THE ECONOMIC AND SOCIAL OPPORTUNITIES OF CASTING TECHNOLOGY FOR RURAL WOMEN

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ABSTRACT

The study examines the economic and social opportunities of additive and casting technology. The Community Casting Project (CCP) is a University of Johannesburg Metal Casting Technology Station (UJ-MCTS) project aimed at converting community-based hand made jewellery and crafts into commercially viable, job creating entities, through a comprehensive number of interventions central to which is additive manufacturing and casting technology. This pilot project which is composed of two phases is the overture to the rollout of the larger project. The six-month pilot project aims to develop and test the business case for the casting technology at three community sites as well as the rollout requirements of the larger project in order to inform the sponsors for the complete project rollout. The paper analyses the rationale and the benefits of additive manufacturing and casting technology. The case study analyses the role of UJ-MCTS in transferring know-how and skills in additive manufacturing and casting technology in an attempt to bring about socio-economic transformation to rural and peri-urban areas of South Africa. The authors propose some opportunities to empower rural women to reap the benefits of additive manufacturing and casting technology to optimise their production processes.

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1. INTRODUCTION

Additive manufacturing [1] helps to build prototypes, models and patterns from the 3D computer-aided design data. There are different additive manufacturing techniques such as Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM) and Stereo Lithography or the 3D printing [1, 2]. Although the printers are expensive, 3D printing e.g. ink-jet printing-based technology by Z-Corp's Spectrum Z510 [3] can create product prototypes or inexpensive moulds for first off production that can then be used to scale-up to large production of jewellery, footwear, art, reconstruction of fossils, for aerospace engineering, surgical parts for the dental and medical field [2]. Generally once the moulds are produced using the 3D printer the melting and casting will be done in low cost furnaces that could be fired up by gas, oil or electricity.

Additive manufacturing or ink-jet printing-based technology which builds a model from 3D Computer Aided Design (CAD) data [4] is very popular in the design and manufacturing sector. The process involves building the part layer by layer. This method is economical for short runs and is a pattern-less technology. The casting process makes use of moulds, first creating a pattern which is the replica of the functional part. Using this we create a negative or inverse shape in a mould, followed by pouring liquid metal into this mould so that upon solidification it will assume the shape of the cavity.

Another way is to create a replica of the original object using the 3D printer which is the positive master pattern which is then used to generate a vulcanized silicon-rubber mould. Here the casting process involves pouring the molten metal into the vulcanised silicon-rubber, which upon solidification produces the part or product. There are many casting techniques such as investment casting, gravity casting into moulds made of green sand and/or resin-bonded sand, die casting, high and low pressure die casting, additive manufacturing (or Rapid Prototyping [4] using SLS, ink jet printer), spin casting using vulcanised rubber moulds.

The paper investigates the role of casting technologies in the development of small and micro-medium enterprises that benefit the communities in South Africa. The University of Johannesburg Metal Casting Technology Station (UJ-MCTS) [5] has the following mandate:

- To facilitate, support and promote increased awareness of metal casting and foundry technology and technology innovation opportunities through developing and leveraging strategic partnerships and University alliance.
- To facilitate development and support of relevant programmes that are designed to attract and increase the skilled human capital in the fields of metal casting and foundry technology.

The case study analyses the opportunities that casting technologies could provide to the SEDA Limpopo Jewellery Incubator, one of the beneficiaries of the UJ-MCTS's Rural Foundry project. The Community Casting Project (CCP) is aligned to the UJ-MCTS mandate. UJ-MCTS's role in the CCP project is to facilitate the socio-economic development of rural and peri-urban women through building capacity in manufacturing, foundry processes and the use of Information and Communication Technology (ICT). The Community Casting Project was initiated to assist the existing jewellery manufacturing operations with a number of interventions.

The rural and peri-urban women are manufacturing jewellery and crafts by hand. The skills in additive manufacturing and spin casting using vulcanised rubber or silica moulds will create sustainable livelihoods in rural and peri-urban communities of South Africa.

Women will use spin casting and vulcanised silicon or rubber molds, instead of creating the complex parts by hand.

UJ-MCTS's production and technology support, the transfer of technology and skills upgrading to these women will optimize the jewellery production process. The majority of funding for the CCP is from UJ-MCTS, NFTN (National Foundry Technology Network) and TIA (Technology Innovation Agency) [6, 7]. The paper concludes with a set of strategies to empower rural women to reap the benefits of skills upgrading and technology transfer such as additive manufacturing, casting technology and optimizing production processes.

