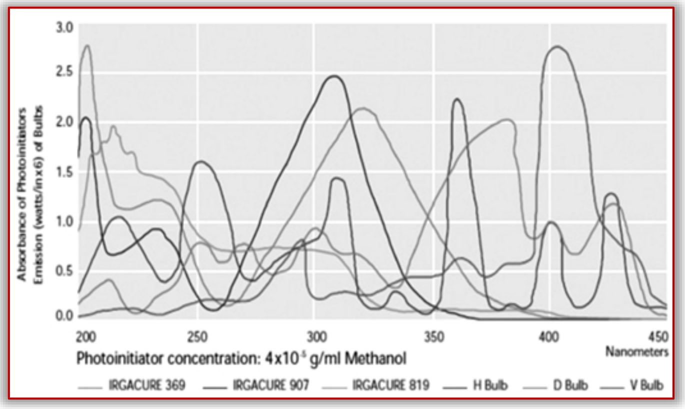

Figure 4. Photo initiator spectral absorbance compared to traditional UV lamp output

A logically compelling fix is possible with a specifying organized expressly for UV-LED relieving using a PI with moved ingestion in the UV-A range.

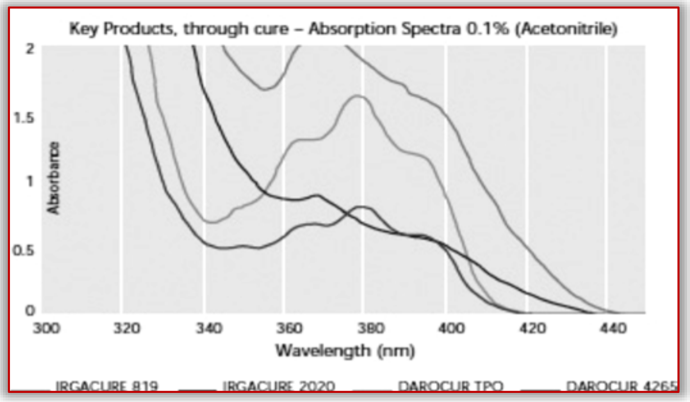

Figure 5. Examples of longer wavelength absorption photo initiators

The monomers in the detailing fill in as the responsive diluents empowering the formulator to control thickness for appropriate application (splashing, moving, screen printing, and so forth.) of the uncured material. As opposed to volatilizing, as is average with customary plans, the monomer responds and turns out to be a piece of the UV-restored material.

— Overcoming surface fix issues

Another option is to include oxygen-expending or searching mixes, for example, amines or amino acrylates to conquer oxygen inhibition.1 Research has shown that top irradiance (W/cm2) and all out UV-A vitality (mJ/cm^2) conveyed are a higher priority than an exact frequency coordinate on definitions created to fix in the UV-A district. Pinnacle irradiance is a significant measurement since power is required to start the polymerization.

Higher pinnacle irradiance, (for example, that found in UV-LEDs) brings about an increasingly forceful polymerization system assisting with defeating oxygen hindrance at the surface and accomplishing the necessary fix rate.

— Conventional / mercury lamp

The utilization of UV light as a relieving innovation has been around for quite a while. Over the most recent couple of years it has gotten progressively well known since the innovation on the lamps and the materials side has significantly improved. Applications are presently on sheet taken care of, web and wide arrangement inkjet hardware. The significant points of interest of UV inks are:

- Press sheets are getting when they come dry the press
- Higher throughput speed than Infra-Red drying
- No Volatile Organic Compounds discharged noticeable all around
- Resist smearing and scraped area
- UV Coatings have a "wet look"
- Do not have solvents to infiltrate uncoated stocks

So as to discover increasingly about UV and how it functions I went to a specialist who has been working with UV innovation for more than 20 years, Norm Fitton, President of Anniversary UV. Most printers purchase UV frameworks which might be provided by the maker of the gear yet made by another person. Seeing how UV lamps work can improve their exhibition and set aside you cash.

