Digital creation of hand engraved copper plates to secure a historic process

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Abstract

Underglaze tissue ceramic transfer printing was first developed circa 1750 and involved the use of engraved or etched copper plates, from which a wet strength tissue paper was printed with an oxide (commonly cobalt for blue colour) the famous 'Willow Pattern' being the best known example. However skilled engravers are no longer trained or available. The project addresses that issue by introducing the potential of printing the traditional potter's tissue and applying it in the same way as the late 18th Century process, but creating the printing plate from a digital file. Thus creating a combination of the digital capabilities of flexographic printing technology and the earliest printing process developed for the ceramic industry. The results of the project reduced the time from one month needed to engrave a roller to less than a day to create a digital equivalent, whilst retaining the integrity of the final product. The authors are collaborating with Burleigh Pottery in Stoke-on-Trent, the last remaining company to produce ceramic tableware decorated using the traditional printed underglaze tissue method. The project title is Combining digital print technologies with 18th Century underglaze ceramic printing to retain an industrial heritage process. The pottery was recently saved from closure by the Princes' Regeneration Trust, who wish to maintain the traditional manufacturing skills for the next 25 years.

Intoduction

This project sought to build upon previous research undertaken by Hoskins in 2000 into the combination of the digital capabilities of commercial flexographic printing technology and the earliest printing process developed for the ceramic industry in the 1780s. In the early grant Hoskins proved the potential of using relief flexographic plates for intaglio printing. This project aimed to replicate the hand engraved copper rollers with a commercially viable intaglio flexographic roller for the company and additionally prove the potential of the process for the artist and maker. In order to achieve this we collaborated with Burgess Dorling & Leigh (Burleigh) Pottery, the last UK Company to print underglaze tissue commercially, based at its Grade II listed Middleport pottery in Stoke-on-Trent.

The Princes' Regeneration Trust acquired the pottery in June 2011 saving it from closure. The Trust's involvement saved 50 jobs and maintained the traditional manufacturing skills unique to Middleport, preserving the historic buildings, collection of moulds, printing plates and machinery. The Princes' Trust specified that pottery production should remain at Middleport for the next 25 years. However the company had a long-term issue with both the maintenance and production of printing rollers and plates, which in the past have been hand engraved.

This project sought to address that issue by introducing digital technology to the printing of traditional potters underglaze tissue, both printing and applying it in the same way as the 18th Century process, but creating the plate from a digital file. Thus reducing the time taken to engrave a roller from one month to less than one day to create a digital equivalent roller, whilst retaining the integrity of the final printed product. Burleigh initiated the collaboration with the Centre for Fine Print Research (CFPR) at the University of the West of England, due to our expertise in the practical application and ability to marry of 19th Century printing processes with digital technology.

The investigation focused on the re-creation of underglaze intaglio printing rollers and plates using the normally relief flexographic process. Our previous research indicated it was possible to create an intaglio plate for research demonstration purposes and some practice based creative uses. We sought to create a visual taxonomy of existing underglaze tissue by using printed examples from museum collections in order to create a benchmark against which the new empirical research could be undertaken. We were aiming to recreate the qualities and visual aesthetic of underglaze tissue using contemporary digital technology whilst retaining all of the craft and artisan skills inherent in the application of underglaze tissue printing.

We achieved this by creating a methodology for the creation of practical examples using flexographic rollers and printing plates. The physical results could then be compared and tested against the benchmark. This methodology ensured that the results are both of a commercial standard and commensurate with the 18th and 19th Century examples highlighted within the visual benchmarks. In parallel, and as a further benchmark standard, an investigation took place into the potential of recreating hand engraved rollers.

History

When talking about underglaze tissue printed ceramics the majority of people, whether based in the UK or the USA, have a collective memory from their family history of using blue and white tableware, particularly on special occasions such as Christmas dinner or Thanksgiving. However the standard text ‘Penny Plain and Twopence coloured’ regarding Blue and White underglaze ceramic transfer printing begins: ‘Transfer printing is a particularly English form of ceramic decoration’[1] (Halfpenny, Pat. 1994).