2. OBJECTIVES OF THE STUDY

The study investigates how UJ-MCTS's pilot project could benefit the peri-urban and rural communities through technology transfer for their socio-economic upliftment. The study highlights 3D printing, additive manufacturing and the spin casting process.

The study has the following objectives:

a) To assess the benefits of additive manufacturing and jewellery casting process at three centres that are managed by rural and peri-urban women.
b) To highlight UJ-MCTS's interventions in creating jobs through casting.
c) To train women in rural and peri-urban areas to manufacture jewellery and crafts through the use of spin and gravity casting.
d) To understand the role of the Community Casting Project (additive manufacturing and casting technologies) to empower rural and peri-urban women in South Africa.
e) Problem solving using ICT technology in an attempt to minimize cost and delays.
f) To propose strategies to empower women by optimizing the jewellery and craft production processes through the casting process.
g) To enhance the productivity of women and the quality of jewellery or crafts produced by the rural and peri-urban women through design, simulation, additive manufacturing and casting process.

3. RESEARCH METHODOLOGY

A qualitative approach was used to collect information and explain and interpret the problem. The literature review enabled answers to only some of the questions related to additive manufacturing technology and casting process that can help in the large scale production of jewellery. Unstructured interviews were conducted with the experts (at MCTS-UJ) in additive manufacturing and casting and those involved in the CCP. All the information relevant to this study was collected during the six month period from Jan 2011.

A case study [8] was one of the qualitative research types used for the study. The authors' and the stakeholders actively engaged in the Community Casting Project to answer some of the questions related to the case study. The case study explores how the community could use the casting and related technologies and the reasons for following this manufacturing route. The SEDA Limpopo Jewellery Incubator is one of the beneficiaries of the CCP. It is a '*typical or representative*' [8] group of many other jewellery manufacturing groups. All the information collected was examined by the stakeholders of the CCP to ensure validity.

3.1 Additive manufacturing and casting at UJ-MCTS

The visualization, prototyping, simulation and the metal casting process is done at UJ-MCTS. The demonstration centre at UJ has the facility to train women to simulate and

cast. UJ uses the simulation packages and the 3D printer for generating the moulds. Additive manufacturing will be used to create a simple or organic pattern which will be customized to the needs. In CCP the master mould will be produced at UJ-MCTS. The moulds can be used to produce between 500-1000 replicas.

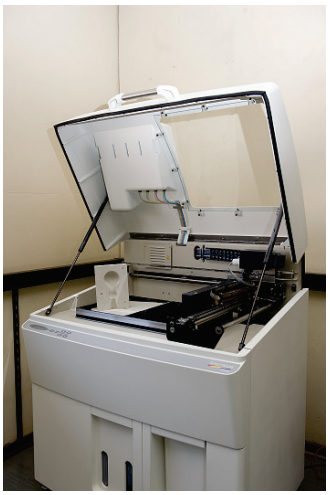

Figure 1: Z-Corp. Z510 printer Source: Z-Corp. [3]

The Z-Corp.'s spectrum Z510 (Figure 1) 3D printer is an ink jet printing system. Once the women bring the drawing or the photo of the jewellery part, the exact replica (pattern) is reproduced using hardware and software such as ProEngineer Wildfire 4.0 and 5.0 [9] and QuikCAST 2010 [10] simulation software. This simulated drawing is fed into the 3D printer to create a replica of the original object (positive). This replica object is now your positive master pattern. This is now used to generate a vulcanised silicon-rubber mould (negative).This master (negative) mould is used for casting and reproducing large scale production of the jewellery part. The molten metal is poured into the vulcanised silicon-rubber moulds which are inserted into a spin casting machine.

The 3D printer would enable the production of inexpensive master patterns that the women would use to produce vulcanised silicon-rubber moulds. For mass production, this technology can be used to produce complex shapes. The master moulds produced by this additive manufacturing technique at UJ-MCTS are consistent in quality, easy to use and the process is fast unlike other methods such as pattern making by hand. Melting in the community sites will be done using furnaces run on gas or fuel.

The six-month pilot project by UJ-MCTS aims to develop and test the business case for the casting technology at three community sites. With regard to skills development six women trainers will be trained to melt and cast. Two women will then be sent to each site to train other women. Low cost energy burners will be used for casting in the peri-urban areas. There are plans to start demonstration centres at Witbank, NorthWest and Limpopo. The women will be provided with a kit that will enhance training in the melting and casting processes.