There are various kinds of UV lamps for various applications. Low weight UV lamps might be utilized for sterilizing purposes, restoring nails and dental fillings, or water refinement. The kind of light utilized in printing applications is normally a medium weight, direct (straight cylinders), and mercury fume circular segment light. Medium weight UV lamps fix inks and coatings in a split second. It is a photochemical not a warmth procedure. It permits the gear to run at extremely high speeds for broadened periods.

General utilize lights have a fiber. The power makes the fiber shine, creating light. Medium weight UV lights don't have a fiber. They use a high voltage charge to ionize a mercury/gas blend in the light making plasma that emanates UV lamp. This framework requires a high voltage/amperage power gracefully (commonly an attractive weight transformer with a high voltage capacitor bank). The counterweight is wired in arrangement with the light and performs two capacities. At first, the counterweight gives a high voltage charge to 'strike' or 'ionize' the mercury. At that point, when the mercury is ionized, the stabilizer decreases the voltage and amperage required to keep the mercury ionized and discharges a steady stream of UV lamp.

These lamps create a particular frequency to fix the inks or coatings. Right now, the greater part of these lamps works at 300 to 600 watts for each inch with some more up to date frameworks utilizing lamps that create up to 1000 watts for every inch. So a 30 inch UV bulb might be fit for a yield of 30,000 watts. They likewise work at exceptionally high temperatures (850 to 950 Celsius or 1550 to 1750 Fahrenheit).

This kind of UV lamp is produced using Quartz. A general glass item would not have the option to withstand the high temperatures. An idle gas (generally argon) is siphoned into the quartz sleeve and afterward mercury is added to accomplish the correct electrical determination. Iron and gallium are at times added to accomplish extraordinary frequencies. The cylinders are fixed and the right electrical end-fittings are added to finish the light.

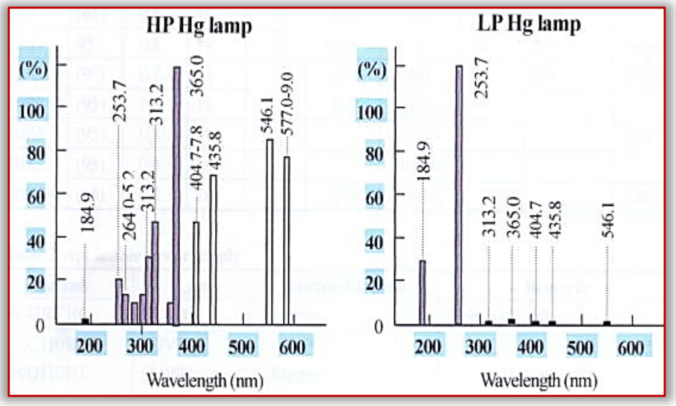

Figure 6. Relative spectral energy distribution of Hg lamps

These lights need an incredible cooling framework to counterbalance the high working warmth. They are normally air or air and water cooled. They additionally use reflectors to amplify the bright light conveyed to the substrate. There must be an even progression of air or water over the light for legitimate relieving. On the off chance that lights run too cool they may not fix the ink or covering. A few frameworks use outside air for cooling. As the seasons change, contingent upon your geographic area, you may need to alter your fan speed or increment/decline water temperature to keep up appropriate cooling.

Pollution is another difficult that can influence light execution. Because of the high warmth air contaminants, for example, shower powder from different presses or residue particles can heat on the lights making cloudiness this abatements the presentation of the lights. In a perfect world, much after broadened utilize the quartz ought to be totally clear.

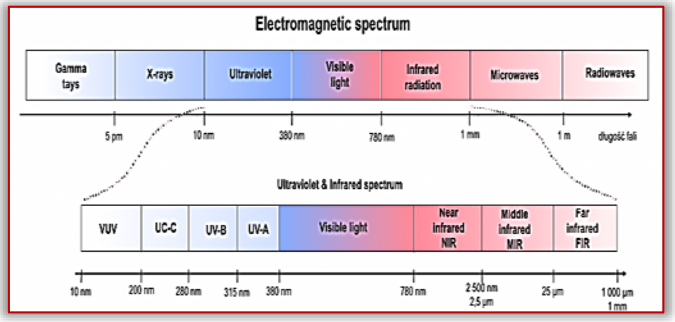

Figure 7. Electromagnetic Spectrum

The metal halide UV medium pressure gallium doped lamps emit UV radiation with peak emission in the UVA range at 420 nm. The metal halide UV medium pressure iron doped lamps emit UV radiation with peak emission in the UVA range at 366 nm and 440 nm.

