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Exploring the art of screen printing asphaltum for etching on medals and trophies for the indigenous metal art industry

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***Abstract*---**Etching remains a primeval craft used to produce interesting images on metal surfaces. The mode of applying resists onto these surfaces presents a challenge for metalsmiths in the indigenous metal art industry to achieve accuracy, precision and details. Recent studies have outlined improved resist application methods developed in the industrial sector as compared to the indigenous metal art industry. This studio practice research explores screen printing as an alternative method to print asphaltum onto metal surfaces for etching. Experimentation at the studio and chemistry laboratory aided in achieving the preparatory stages or variables like ideal consistency of the resist, ratio of acid to water for etching, the mesh count for screen printing the resist and the best squeegee type to use. Relevant results from the studio experiments proved the possibility of screen printing asphaltum which match the viscosity of toothpaste onto the surface of a metal for etching.

***Keywords*---**asphaltum, etching, precision and accuracy, screen printing, indigenous metal art industry.

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Introduction

The art of producing designs on metal sheets has been a recurring practice that employs varying methods which are unique in its approach and outcome such as etching. This method is employed by industrial manufacturers and craftsmen in the indigenous metal art industry to produce relief and intaglio shape images on metal pieces. Achieving very sharp and refine edges on the surfaces was extremely important, thus different application approaches and inventions were developed. Notable amongst is chemical etching and photocopy transfer, which is an advanced technology used in the industrial sector. As a non-contact process according to Dullaghan (2019), an etchant i.e. ferric chloride is sprayed on the metal surface at the same time of which unprotected areas (without a resist layer) are etched. Depth achieved makes it easier for colour application or filling. Furthermore, the availability and use of screen printable etch resists i.e. vinyl makes it easier to print directly any image onto the metal surface in the industry.

Aside the successes in achieving refined shapes in the industrial sector, detailing, precision and accuracy of images remains a challenging problem for the indigenous metal art industry due to their mode of resist application on the metal surfaces. Natasha (2019) outlined those artists or craftsmen draw directly or hand stamp images using permanent inks (resists) such as stazon and magic marker onto the metal surfaces before acid etching. She further added that stamps ensure the making of very fine and intricate images on the metal surfaces as compared to drawing. The mode of applying these resists on the surfaces evidently influences its outcome hence the cost. Brepohl (2020) and IMS (2018) stipulated different application approaches; vinyl stencils, electrical tape, transfer paper and drawing directly by hand (Figures 1 & 2). The latter carefully entails using a brush with a resist to draw images on a metal surface or using a sharp object to scratch off the resist covering the surface of the metal. Another direct method involves transferring images from printed surfaces of vinyl stencils or transfer paper onto the metal surface. This employs the use of hot-pressing iron to heat transfer black resist (Christians, 2011).

Figure 1. Applying resist with a sable brush
Source: Ganoksin, 2018 & hand-drawn

Figure 2. Resists applied with rubber stamp
(Source: Cindy, 2011)

In a studio practice to produce designs on metals, Cindy (2011) employed rubber stamps to print resists (toner transfers, stazon ink, sharpies) directly onto the metal. This produced interesting images with less precision and accuracy, resulting in uneven edges. Such difficulties are faced by metalsmiths when producing simple or complex designs on metals for small or high volumes orders. There is always unevenness of resist application resulting in crooked edges of etched motifs on the metal plate. This is because it is extremely difficult and time consuming to achieve well defined edges by painting large numbers of resists on metal work pieces by hand with a paint brush. A situation most clients rely on industrial manufacturers to employ advance application methods to etch their designs.

Considering such critical problems of metalsmith in the indigenous metal art industry, an alternative approach of applying the resist onto the metal was experimented on. As a studio practice, screen printing which remains a popular method of transferring designs onto substrate was adopted in this study to print asphaltum (commonly used by metalsmiths for etching designs). Because it does not dry quickly, it is best for being used as a paste to register images using the screen-printing method (Shaffer, 1998). It is hoped that such a method will improve precision of the edges of etched motifs, reduce etching time and reduce the cost of etching. This would aid metalsmiths in the indigenous metal art industry to produce images with shape images and edges on metal surfaces.

Materials and Methods

The studio-based practice was used for appropriate experimentation of screen printing asphaltum onto a copper metal plate. Marshall (2010) states that studio research represents typically the production of artwork and writing components. Materials and tools used were asphaltum, acid, mesh, copper plate and squeegee types. It also includes capturing the pictorial description of the process of producing the work piece. Experimenting such materials involved the mesh and squeegee types, the need to test for the ideal ratio of acid to water because that also affected the accuracy of etched edges of motifs.