Future plans are to reach out to most of the 23 locations identified. The casting station at UJ might find it expensive to send somebody to all the locations to monitor them. The proposal is to buy a laptop, monitor and at least two cameras for each demonstration centre so as to monitor and engage with the community via Skype [11] or other VOIP [12] packages. It is envisaged that using ICT will save cost and time to resolve problems experienced by the women.

3.2 Case study: Community Casting Project (CCP)

The focus on mineral beneficiation, introduced by the South African government more than ten years ago, brought about an opportunity for the speedy development of Small and Micro Enterprises (SMEs) in the jewellery and craft industries. This saw the establishment of a number of initiatives to train people in jewellery manufacturing, production of uniquely South African jewellery and showcasing on international platforms, all in the attempt to create sustainable livelihoods in rural and peri-urban communities.

A number of mining industry players and government institutions put in funding to ensure that this objective was met. As a result of these efforts, a total of approximately twenty-three community jewellery and craft manufacturing groups exist in the nine provinces, all at different levels in their development trajectory, averaging five to fifteen people at each site. These are independent entities, some registered as co-operatives or Close Corporations, free to receive services, support and collaborate with any organization they choose. However, many of these initiatives have not come anywhere close to realizing their full potential as they continue to lack much crucial support that would enable them to be competitive and sustainable in the long-term. These manufacturers are facing challenges of inconsistent quality, low volumes made by hand as well lack of competitiveness in terms of price, which has resulted in their remaining survivalist.

It is against this backdrop that the Community Casting Project (CCP) was initiated in order to intervene in the existing jewellery manufacturing small enterprises through a number of programmes i.e. technology transfer, production support, business and life-coaching, design intervention, demonstration and market access. At the core of the project is the rollout of a low-cost spin casting technology that uses gas or electricity. The technology and production support will be provided using the additive manufacturing machine and other equipment at the MCTS. The spin casting will improve the manufacturing capacity of the SMEs and enable them to be more productive, quality-driven and price-competitive. The additional interventions will impart valuable skills, all of which will enable the SMEs to be sustainable in the long run.

3.2.1 SEDA Limpopo Jewellery Incubator

The SEDA Limpopo Jewellery Incubator is one amongst the approximately twenty-three rural and peri-urban jewellery manufacturing SMEs across South Africa and is one of the beneficiaries of the CCP. The community group is an initiative of a local coal mine, which provided funding to sponsor their training, the set-up of the jewellery manufacturing workshop, as well as some raw materials. The SEDA Limpopo Jewellery Incubator programme provides the infrastructure such as premises and equipment for the women to work in and the UJ-MCTS will provide technology and know-how transfer.

3.2.1.1 Training for the SEDA Limpopo Jewellery Incubator

A workshop on additive manufacturing, casting technologies and ICT was held on the 10th August 2011 (Figure 2). The women from the Limpopo Incubator are made up of young and middle-aged women from the community who were previously unemployed. The activities of their business involve manufacturing hand-made jewellery and craft items that they sell at low prices. As with most existing community jewellery manufacturers, their output and quality are not adequate to enable their business to be self-sustainable and grow to the levels that can meaningfully sustain the members and create further jobs.

Figure 2: SEDA Limpopo Jewellery Incubator group, Ms. P. Riba, Mr. F. Varachia and Mrs. M. Joseph during the training at UJ-MCTS

The women from the Limpopo community site brought and displayed their design and handmade jewellery part to UJ-MCTS as shown in Figure 2. Some of the designs were left behind for UJ-MCTS to reverse engineer using CAD software. The designs will go through additive manufacturing (3D printer at UJ) to produce a resin replica (mould) of the original object. Rapid prototyping (RP) or additive manufacturing is a complex process that needs patience and expertise.

Initially additive manufacturing will be done only at the station located at UJ. This master mould produced by the printer will be used by women to create more jewellery parts through the use of vulcanised silicon/rubber moulds. The casting process (at the community site) used by women will be either spin casting or gravity casting.

At the workshop facilitated by the authors, there were informal discussions with the women on what their expectations were, by attending such a workshop. It was evident from the discussions that UJ-MCTS could play a meaningful role to produce new intricate designs and products which will make them more marketable. There was a strong recommendation for training and casting technologies.