DATA ANALYSIS REPORT

We have to record the data of both UV lamps aspect to Cost of Electric power and time saving cost/Ozone generation Cost, / Cooling Equipment Cost, /Quality wise cost, / Repairing/maintenance Cost.

Table 1. Properties wise UV LED Lamp Vs. Tradition UV Lamp

PROPERTIES	UV LED LAMP	TRADITIONAL UV LAMP
Energy Vs. Spectrum	"Narrow Bend"365/375/385/395 nm	Broadband spectrum 200-440 nm
Spectral efficiency	100%	30%
Service life	16000-20000Hrs.	1,000-2,000 hrs.
Lamp shape flexibility	Yes	No
Instant on/off	Yes	No
Warm-up time	No	Yes(5-7 minutes)
Dimming range	0-100%	20-100%
Energy consumption	Lower	Higher(6x higher Vs. LED include warm up time)
Mercury	No	Yes
Ozone generation	No	Yes
Exhaust air ducting	No	Yes
Size	Compact	Bulky
Spectrum tuning	Simple	Complicated
Heat damage to target	None	Can be serious
Robustness	Shock resistant	Fragile

— **Electric power cost wise comparison between mercury UV lamp and LED UV lamp**

We have to analysis four month electric data of electric power consumption, First two month we have to analyze the electric power consumption data of Traditional/mercury lamp and the second two month we have to analyze the electric power consumption.

The Electric power consumption data collect with Gloss Meister plant of acryl ate/PU coating Merino Industries Ltd. We have collect the Three month energy consume of traditional/Mercury lamp. Next three month we have collect the Three month energy consumption data of LED-UV lamp. In Month November 2019 and in Month December 2019 we have to collect the data of power consumption of conventional Mercury (Hg) Lamp. See in attach files.

Table 2.Comparison chart of (Hg) UV LAMP & LED-UV Lamp power consumption

Comparisons chart of power consumption	
MONTHS	Unit consume per/Kwh
Nov.2019 (Hg-UV Lamp)	19801.49
Dec.2019 (Hg-UV Lamp)	30645.93
Jan.2020 (LED-UV Lamp)	16288.28
Mar.2020 (LED-UV Lamp)	10741.35

On an average we can calculate the LED –UV Lamp have reduce the energy consumption up to 25%

As compare to conventional UV Lamp method (Hg).

— **Environment pollution wise comparison between Mercury UV lamp and LED UV lamp**

More UV light produce Ozone gas in environment, we have checked the Ozone level in working place where we use the UV lamps. We are examining two months ozone gas level data.

First month December 2019

In month December 2019 we are working with Conventional (Mercury-Hg) UV lamps and record the data of Oz gas level.

Second month March 2020

In month March 2020 we are working with New LED- UV lamps and record the data of Ozone gas level.

Table 3. Comparison chart of (Hg) UV LAMP & LED-UV Lamp power consumptions of Ozone (O3) Emission

Comparisons chart of Ozone (O3) Emission		
MONTHS	Test Parameters (µg/m3)	Limits as per NAAQS (8hr.)
Dec.2019 (Hg-UV Lamp)	200	100
Mar.2020 (LED-UV Lamp)	‹ 5.0	100

Table 4. Repairing cost wise comparison between Mercury UV lamp and led UV lamp

Cost analysis of two typically ozone monitors		
	TUV 11 W mercury UV Lamp	UVC LEDs
Instruments Cost		
Lamp	$25	$300
Filter	$350	n/a
Power Supply	$50	$50
Detector	$5	$5
Heat Enclosure	$150	n/a
Total	$580	$355
Operating and maintenance over 5 years		
Power consumption*	$58	$1
Replacement Lamps	$100**	n/a
Lamps Disposal	$25	n/a
Total	$183	$1

Energy cost of $0.12/KW-hr

Four annual replacements for the mercury lamp at $25 each.