Underglaze tissue ceramic transfer printing first developed circa 1750 and involved the use of hand engraved or etched copper plates, from which tissue paper was printed with an oxide (commonly cobalt for blue) in a printing medium, the famous 'Willow Pattern' being the best known example. Underglaze tissue has a very distinctive, subtle quality – and is an integral part of

both ceramic history and the history of copperplate engraving. From a practitioner perspective it is clear that the initial process must have developed by appropriating printing plates from the commercial etching and engraving industry. This is perhaps best exemplified by Sunderland and Liverpool ware in the UK.

Figure 1 *19th Century underglaze printed Willow pattern plate*

Whilst both under glaze and on glaze or over glaze printing occurred at this time, the first patents seem to suggest that enamel transfer printing on metal with on glaze colour may have occurred earlier than ceramic transfer printing[2] (Turner, W.1907). The origins of the tissue almost certainly date from the practice whereby the best quality prints in the traditional intaglio process were always printed on India paper - a thin tissue like sheet used between the heavy backing sheet and the plate to pull out the detail and supply a delicate background tone to the printed image. In a contemporary context this process is known as Chine Colle.

Commercially the process was common in the UK ceramics industry until the1980s and over the years had evolved as a process that could be printed from both hand engraved copper rollers and flat copper plates, both of which were chrome faced before printing. However from the 1950s onwards the process began to be supplemented by screenprinting, screenprinted transfers are printed on top of the glaze, - having none of the delicate qualities and permanence of underglaze. In addition screenprinted transfers are easier to apply and can easily be repositioned on the existing glazed surface, therefore are not reliant on the skills necessary for underglaze tissue application.

Primary aims and objectives

The primary aims of this project were. To prove the commercial viability of Flexographic printing for underglaze tissue, printing by using an intaglio roller and a doctor blade in the manner of traditional underglaze tissue printing and to demonstrate commercial sustainability and create a long-term future for our industrial ceramic heritage by combining digital technology and traditional craft skills through a revised under-glazed tissue process.

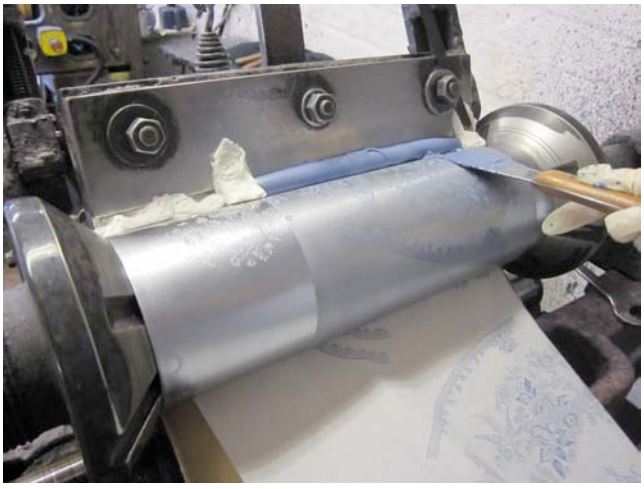

Figure 2 *Tissue printing from a hand engraved roller at Burleigh*

The primary objectives were to collaborate with designers and engineers from Burleigh to develop a method of producing intaglio printed underglaze tissue transfers onto ceramic tableware, using contemporary technology to accurately replicate the traditional process. To introduce new technology to Burleigh in order that they remain competitive, whilst retaining and recording all of the traditional craft skills and attributes that are essential, both to this process and to the unique historic context that applies both to the company and the process. Finally to collaborate with Burleigh to re-engineer their existing 19th Century machinery to be able to accept a 21st Century flexographic roller alongside a traditional hand engraved steel roller and generate the capacity for Burleigh to manufacture flexographic rollers in-house.

Research Methods

Inks

Initial investigations for both this and the previous project revealed very little primary reference material in regard the details of the technical process, such as the constituent parts of the inks historically used, i.e. oils, varnishes, waxes and dryers.

There is far more written archival material listing the constituent parts of the oxides used, but unfortunately the majority of extant ink recipes consist of lists of constituent parts rather than actual recipes. This makes it very hardtop recreate the recipe. Also the physical and chemical construction of the component parts bear very little resemblance to the traditional products used. For example, linseed oil is no longer double boiled, and burnt, but, created under immense pressure (S, Hoskins Inks 1999) In addition the vast majority of the historic material is either socio-historic - dealing with the life and work of the pottery and its employees, or primarily details the number type and variation of the artefacts produced, which is mostly generated by collectors and museum curators.