Figure 3: Mrs. M Joseph provided ICT training to SEDA Limpopo Jewellery Incubator women

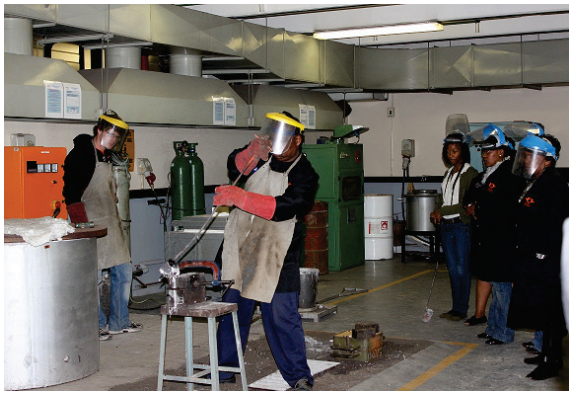

Figure 4: Casting demonstration at UJ-MCTS

Five women were provided training on the use of digital ICTs (Figure 3), demonstration on the casting process (Figure 4), and video demonstration of spin casting during the workshop. Cameras will be installed in the facility. The cameras at the community sites will help UJ-MCTS to assist the women at the community sites in troubleshooting their manufacturing processes. There are plans to provide the community site with a laptop or IPAD 2 [17] and broadband connection (free internet connection) to communicate with the rural and peri-urban women via Skype / Google Talk [13] or FaceTime [17]. It will help to interact with the women and exchange information regarding the jewellery parts and casting. UJ-MCTS has plans to set up a video-conferencing facility at its premises that will benefit both parties. There are also plans to provide women with free airtime packages so that women can SMS the engineers and staff at UJ-MCTS.

4. RESULTS

4.1 Benefits of using additive manufacturing and casting technologies for the CCP projects

Additive manufacturing (AM) helps to produce any complexity of geometry at no extra cost and provides more design freedom [4].The AM printing helps to create the master resin replica of the jewellery part more cost effectively than conventional processes in terms of time and cost.

The conventional processes are fast in terms of making a mould. The lead time from concept to casting will be longer in conventional processes. The ‘master’ jewellery part produced by additive manufacturing is getting less expensive and since patterns are not produced it is going to be quicker than conventional processes.

The ‘master’ jewellery part will be used to produce a vulcanised silicon-rubber mould for larger scale production of jewellery parts by the women. The women would have opted for a hand-made jewellery part which would in most cases be more costly and to reproduce the part there is the possibility of inconsistency in quality or of low quality and low volumes.

The new production process using the AM and casting technologies will lead to jewellery parts or crafts which are of good quality and reproducible. The technology offers the possibility of a variety of parts that can be made which can then be assembled later to make many different combinations of new jewellery or crafts. The parts are easy to use and the additive manufacturing process is faster unlike the manual method. The melting of the metal (if needed) will be done using low cost furnaces run on gas or oil. Production

efficiency will be increased through the use of additive manufacturing and casting technologies.

4.2 UJ-MCTS's intervention in creating jobs through additive manufacturing and casting technologies

There are no clear statistics available on the number of women unemployed at a time in the specific community under study. This is due to the fact that there is a steady migration of women (and men) from rural and peri-urban areas to the cities or urban areas in search of jobs [14]. These women prefer to settle down back within their community when they lose their jobs in the cities.

Many women in the community identified were previously unemployed. UJ-MCTS's intervention will enable the growth of self-sustainable business in the rural or peri-urban areas of South Africa. The aim is to provide skills on casting methods and to use digital ICT to communicate with the technical staff at the University. The station has not ruled out the possibility of using social networking sites such as Facebook [15] to network with many communities.

UJ-MCTS's role will be mainly assisting in the design of the jewellery, the technology to manufacture these parts and ICT training which will be done at the station initially. The additive manufacturing will be limited to the premises of the MCTS due to the high cost of printers and to the expertise needed in using CAD or simulation software. The ink-jet printing at UJ-MCTS helps to create the exact replica of the jewellery part by the experts at UJ-MCTS. The women will also be provided with training to melt and cast.

The hand-made jewellery parts and crafts manufactured by the women are sold at low price mainly due to quality issues. The casting technologies provided by UJ-MCTS will enable the women to produce the parts on a medium to large scale. UJ-MCTS's intervention will attempt to improve productivity and the efficiency of processes in the jewellery manufacturing sector.

4.2.1 Economic and Social opportunities for women

This section elaborates the economic and social opportunities that casting technologies may provide for the rural women.