COMPARISON OF UV-LED LAMP TO MERCURY-ARC UV LAMPS

— **Conventional UV lamp**

- Deflection in angle in conventional UV lamp is not uniform as in UV LED is constant.
- Pan Iteration is irregular due to broad range spectrum and non-constant eminence.
- Conventional UV lamp gives ozone and mercury reaction which have a less life and deteriorates after interval of timer resulting in harmful gas generation.
- Emission of ozone affects the health and environment.
- There is lot of chance of miss hit.

— **LED UV lamp**

- Low power consumption
- Constant violet emits 395nm so give best curing
- Life is 85% higher than conventional lamp.
- Can be use in food grade

Table 5. The advantages of UV-LED lamp when contrasted with customary Mercury arc UV lamp

MERCURY ARC UV LAMP.	UVC-LED LAMP
Bulky	Compact
High Energy Consumption	Low Energy Use
Long Warm-up Time	Instant On/Off
Large Heat Generation	Low Heat Generation
Mercury, Ozone Generated	No Mercury
Limited Life	Longer lifetime
Dispersed	Single Point Source
Fragile	Sturdy

RESULT & DISCUSSION

UV curing innovation is seeing expanded use in the printing business, basically for inks and coatings. UV lamps are an elite part of the drying framework. Appropriate support just as looking for sources can assist you with taking full advantage of these frameworks.

The utilization of UV light as a curing innovation has been around for quite a while. Over the most recent couple of years it has gotten progressively well known since the innovation on the lights and the materials side has enormously improved. Applications are presently on sheet taken care of, web and wide configuration inkjet gear. The significant favorable circumstances of UV inks are:

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CONCLUSIONS & FUTURE PROSPECTIVE

The future for UV-LEDs looks splendid given the headway made to date by rough material suppliers and formulators. What's more, if the patterns for UV-LED advancement proceed with to be specific expanding top irradiance (77% compound yearly improvement) and diminishing costs we should see fast appropriation by end-clients sooner rather than later for some new applications.

As per Sledge, Flint Group is making UV-LED inks for offset and letterpress applications and he completely anticipate that this should mean sheet fed and wide-web applications also. Sledge likewise observes food bundling as a development territory, when low movement inks are accessible.

The reasonable, thick fillers are a perfect application for UV-LEDs. As showed by Sandqvist, another application that will in a little while be available is UV-LED coatings on wood moldings. The coatings are arranged and seemed to fix at the vital paces of 40-100 m/min. All that is required is an end customer prepared to be first, without any certifications so much of the time the case with "new" progressions. Richard Baird, a system engineer for Boeing, wrote in the fall 2011 issue of the Rad Tech Report that he expects UV-LED curing to transform into an appropriate option for tremendous degree flying paint reestablishing in the outstandingly close future. By all signs, this and various other UV-LED curing applications will to be sure be taking off soon.

Table 6. UV LED Lamp curing Benefits

Benefits UV/LED Lamp Curing	Features UV LED Lamp Curing
Financial aspects	Vitality Efficient Long Lifetime Low Maintenance Low Operating Temperatures
Ecological	Ozone Free Working environment wellbeing UV-A Wavelength Range
Propelled Capabilities	Warmth Sensitive substrates Profound Through Cure Little, Compact Machines Controlled Curing Intensity

This technology continues to win over many users in the printing world, replacing traditional methods. To utilize the advances in technology from UV LED light sources, there has also been growth in high-performance, UV LED energy curing inks and coatings. UV LED curing is now in the forefront, because it provides many benefits, including increased production speed, lower cost of ownership and less waste, while also providing an enhanced visual appearance and packaging

UV LED curing is now an accepted tool in the printing industry. It allows for advanced capability on challenging applications for industrial printers. Printers can offer media versatility and can now run thinner materials through the machine without warping or wrinkling. UV LED technology offers the ability to print on uncommon substrates. As a side benefit, these thinner substrates also reduce shipping costs, both of the raw materials and the finished product, providing further economic benefit to end users and their customers.

UV LED curing technology is now rapidly growing inside the UV printing market with compelling advantages of better economics, system capabilities, and environmental benefits.