Therefore the researchers had to physically create new inks that would be healthier for the artist maker to use rather than the ink that is specifically heated and used by the industry. It was not possible to ascertain when the current commercial ink changed from a linseed oil based product to the current product, which is

based upon pine tar. It is assumed that the change was a commercial decision made when the volumes of production were vast. Linseed oil is a far more sustainable and healthier than the tar, so a decision was taken to create our replacement inks for artists only from linseed, which is the primary vehicle used by specialist ink manufacturers.

Currently Burleigh use ink that contains pine tar. This has a problem, in that when heated to the required 40 degrees Celsius for printing the ink gives off unhealthy Volatile Organic Compounds (VOC's)[5] (Hoskins, S. Risseeuw, J. 2011) Furthermore the ink will vary in printing quality dependent upon the oxide that it is mixed with. Each oxide has a different molecular structure that creates a different surface topography to the oxide particles. Therefore to make an individual ink each oxide requires different oil volumes to coat the surface topography of the particles evenly. For example some blues can print easily and crisply and in addition be easy to apply to the biscuit ware. Cobalt blue prints easily but is hard to apply as the ink bleeds and rubs off onto the hands of the applicators. Other colours such as black can be very hard to get to even stick to the biscuit. Traditionally the ink medium was a very heavy linseed oil measuring around 400 poise in the UK scale for viscosity and number 7 in the American measurement scale [6] (Burns, R. 1947). In order for the ink to be tacky enough to stick to the ware, modern tradition dictates that the ink and the plate are heated to loosen the viscosity of the ink to a stage that is akin to traditional etching ink and to enable the process to take place without using dampened paper. Once printed dry onto the tissue, the ink (as it dries) becomes very viscous and sticky thus creating a good transfer ink.

Existing Standards

The original intention was to create a taxonomy of visual examples in-order to ascertain a standard for comparison with current prints. It quickly became clear that there are a number of aesthetics, which apply to underglaze blue printing and these are based on a number of technical or habitual histories, which have little to do with the quality of printing. After visiting a number of museum collections including the Victoria and Albert Museum, Stoke City Museum, Bristol City Museum and Art Gallery and the Metropolitan Museum in New York. It quickly became very clear that very little could be gained by viewing collections in terms of technical production standards. This is perhaps best illustrated by viewing examples from a particular part of the ceramic collection in the Metropolitan Museum, New York. All of the examples on display in a set of cases are of a dark blue cobalt that has bled profusely and far beyond the engraved line of the image - thus rendering the image hard to read. Yet just judging by the sheer number of examples on display, this over-bleeding was a feature much loved aesthetically by a mid-Nineteenth Century American audience.

A similar scenario can be found between different patterns both in the archive at Burleigh and those in current use, such as the blue and white *Calico* pattern. Which when printed in cobalt bleeds (and carries a very heavy weight of ink) and yet an equally popular pattern such as *Asiatic Pheasants* carries much less ink particularly when printed in colours other than the blue. Even within Calico the pattern prints in different weights and remains crisp or bleeds dependent on colour used. So the black prints cleanly with a thin line and the classic blue is very heavy and slightly bled. Even the patterns themselves were common across a number of companies and both the pattern and quality of printing varied quite significantly depending on each companies interpretation of a pattern.