A Case from a Field Practice

Obuobi Jeremiah who is a designer and a co-author of this paper, was contracted to design and produce trophies for the first ever British Broadcasting Corporation's Africa Radio Awards in May 2007 (BBC Africa Radio Awards). The motif was needed in a relief form and then 'pierced' around the contour according to the BBC's design brief. Adopting the wet etching technique, it took approximately three months to produce 20 trophies due to the mode of resist application (hand painting diluted asphaltum using a sable brush). After etching, there was the problem of uneven edges of the motif due to the high volume of work. Furthermore, effects of body oils and sweat from the designer's palms soiled the surface of the metal. When the diluted asphaltum was painted over, it was unable to adhere to the surface of the metal to be etched, so the resist peeled off during etching causing undesirable results. The designer had to produce more than 20 pieces requested, because some of the work pieces went bad during etching.

Experimentation and Findings at the Studio

Experiments were carried out at the studio and chemistry laboratory to test the efficacy and suitability of screen printing asphaltum unto the surface of a copper metal for etching. To give a systematic account on the procedure employed at the studio, the following activities (experiments) were carried out:

- Testing for the ideal asphaltum consistency
- Testing for ideal acid solution that can etch motifs accurately
- Testing for the ideal mesh count
- Testing for the ideal squeegee blade type

Testing for the Ideal Asphaltum Consistency for Printing on the Metal Substrate

In an interview with Richard Peprah, a technician at KNUST Printing Studio (personal communication, 25th November, 2018), the authors were advised to use the consistency of a tooth paste to match the right consistency suitable for going through the tiny holes in the screen. Anatol (2017) also confirms the importance of the need for printing inks to be heavy enough to maintain its right consistency throughout the print operation and still being thin enough to penetrate the screen easily and evenly. Asphaltum is often sold on the market in lumps. Dissolving asphaltum lumps in turpentine could take maximum of four days and two days to dissolve if they were broken down into tiny bits and stirred often. Based on the information from the technician, after dissolving the asphaltum, the consistency of a toothpaste was matched to the dissolved asphaltum, with bits of turpentine added at certain intervals during stirring to arrive at the right consistency to match that of a tooth paste before using it to print (Figure 4).

a b

Figure 3. (a, b) Matching the dissolved asphaltum in turpentine with the consistency of tooth paste

After the mixture at the Metal Smith studio, further experiment was carried out at the at the Chemistry Laboratory, on KNUST Campus to check the actual millilitre of turpentine needed to dissolve the particular grams of asphaltum to achieve that absolute consistency to register prints on a metal substrate. Carefully outlined are the process and findings of the experiments carried out in the Chemistry Laboratory.

Process

- 10g of Asphaltum was added into 50ml of Turpentine and stirred.
- Noted grams of asphaltum were added in bits and stirred constantly whiles observing closely for 6 hours.

Conditions

The solution was left overnight for semi solid particles of asphaltum to dissolve for 8-14 hours.

Findings

- 44.29g of asphaltum in 50ml of turpentine = Absolute viscosity of the solution
- Ratio of 44.29g in 50ml of turpentine = $44.29 \div 50 = \frac{0.8858g}{ml}$

Therefore, if one has 200ml of Turpentine (Solvent) to find the grams of asphaltum needed to dissolve to get that Absolute Viscosity to be used as printing paste is

= 0.8858g/ml x 200ml
= 177.16g of Asphaltum

Further experiment was carried out to test if the turpentine would remove the photosensitive chemical that was used to develop the design onto the screen. It turned out that the asphaltum was easily wiped off by the turpentine from the screens' mesh (Figure 4) without affecting the photosensitive chemical on the screen. That also meant that one may not bother to make a series of screens to screen print a resist on a series of metal sheets for fear that the turpentine may remove the photosensitive chemical or sensitizer used to develop the designs on the screen. For that matter, one screen with a developed design can be used to print more than a hundred pieces of artwork onto a metal to be used for etching if the photosensitive chemical was made with the right potency of chemicals.

a b

Figure 4. a, b Pouring turpentine on the screen to dissolve asphaltum, Studio Practice, 2019

In order for the copper metal sheet not to shift whiles printing the asphaltum, a thin film of leather glue is applied onto the aluminium printing head that t-shirts are fitted on for printing. This is then allowed to dry. But when a plain t-shirt is fitted onto the printing head, because the glue is somehow sticky (not too sticky to stain the t-shirt) the t-shirt is held down. With this process, it was realised that the copper sheet could shift and mess up the printing also applied some glue behind the copper sheet and the surface of the printing board. The copper sheet stayed intact for the printing operation.

