CONVENTIONAL PLATE TECHNOLOGY FOR DIRECT-TO-PRESS DIGITAL IMAGING

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Abstract: Conventional printing plate technologies are potential candidates for direct-to-press digitally imaged systems. In these technologies, the most successful image carrier has been aluminum sheet and, as practiced, this substrate becomes intricate with the imaged plate printing characteristics. For direct-to-press imaging, the printing cylinder must become the carrier. Consequently, we investigated applicability of reported lithographic plate base technologies to our direct-to-press imaging research program.

This paper investigates conventional printing plate base preparation technologies. It also discusses the implications when conventional base carrier technology is considered as a more-or-less permanent, reusable cylinder material. One conclusion is that the present technology is not practical for direct-imaging modes. Reasons are discussed.

INTRODUCTION

In the last few years Rockwell Graphic Systems (RGS) Division has been investigating direct to printing cylinder imaging techniques. This project is called Automatic Image Make-ready (AIM). One of this project's conditions has been that it must not require changing the lithographic printing process. Thorough understanding of the present printing plate technologies seemed appropriate to determine if any of the specific approaches or principles of conventional plate technologies are of value in the AIM program.

This paper evaluates the results from a typical technology literature and patent search. Only metallic plate substrate have been investigated.

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DISCUSSION

Conventionally, an inexpensive, disposable, bendable support base is required. Most plastic or paper base supports are deficient in strength and dimensional stability. These supports are finding use mainly in short print runs. Aluminum or aluminum alloys are the dominant substrate for medium to long print runs. Lately, several new aluminum alloys with various purposeful impurities have been used to increase durability, providing the base support with a good compromise between bending and wear resistance characteristics.

A brief description of the steps required to prepare conventional disposable aluminum plate base materials follows.

METAL SURFACE CLEANING

The aluminum sheet support base is de-greased with an aqueous solution of a surfactant and/or with an alkali to remove fabrication oils, which would otherwise interfere with uniformity of subsequent surface treatments.

GRAINING

The de-greased aluminum surface is grained to form a primary structure having uniform mounds. The otherwise detrimental surface directionality caused at the rolling mill is essentially eliminated by modern graining techniques. Graining is accomplished by etching some of the metal from the natural grain boundaries near the surface, either by mechanical, chemical or electrochemical methods. The aluminum sheet is grained primarily as a means to increase its surface area, consequently its water holding capability. Graining forms pits that extend below the plate's nominal surface. It is reported that this structure also provides reduced water interference with ink transfer to the image area. In any case, graining promotes a good mechanical bond, strengthening adhesion of any subsequently applied coating.

It appears important in the literature that lithographic plates be able to maintain an inventory of water in non-image area locations. This thin water layer inventory acts as a weak boundary layer preventing ink from adhering to the non-image areas during printing. Stated another way, surface grain provides a dampening solution reservoir on the plate whilst it is on the press.

As a general rule, fine grain leads to better dot reproduction and dot shape, as well as better fidelity and fine resolution of the image on the plate itself. The reported disadvantage of very fine grain is reduction of ink/water latitude on press. Printing plates with very fine grain tend to dry out more quickly during stops; a smaller reservoir of dampening solution is available. Upon restart the non-image area will tend to accept ink and cleaning ink off these nearly dry non-image interstices is more difficult. With very fine grain, the dampening solution is carried at or just below, rather than far below, the nominal printing surface. In this case, fountain solution can move laterally while printing and interfere with ink transfer, which leads to a tighter dampening control requirement during printing.

A compromise in the graining operation is normally reached relative to grain quality to achieve both acceptable ink/water balance and dot reproduction fidelity.

Different grain structures, even with similar apparent roughness or profile, can give different printing results due to the shape, configurations and micro-roughness or pitting depth of the grain pits or valleys. Reportedly, a plate with a micro-pitted structure, i.e. pits within the pits, provides wider printing latitude than one with similar apparent grain profile but having a smooth-sided pit structure. Micro-pitted grain structures enable low and high dampening feed levels to be used with fewer printing problems.

Graining can be achieved by mechanical, chemical or electrochemical means. Mechanical means may involve marble graining, brush graining, slurry brush graining, ball graining, blast graining and buff graining. Mechanical graining by itself is reported to be inferior. Modern graining is accomplished by a combination of mechanical, chemical and electrochemical techniques.

The parameters reportedly used to evaluate lithographic plate graining are as follows:

(D_a) is the average pit diameter. It is calculated as the average of the arithmetic mean diameter of the pits parallel and perpendicular to the rolling axis. This can be determined from photomicrographs at magnifications of 1000 X to 2000 X using a scanning electron microscope with the incident electron beam perpendicular to the aluminum surface. Normally an area containing 1000 pits is chosen.

(D_d) is the diameter directionality. This is the percent difference between the parallel and perpendicular arithmetic mean diameters of the pits.