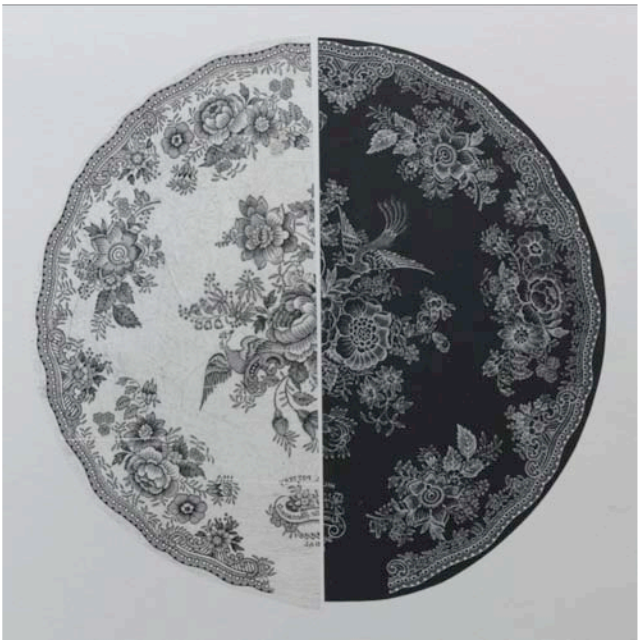

Figure 3 *Intaglio prints from original copperplate relief prior to digitising*

Image Capture

Much of the project centred around the creation of new digital rollers for Burleigh to trial. This would enable three important aspects for Burleigh. Firstly new designs could be created and trialled at low cost and secondly for Burleigh to be able to print images from their extensive roller archive that are too worn to use, without extensive re-engraving by a skilled engraver, thirdly by continuing to use their archive they are wearing the rollers that at some point will need re-engraving. In order to be confident that the digital rollers would recreate a hand engraved line, three problems had to be solved. First how to capture the image from an engraved plate, that retained the integrity of the engraved line. Second how to then repair and clean up the image without losing the integrity of the original engraving and third what method of plate manufacture to use in order to retain the integrity of the engraved image?

The initial and obvious solution for capturing the image was to print the intaglio plate onto either tissue or onto a good quality sheet of artists rag paper and then scan the result. However the problem with using this method is that the resultant image loses image quality and the width of the line degenerates through the printing process. A decision was taken to create a relief print in black from the surface of the plate, onto a sheet of smooth, calendared artist's paper. When this has been printed the sheet was then scanned and the image reversed in Photoshop. This resulted in an accurate capturing of the width of the original engraved line, and there is a direct correlation between line width and line depth.

So when the file was digitised and sent for engraving the line depth was dictated by line width.

Figure 4 *Images from left to Right: In –house processed photopolymer plate, outsourced photopolymer plate, laser engraved plate*

Once the file had been captured it had to be digitally 'cleaned' in order to remove any artefacts or imperfections that had arisen during the relief printing process and the subsequent scan. In addition, the Burleigh plates from the archive have been used for many years and have become worn, scratched and rusted or oxidised, dependent on whether they were chrome or steel faced. A mostly automated method for cleaning up and repairing these problems was developed in Adobe Photoshop that did not interfere with the original integrity of the engraving. The research team took a decision, that we would try and restore the plates to their original pristine condition without affecting the integrity of the line rather than recreate the plate, as it currently existed. Thus creating a result closer to the original intention rather than a faithful reproduction of a already extensively worn printing plate. This was primarily because Burleigh, as a commercial enterprise need to offer their customers the best quality artefact that they can create. This was not a restoration or conservation project in the traditional museum curatorial sense.

Creating Print Rollers

Next we investigated the potential for creating a printing roller from a digital file. We needed to recreate a roller that would have the print characteristics of the chrome faced, hand engraved copper rollers currently used by Burleigh. One of the problems they have is that the chrome facing wears particularly quickly. In full use a roller has to be refaced every week or more frequently. One of the issues they face is that they use a steel doctor blade on the chrome surface and both wear very quickly.

Initially we investigated the possibility of using relief flexographic plate that was exposed intaglio rather than for relief printing. This was based upon the earlier research undertaken by Hoskins in 2000. Plates made internally to the Centre for Fine Print Research (CFPR) were initially too shallow. So a decision was taken to have a series of plates made commercially in order to be able to try a much wider range of options. Metal and polymer backed plates in a range of shore hardness's were tried. Once we had surmounted the problems of persuading commercial plate makers that we wanted intaglio plates rather than relief plates which they make as standard, the results looked promising. We were initially hoping that we could create a metal backed plate that could be wrapped around a steel core roller with magnetic or tape adhesion.