Testing for Ideal Acid Solution That Can Etch Motifs Accurately

According to Shaffer (1998), a ratio of 1:2 parts of acid to water gives a fast etch but wreaks havoc to a resist. Based on this, the following procedures were carried out:

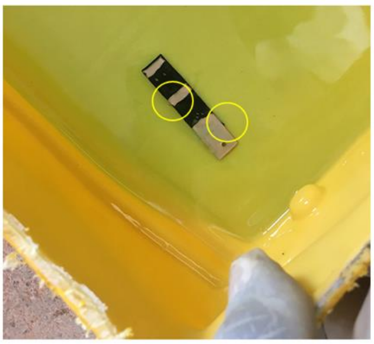
- Pieces of copper strips were cut out as test pieces.
- The copper test pieces were 1.15mm in thickness. Parts of the test pieces were covered with a layer of .2mm asphaltum (Figure 5).


a -Test Pieces b - Test piece without

c - .2mm is an ideal layer to asphaltum resist a non-violent etchant

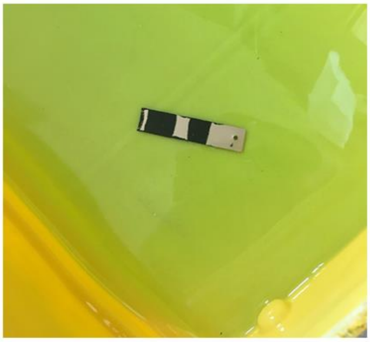
Figure 5. Covering metal plate with asphaltum

- A test piece was dropped into a ½:1 parts of acid to water etchant. But this solution also etches faster and peels off asphaltum.
- Another test piece was dropped into a ½:1½ parts of acid to water etchant. This ratio of acid to water turned out to be the best for the job.
- In 40 minutes, the etchant etched .2mm of material off the copper test pieces. Figure 7 shows the pictorial process.



a – ½:1 acid to water etches faster

b - A violent etch but gives a violent etch



c – ½:1½ acid to water gave a clean slow etch

d - clean accurate edges in etching

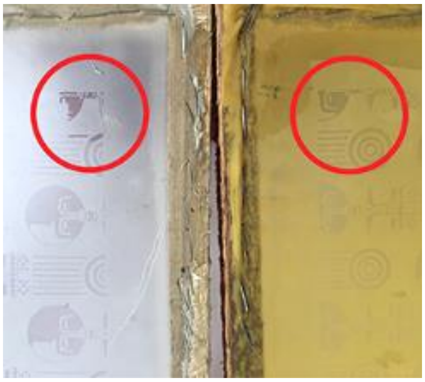
Figure 6. Etching of the metal plate with asphaltum with different acid to water ratio

Testing for Ideal Mesh Count

The information recorded from experts in the KNUST Textile Printing Studio on campus and t-shirt screen printing houses across Kumasi, Accra and Tema metropolis indicated that there are two major types of mesh used for screen printing available in Ghana. This is because most printing workshops do not have the most advanced mesh types and equipment that can handle extremely intricate design detail. Upon close observation the authors were able to categorize the meshes into the 40-86 mesh count type and the 120-156 mesh count type. A statement claimed that, the industry name for the 40-86 type of mesh count is called *Normal Mesh* and the other type which has its count pitched at between

120-156 count is called the *Fine Mesh*. The screens, unlike the earlier types which were made of silk, nowadays are made of nylon and sometimes polyester fabrics running as it were, perpendicular to each other (Isaac Ekow Jackson, Fresh Print Ghana Limited, 15 September 2018). A nylon normal and fine mesh with an Akan Adinkra and Duafe motif was developed on it. The 40- 86 mesh count is the lowest so far even on the international market in the screen-printing industry.

a - Left: shows a 'Normal Mesh', with between 40-86 mesh count, Right: 'Fine Mesh' with between 120-156 mesh count

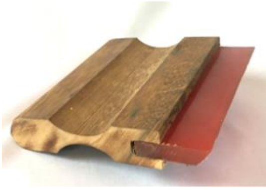
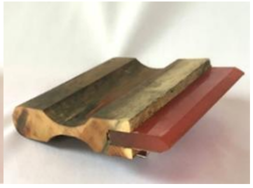


b - The circled parts show loose threads in the mesh on the left, that is the 'Normal mesh' and close-knit threads in the mesh shown on the right which is called 'Fine mesh'