(R_a) is the center-line average pit depth. This roughness value of the pitted surface is measured both parallel and perpendicular to the milling or rolling axis using a profilometer over a representative length of at least 2 mm.

The overall practical surface roughness for litho plates as defined by the center-line average pit depth R_a is in the range of 0.3 to 1.20 μm.

(R_d) is the roughness directionality. It is calculated as the percent difference between the parallel and perpendicular center-line R_a roughness values.

Mechanical Graining

The most popular mechanical methods are ball graining or brush graining. Both techniques involve a silica abrasive slurry which contains pumice and quartz. Some of the abrasive is expected to be worked into the aluminum surface. This is not a problem unless the aluminum plate is going to be anodized. Ball grained aluminum plates contain up to 20% of silica imbedded in the plate. The ball graining process produces greater roughness than brush graining and the latter contains only up to 3% silica.

The mechanically roughened surface may optionally be further etched with an aqueous solution of an alkali and then washed to neutralize the alkali.

If the sheet material is to be anodized, the mechanically grained aluminum surface should be cleaned to remove the silica and other surface contaminants. A maximum purging of surface residues with minimum change in the surface roughness is desired. This can be achieved for instance by room temperature treatment with an aqueous solution of about 50% by volume nitric acid and about 25 grams per liter of ammonium bi-fluoride. If sodium hydroxide is used temperature control is required since warm sodium hydroxide tends to attack aluminum more rapidly than it does silica. Sodium hydroxide substantially etches the aluminum, with an accompanying adverse change in grain profile, before the silica is undercut and removed from the surface.

Chemical Graining

This approach grains aluminum or aluminum alloy by means of a chemical etching reaction using an acid or an alkali etchant. This graining method is simple in that fewer steps are involved and it is therefore better suited for continuous production treatment of aluminum or aluminum alloy strips.

It has been reported difficult to produce high quality printing plates by means of the chemical graining method alone using commercially available aluminum or aluminum alloys. The literature suggests that further control of the aluminum alloy composition could solve this problem.

Electrochemical Graining

To accomplish uniform, non-directional and stable graining, an electrochemical process has been adopted for manufacture of modern aluminum plates. Electrochemical graining can be carried out in an electrolyte such as aqueous hydrochloric or nitric acid solution while applying an alternating electric current. This graining process makes possible the control of grain depth as well as control of the grain structure by controlling the amount of electricity and solution concentration.

This method is more advantageous than the above-mentioned mechanical or chemical graining. Particularly, one can control grain depth with process precision and quantitative stability. Electrochemical grained aluminum has deep, fine and uniform grains, thus providing superior lithographic characteristics.

ANODIZING

Anodization for plate making purposes can be defined as the formation and deposition of a porous aluminum oxide layer on the previously grained aluminum base material. Formation of the thin anodic oxide layer naturally follows the surface topography of the grained aluminum surface. This explains why the desired plate surface texture must be achieved by graining before anodization. The anodic layer is not dense but instead consists of an abundance of vertically oriented, uniformly packed micro-pores.

A number of different processes may be employed for the production of the anodic oxide coatings on aluminum. In all cases, anodizing is achieved by connecting the aluminum plate to the anode (positive pole) of a direct current cell while immersed in an aqueous sulfuric or nitric acid solution. Harder anodic layers can be formed by using anodizing solutions containing organic acids such as sulfophthalic acid or sulphanilic acid.

Anodic oxide coatings are industrially applied to the surface of many forms of aluminum structures to obtain a harder surface and thus to improve wear resistance. The same applies to printing plates. The anodic film provides crush stability and resistance to caving in and collapsing of the grain regions. The oxide coating also tends to increase the hydrophilicity of the aluminum surface and protects the aluminum surface against the adverse effects of the atmosphere and corrosive media.

To illustrate the relative hardness of aluminum oxide, GATF has reported values on the Moh scale. This scale ranges between 1 (soft talc) and 10 (diamond). Anodized aluminum rates between 8 and 9.

Aluminum oxide mass density has been used to specify its porosity. The practical range is between about 0.8 and 10 g/m^2. This large range indicates that anodization can be controlled to range from low to high porosity. The cellular structure of the anodic layer contains pores ranging in average diameter from 5 to 100 Å (10^{-4} microns). Typical anodic layer thicknesses are from 1.0 to 2.5 microns.

An instrument used to evaluate porosity is the Z Scope, an electrical device that measures impedance. Impedance is like resistance except AC instead of DC current is used. The value of the impedance measured by the Z Scope gives information about the anodic coating, notably porosity. For example, an anodic coating with low Z value will be highly porous and vise versa (see ASTM method B 457-67).

The thicker the anodic film the more resistant it is to abrasion, corrosion and scratching during printing. It should also be noted that the thicker the anodic layer the more difficult it is to remove the unhardened photosensitive layer from the pores in the non-image regions during lithographic plate-making development. A compromise is always required.