The Community Casting Project (CCP) could provide employment opportunities for women in the peri-urban and the rural areas. The jewellery manufacturing sector was is new to these women, but the training on additive manufacturing, casting technology and ICT could provide a window of opportunities for medium to large-scale production of quality jewellery parts. A typical example is the employment opportunities the project could provide to the unemployed young and middle-aged women at the SEDA Limpopo Jewellery Incubator. Apart from providing employment opportunities, the CCP could provide the necessary skills to optimize the jewellery production process.

4.2.2 Self-sustainable income-generation opportunities

SEDA Limpopo Jewellery Incubator group felt the casting technology could enable their business to become self-sustainable. The technology provided at the UJ-MCTS demonstration centre could gear up the jewellery manufacturing process. The 3D printer enables the production of the master jewellery part. Currently the profit margins of the hand-made jewellery are low due to the high cost of manufacturing. It is difficult to assess how much income women could generate as no record of cost and sales are recorded yet.

Once the project is up and running there is scope to market and sell crafts and jewellery making use of ICT, to the local and international market at a reasonable cost. There are plans to market the jewellery via an independent website to help the community reach the local and international market. Women will be trained to use alternative technology to market and produce their wares more cost effectively.

4.2.3 Empowerment strategies

Community Casting Project (CCP) could improve the quality of life of peri-urban women by improving skills and the profit margin. More than improving their welfare it could 'empower' women through socio-economic transformation of the area itself. CCP could provide economic security to the rural women through the proposed income generation opportunities. The women have more confidence in developing new products because of know how support from UJ-MCTS. CCP will use reliable low cost technologies for jewellery manufacturing. Rural women involved in the CCP will have the freedom to express their views and recreate their traditional imprints. The CCP could improve the capabilities of rural women. Some experts opine the use of gender sensitive training methods to enhance the capabilities of the rural women [16].

4.2.4 Skills development through additive manufacturing, casting technologies and ICT training

The main aim of the Community Casting Project (CCP) project by UJ-MCTS is to provide casting and ICT skills to the women in the community and enable them to run self-sustainable businesses. Some of the women and staff from the SEDA Limpopo Jewellery Incubator were exposed to the UJ-MCTS technologies at a workshop held in August 2011 at the UJ-MCTS laboratories. UJ-MCTS provided demonstration on casting process, additive manufacturing, video-demonstration on spin casting and training to use laptop, IPAD 2, and the use of camera to exchange information.

Most women even in rural areas use Short Message Service (SMS) on a daily basis. The women could be provided free airtime to use SMS, for any assistance from the experts at UJ-MCTS. Marketing of the jewellery and the CCP information will be done through the website. Women will be trained at least to upload the latest crafts and jewellery manufactured.

5. CONCLUSION

The paper investigates the role of additive manufacturing (AM) and casting technologies in job creation at the peri-urban and rural areas of South Africa. Additive manufacturing has the potential to impact positively on jewellery manufacturing and design. The rural women involved in the UJ-MCTS's Community Casting Project (CCP) would use casting technology to optimize the production of quality jewellery parts through economically viable solutions. UJ-MCTS's CCP would assist women to build the real resin replica of the master jewellery part using ink-jet printers. These parts are in a way the rural women's traditional imprints. The casting process selected will contribute to economic viability and there are plans to use low cost gas furnaces for melting the metal.

Some of the benefits of additive manufacturing and spin casting technology to be used by the CCP would enable medium to large scale production of jewellery parts that will be consistent in quality. Jewellery parts manufactured through the CCP interventions are of better quality than those manufactured by hand. Women could sell these products to the local and international market in the near future. The CCP has other scope such as skills development through casting and training on ICTs. The use of ICTs such as cameras,

laptop, and CAD/simulation software is crucial for this project to exchange information with the experts and for women to get assistance from UJ-MCTS for the casting process.

The CCP could enhance the capabilities of rural women in South Africa. It could provide more socio-economic opportunities and will improve the quality of life of rural women and especially for the communities identified. More than job creation the CCP could provide economic security and boost the self-confidence of the women.

There is literally no information available on the internet on the use of casting technology by rural women for their socio-economic upliftment. There is scope for the use of independent websites to market the jewellery manufactured by the peri-urban and rural women through novel projects such as CCP. The use of social networking sites to enhance capabilities and to exchange information on casting by women will be a novel way to understand and develop skills of these women.

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