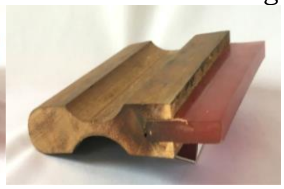
Figure 7. Testing the ideal mesh to give the best print outcomes

Testing for Ideal Squeegee Blade Type

The four major types of squeegees available on the Ghanaian market are also available in other parts of the world. A few screen-printing workshops visited had improvised squeegees but workers confirmed that it is not the best thing to do. Because the kind of rubber used in making squeegees are tried and tested with particular chemical content and particular strength of hardness and flexibility called the *Shore* of the plastic. Figure 9 shows the four types of squeegees available to test which one had the best effect in moving resist on the screen and forcing it through the tiny holes onto the metal substrate.

a - Chamfered edge b - Bevelled edge

c - Round edge d - Square edge

Figure 8. Squeegee types

Chamfered Edge Squeegee and Bevel Edge Squeegee

These squeegees with similar blade edges were categorized into the same group of squeegee types, because both squeegees gave the same effect (Figure 9) when they were used to screen print the asphaltum with a printing paste consistency (absolute viscosity). Both tools 'cut' asphaltum from the mesh upon screen printing operation and leaves the printed metal beneath the screen with the most minimum asphaltum (printing paste). Based on prior experience, the authors were aware that such thin layer of asphaltum will not help in protecting the surface adequately from acid action during etching. The aim here is to transfer enough asphaltum (resist) onto the metal surface; not too much and not too less. These two types of squeegees with *chamfered* and *bevelled* edges left a lesser amount of asphaltum upon the screen-printing operation on the metal. Therefore, a second test was done with these squeegee types by going over the print twice after the first printing operation. It turns out that three strokes of these squeegee types (to move asphaltum onto the sheet metal) was enough to help transfer ample amount of resist through the screens mesh onto the metal substrate. Therefore, the bevelled and chamfered edge squeegee types need to be applied in 3 printing operations namely; left to right, right to left and top to bottom strokes. The application of pressure on the Bevel and Chamfered Edge Squeegee during a printing operation is the same pressure used in every average manual screen-printing operation on a screen-printing workstation.

a - effect from bevelled edge blade

b - effect from chamfered edge blade

Figure 9. Print effects from bevelled and chamfered edge squeegee type

Round Edge Blade Squeegee

This type of squeegee deposits more paste in traditional screen-printing operation. Squeegeeing with the round edge blade type deposits more 'paste' on the metal substrate (Figure 10), so it is best for the printing operation to be done once; either moving the printing paste from left to right or right to left; top to bottom or bottom to top depending on what works for the person. When printing with a round edge blade squeegee, printing must be carefully done. Printing must spread the asphaltum (printing paste) wide enough to cover the whole length of the artwork so that in a single operation, the printing on the metal substrate can be evenly covered. The best operation is a onetime operation with the round edge blade Squeegee type, because the round edge squeegee type naturally deposits more paste onto a substrate because of the blades rounded edge.

Alternatively, there can be two printing operations done when using the round edge blade squeegee, but the pressure in moving the paste with the squeegee operation must be a little higher than the average pressure in a normal screen-printing operation. The reason is that the round edge blade squeegee deposits more asphaltum even upon a single stroke. Therefore, for the sake of not leaving some areas of the motif on the screens mesh unregistered on the metal substrate, one can do two strokes with a little pressure applied on the squeegee to deposit enough paste and a second operation to cover up other areas that may not have been covered in the first operation.

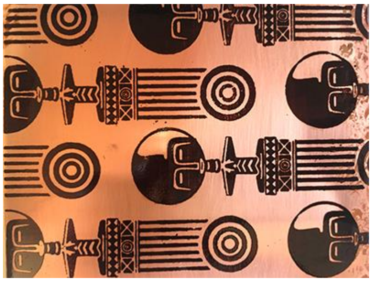


Figure 10. Effects from the round edge blade deposits more paste (asphaltum) than bevelled and chamfered edge blade types

Squeegee with Square Edge Blade

The squeegee with square edge blade is the ideal squeegee for screen printing operations worldwide and it has also proven upon several tests conducted to be the most effective tool for this operation. If the printing paste is well spread out, one printing operation is okay for a great print. The only thing is the printing operation must be done from top to bottom. If one wants to go over the print operation that will still be fine to add up some good layer of resist on the work. But one operation if done well is okay to register enough asphaltum on the metal. The square edge blade type does not leave too much or too less asphaltum on the copper substrate (Figure 11) that is why it is the best squeegee to use.