The intricate, porous, channel structure of the anodic layer can advantageously be partially filled with any of a choice of subsequent materials. The coating material inside these channels acts as a strong root system enhancing adhesion of the thin image and non-image areas at and above the nominal surface of the base. The combination of strong image and non-image adherence regions to the plate support leads to longer print run length.

SEALING

The above-mentioned anodic coatings do not fulfil all requirements in respect to aluminum corrosion protection because of their porous structure. Also, some of the light-sensitive imaging compounds have been known to decompose when in contact with a bare aluminum oxide surface. These factors make it necessary to further treat the surface to form a permanent protective layer between the anodized aluminum and the lithographic light sensitive layer. This step is referred to as "sealing".

Sealing of anodized aluminum may be accomplished with any of a variety of aqueous solutions or even with boiling water. The process seals the pores of the anodic coating. It also increases the hydrophilicity of the aluminum oxide surface by partially hydrating the largely anhydrous aluminum oxide layer. It thereby forms a lithographically advantageous barrier between the to-be-applied light sensitive coating and the metal oxide carrier base.

An early example of sealing involved coating the anodized aluminum sheet with an aqueous solution of an alkali metal silicate. Plates treated with silicates are characterized by markedly shorter press runs and shorter shelf-life compared with modern plates. Many new developments to form sealing films have been reported in the literature. For instance, the hydrophilic sealant layer that becomes the non-image area may be formed by metal coordination or by using polymeric films or a combination of both.

All sealing processes at least partially close the anodic pores. It is of prime importance to seal the plate pores to an optimum level. It is important that photopolymer hardening during exposure reaches to the bottom of the pores so that the image adheres properly to the base during printing operations. Slight sealing leaves deep anodic pores and requires longer times to expose the resulting thicker light-sensitive film. This reduces the exposing latitudes required in the pre-press graphic arts operations.

The extent of the sealing treatment can be measured with the aid of the Z Scope. Typical Z values of anodized aluminum sealed for less than 20 minutes in boiling water are 6-12 kilo-ohms. Continuing the sealing process reduces the number of pores in the metal and increases the Z value to for instance 100 kilo-ohms.

The remarkable printing quality and stability of modern plates are attributed to the use of polymeric solutions during sealing to form a polymeric hydrophilic layer. With proper polymer selection, the finished lithographic image carrier support would be expected to have substantially improved wearing qualities.

IMPLICATIONS TO AIM

New outermost surface properties will be required whenever a more-or-less conventional steel printing cylinder is considered as the image carrier in place of the usual removable aluminum plate image carrier. Some of the considerations are: 1) Preparation of the cylinder surface can be relatively expensive because it is not done often but obviously cannot involve an exotic process that would be inapplicable to a relative large cylinder of up to about 14" diameter and up to about 72" long, 2) The cylinder surface must be able to resist thousands of repeated imaging steps and a billion or so printing impressions, requirements that are new in the annals of lithographic printing, 3) The cylinder surface must be amenable to removal of both residual ink and image after each printing run, without change in the cylinder's original surface character; this quality is a subject in itself and not addressed here.

If the printing cylinder for the AIM project is chosen to be a metallic hydrophilic cylinder, aluminum, being soft and amphoteric, must be excluded. In addition, grained anodized aluminum is not known to resist more than about one million impressions and that is largely dependent upon multiple coatings applied to the oxide base.

If a cylinder image carrier surface that requires graining is used for imaging, repetitive graining to maintain structure would likely be required. This would reduce the inherent cylinder life expectancy to below the stated requirement. Shut down for cylinder surface restoration or removal would become necessary. On-press graining would be·time consuming, chemically dangerous and mechanically complicated.

Graining may primarily be only a biasing means to assure the existence of a weak water boundary layer that disallows contamination of the non-image area with ink. It may be possible that a different longer-lived means to assure the presence of this weak boundary layer can be found.

If conventional photo polymer image formation is adopted, it appears beneficial from past experience to incorporate an overall hydrophilic sealing treatment for the metallic plate cylinder regardless of the nature of the base printing cylinder material. This approach might be expected to increase the hydrophilicity of the non-image areas of the cylinder, to increase the useful lifetime of the cylinder and to act as an adhesion promoter between the light sensitive coating and the cylinder's base metal. Sealing should also provide fast non-image area recovery from ink contamination.

CONCLUSIONS

The application of conventional aluminum/photopolymer lithographic printing plate technologies for direct-to-press applications is likely not a cost-effective nor practical approach primarily because cylinder lifetimes will be far too short for all but removable-cylinder press configurations. However, certain of the principles derived from extant plate technology suggests that if superior corrosion and wear resistent cylinder surfaces can be developed, chemical biasing for hydrophilicity used in conventional plate systems would be useful for direct-to-cylinder systems as well.

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