Figure 5 *Hand engraved Dandelion image printed onto potters tissue*

After several months of trials it gradually became clear that the best option was a laser engraved plate or roller. Laser engraving gave a cleaner line with a greater depth combined with a finer line and more closely matching the hand engraved line. A series of rollers were ordered and trialled both in rubber composition and in polymeric materials. At this stage in the research Burleigh had restored a redundant printing press, which was stored in their basement, which CFPR used for running trials. The press was temporarily housed in the premises of the ceramic engineers, Goodalls in Stoke-on-Trent. Once the polymeric rollers were tried on the printing press they were quickly discounted because the surface could not be easily wiped clean with a doctor blade. The composition roller however proved effective, but collapsed and broke up at the edges, when screwed under pressure into the press to avoid the roller slipping. A roller core in steel with a locking keyway had to be ordered and specially coated with composition rubber, before a suitable new roller could be laser engraved.

With the new roller it became clear that the traditional steel doctor blade would not be compatible with the composition roller. Therefore experiments were undertaken with various grades and shore hardness's of urethane blade, used primarily for screenprinting and PTFE and PVC blades used in the flexographic industry. The best blade proved to be a triple shore urethane except that the blade was to wide to fit the current holder, therefore the edge of the blade was not tangential to the roller. A new housing needs to be created in order for the blade to be at the correct angle and properly supported. Burleigh have asked the engineers Goodalls to create a new adjustable housing for the blade. The

results of the final trial at Burleigh on the current production machine prove that the system is viable and that the copper rollers could be replaced with digitally created composition rollers.

Figure 6 *Dandelion image engraved onto a roller, produced at DSS Liverpool in conjunction with CFPR*

During our investigations and relying on the memory of the co-investigator David Huson, it became clear that there was more than one method of printing the tissue used industrially. Investigations proved that individual factories each had their own approach to printing underglaze tissue. Burleigh prints very hot (around 140 degrees Celsius) onto a dry tissue when printing rollers or plates. It was found that before they closed their production in the mid 2000's Spode heated a very hot flat plate but wetted the tissue with two coats of soft soap before applying the wet tissue to the hot printing plate.

Applying potters tissue is an extremely skilled process, most of the female employees who apply the tissue at Burleigh have worked in the factory for many years and are highly skilled. In fact it is clear that a good applicator requires several years continuous training on the job, before becoming very proficient in the process. Once printed the tissue is cut to size and applied to the pot with a specially hand made stiff brush (a Stumper brush) and soft soap. However this is only part of the story. First the applicator rubs the tissue to the pot to get the tissue to stick to the biscuit surface initially, then a small amount of soft soap is applied to the brush and the tissue is vigorously burnished onto the biscuit surface to transfer the maximum amount of print to the surface and allow clean release of the tissue. For this stage of the process the tissue applicators use very stiff brushes and hard toothbrushes for the compound surfaces such as that found on the cow creamer jug. The object is then left for a few hours for the print to dry on the surface of the pot before the tissue is washed off, leaving the print (printing medium and underglaze oxide) attached. The biscuit ware pot is then fired to approximately 600 degrees Celsius to remove the printing medium and fuse the oxide to the biscuit surface. The pot is then dipped into the transparent surface glaze and only fired in the kiln for the third and final time when the glaze has dried.

Collaborations and Partnerships

In addition to working with Denby Potteries, who are the current owners of Burleigh, all of the work undertaken in collaboration with Burleigh had to be agreed with the Prince's Regeneration Trust. In terms of a working collaboration it is easier to break this down, into the following. Denby have control over the design and marketing, Burleigh deal with production and the Princes regeneration Trust are responsible for the building and the historic aspects of preserving the factory and all of the processes within it. All parties have been in discussion to formulate a strategy for digitising the archive of existing plates and rollers and how some of that collection may be presented for public display. However much of this project is on hold as the owners of both Denby and Burleigh have put the factoroes up for sale.Thanks must also be given to Tom Keaney of DSS Liverpool, who generously donated a great deal of time and resources to creating laser engraved rollers for the project.

Conclusion

In conclusion the project successfully created a method of digitally engraving a rubber composition roller that would print on Burleigh's existing printing presses without modification (The printing presses date from the 1930's although some additions have been made). This was very important as the Princes Regeneration Trust were keen that the existing machinery would remain as it had been used when they took over the preservation of the factory in 2012.

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