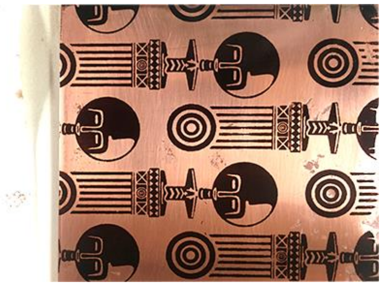


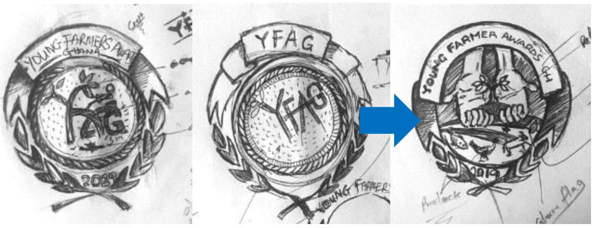
Figure 11. Square edge blade gave the best print with a crisp effect and better in definite edges of the motifs or designs printed

Design Process

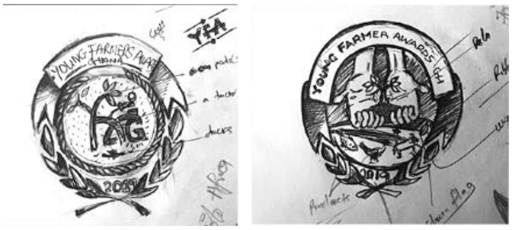
Based on the successes gained from the experiments, a design practice was undertaken to produce images on metal pieces for trophies and medals. The authors decided to choose the theme; *Youngest Farmer Awards*, as the design brief for the trophy design and manufacture. Over the years, there has been a hammering on the need for Ghanaians to look into agriculture by the government as a form of employment. Unfortunately, the awards for farmers are often focussed on adult farmers. Therefore, the authors believes that instituting a farmer awards for the youth will advance the cause of Agriculture and encourage the youth to go into it. It is believed that there is a need to institute an award of this category so that the youth would begin to look into farming as a potential employment avenue and not see this as an adult only job. With the youth being a stronger force in the nation, this category will create the awareness which will direct the attention of the youth to agriculture as a viable business activity. With this idea, the trophies and medals would be presented to the Ministry of Agriculture, as a contribution of his quota as a Ghanaian product designer towards nation building.

Sketches for Medal Design

Based on the theme, appropriate thumbnail sketches were created (Figure 12). These ideas were further scaled down to two preliminary ideas as appropriate for the project at hand. It is out of these two, that one idea was selected and recreated in a 2D graphic software and later in a 3D software application.



a - thumbnail sketches



b - selected logo ideas

Figure 12. Sketch ideas for Youngest Farmer Awards

The focus here was a logo or a symbol that will represent the whole embodiment of farming in Ghana. So that, apart from being incorporated in the design of the trophy and the medal, it could also be easily printed or carved or embossed on any material when need be. The selected image was rendered in a vector software (Figure 13). This was done to check the look, workability of the design and also correlation of design elements to bring out the whole embodiment of farming. Additionally, these designs were to depict the importance of farming, the fact that it is not a "get rich quick" activity but that the ultimate result of farming is quite rewarding, a quality that is almost becoming extinct amongst the youth of today. This idea is also captured in the incorporation of the human hand in a tenderly manner carrying a sprouting crop.

Figure 13. Rendering of the selected medal sketch idea for Youngest Farmer Awards

Sketches for Trophy Design

Illustrated in Figure 15 are two (2) trophy ideas created of which the ideal design was chosen and developed in 2D graphic and later in 3D modelling.