Table 7. Benefits of UV curable Inks in printing Industry

Solvent inks System Vs. UV-Curable Inks System		
Solvent Inks System	UV-Curable Inks System	Benefits of UV-Curable Inks
Contain VOCs	Almost No VOCs	Environmentally Safe
Require long bake cycles or use of special wicket drier	No post baking	Energy savings Time savings
Slow printing process limited printing format Print consistency issue	Use of high-speed cylinder press with updated curing units inks are designed to be long flowing	Faster throughput Time savings
Require ink reduction	Press ready Better screen stability No drying in the screen	Better color consistency and control Less handling
Require forced jet air dryers Solvent not completely evaporated on drying cycles	Require UV curing and LED curing systems	Lower energy costs Increased manufacturing space
Good print quality on solid flood areas Small reverse-out images are difficult	Improved print quality with finer mesh counts	Better print quality

UV-LEDs are all the more ecologically inviting in light of the fact that they don't produce ozone and contain no mercury as curve lights do. They are a cool source contrasted with arc lamps, to a great extent because of no yield in the infrared range.

This diminished warmth disposes of entangled cooling components, for example, chill rolls and outer screens, and empowers applications on heat-delicate substrates. The electrical-to-optical change capability of UV-LEDs is extraordinarily improved and the ability to quickly slaughter the unit and on enables saving around 50-75% on power. Table shows a relationship of key characteristics of UV-LEDs versus standard mercury-bend UV lights. Stood out from a roundabout fragment light's 500-2,000-hour life, most UV-LEDs is resolved for 10,000 hours, anyway can last more than 20,000 hours.

It's likewise critical to take note of that over this lifetime UV-LED yield just drops about 5%, contrasted with arc lamp that can lose about half of their unique yield before an incredible finish. In a creation circumstance, UV-LEDs require through and through less space, watching, backing and individual time. That changes over into higher productivity rates, less piece and more prominent conclusive outcomes. Remunerations for retrofitting onto existing machines or replacing existing UV bend lights can be as low as a year.

References

[1] J.Michael Adams -Printing Technology-3rd Edition.
[2] J.Michael Adams -Printing Technology-5th Edition.
[3] Michael Barnard-Print production Manual-8th Edition.
[4] Handbook of Print media- Helmut Kipphan
[5] http://www.printing.org/abstract/11609
[6] https://www.osapublishing.org/ol/abstract.cfm?uri=ol-6-7-319
[7] https://www.osapublishing.org/ol/abstract.cfm?uri=ol-5-3-132
[8] http://www.scientific.net/AMM.262.334
[9] http://ci.uofl.edu/tom/papers/Turbek00pics-titled.pdf
[10] http://www.ingentaconnect.com/content/ist/nipdf/1998/00001998/00000002/art00058
[11] http://www.tappi.org/content/06IPGA/5-4%20Kawasaki%20M%20Ishisaki.pdf
[12] http://liu.diva-portal.org/smash/get/diva2:658194/FULLTEXT01.pdf
[13] http://c.ymcdn.com/sites/www.atmae.org/resource/resmgr/JIT/dharavath063005.pdf
[14] http://www.technicaljournalsonline.com/
[15] Allen, D.M., 1986, The Principles and Practice of Photochemical Machining and Photo etching, Adam Hilger, IOP, Bristol, [ISBN 0-85274-443-9].
[16] Van Luttervelt, C.A., 1989, on the selection of manufacturing methods illustrated by an overview of separation techniques for sheet materials, Annals of the CIRP, 38/2, 587-607.
[17] Harris, W.T., 1976, Chemical Milling – The Technology of Cutting Materials by Etching, Oxford University Press, Oxford, [ISBN 0-19-859115-2].
[18] Allen, D.M., Gillbanks, P.J. and Palmer A.J., 1989, The selection of an appropriate method to manufacture thin sheet metal parts based on technical and financial considerations, Proceedings of the International Symposium for Electro- Machining, (ISEM-9, Nagoya, Japan), 246-249.
[19] Rajukar, K.P. et al, 1999, New developments in electro-chemical machining, Annals of the CIRP, 48/2, 567-579.

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