Figure 14. Sketches and rendering of the selected trophy idea for Youngest Farmer Awards

Production Procedure in the Studio Setting

Studio experiments clearly revealed the appropriate asphaltum viscosity, acid to water ratio and the squeegee type to employ in registering sharp images on the metal surface. With such knowledge gained, the production of the medal and trophy based on the theme mentioned early on started with the cleaning of the metal surfaces.

a b c

Figure 15. a, b, c Cleaning and resist application using screen and square edge squeegee

Isopropyl alcohol was used to clean and remove any dirt or oils from the metal surfaces (Figure 16a), which prevents the adherence of asphaltum. The metal plates were carefully secured on the table, where designs were printed on its surface with asphaltum using a square edge squeegee. Upon drying, an adhesive tape, cello tape (Figure 16 b, c) was used to secure the back of the metal plate since it resists nitric acid from etching.

a b c

Figure 16. (a-c) Etching in a bath with ratio of ½ acid : 1½ water

a b c

Figure 17. (a-c) Refined and accurate edge of images on metal plate

The printed metal pieces were etched (Figure 17) in a bath with ratio of ½ acid: 1½ water for 40 minutes. The outcomes of the etching process showed a refined and accurate edge (Figure 18). Unwanted portions were cut out using a jeweller's saw. Different parts were carefully joined or soldered and polished using an emery paper (grade ranging from 600-800). Subsequently, the medal and trophy were electroplated to give it a gold finish (Figure 19).

a b

Figure 18. (a, b) Electroplated finish for the medal and trophy.

Findings from Studio Practice

The major focus was to develop an ideal process to etch well defined edges of motifs on series of work pieces. Screen printing technique which is a Textile Industry technique of registering colour on fabric substrates can be used to register motifs of diluted asphaltum with the right consistency as a resist onto sheet metals. Because a screen can carry repeated motifs on them; for example, if 10 motifs can fit on say an A3 size screen, in 20 minutes one can print 200 pieces of motifs if they have available 10 copper plates. This is because for a maximum of 2 minutes a print can be made. The ideal mesh type that could help register these designs in the finest detail on the metal substrate is the 120-156 mesh count type which is referred to in Ghana as the 'fine mesh' or 'sticker mesh'. All the squeegee types could be used to push asphaltum with absolute viscosity through the screens' mesh to register on the metal substrate. But the best squeegee is the one with square edge blade.

In order not to make the metal plate move during a printing operation, and disturb the quest to achieve accurate and finer detail, glue have to be applied to the back of the sheet metal plate and mounted onto the surface of the working table. A cotton rag can be soaked in turpentine, to wipe off asphaltum paste on already used screen to be stored for later use. The turpentine does not disintegrate the photosensitive chemical that was used to develop the motifs on the screen. If there was a mistake in the printing on the metal, the design could easily be wiped off with a turpentine-soaked cotton rag and then allowed to dry after which a reprinting can be done until the best result is achieved. This can never be achieved with fabric printing.

The accuracy of the edges of printed motifs and rapid reproduction of motifs for etching using screen printing also depended on the vector drawing in a graphic application software. Images with JPEG (Joint Photographic Exchange Group) image formats and PNG (Portable Network Graphics), Bitmaps and other *photo* file formats were not suitable to be used to develop designs on screens due to the fact that these photo file formats printed in pixels and often gave pixelated edges of motifs. Rather .EPS (Encapsulated Post Script), or vector generated drawings, such as CORELDRAWS' .CDR file type or ADOBE ILLUSTRATORS' .ai files are the best file formats because these file formats can be resized in any bigger or smaller size and will never pixelate or loose quality, unlike photo file formats that lose quality when they are being resized.

Conclusion and Recommendations

Evidently, it can be concluded that asphaltum, when dissolved to an absolute viscosity rate, can be coerced to register motifs using screen printing on copper plate. Also, the best ratio of acid to water suitable to etch screen printed asphaltum with an absolute viscosity is ½:1½ respectively. At a market survey for the best mesh type to aid in printing intricate detail of motifs in asphaltum through screen printing, the type with between 120-156 threads per square inch was the most suitable for holding asphaltum as paste to allow penetration of the resist on a metal substrate. Also, the best squeegee type to use to aid in screen printing asphaltum on a metal substrate is the square edge blade type.

A lot of businesses that are human powered are seeing machines taking over. But in this same industrialized world, the same force driving the industries is innovation. The great thing about innovation is, it is a free faculty that anyone can possess as a human. Based on the methods of identifying innovation mentioned earlier, Jewellers and Metalsmiths can employ these ideas to stay ahead of their competition to continue to stay relevant in the industry. The same world is interested in hand made goods and even respects designers and artistes that make works 'by hand'. To be able to serve a niche market and counter the influx of generic products which many customers abhor, Jewellers and Metalsmiths may have to explore ideas and new techniques for making their work easier, faster, safer and more cost effective. A Textile Industry idea has been used to solve a problem in the Jewellery and Metalsmithing industry. Etching has been a technique often applied on a smaller number of workpieces. With the screen-printing technique, series of works in greater numbers can be printed in just a week.

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