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Impacts of using non automated technologies on the Business Performance of Zimbabwean metal recycling industries.

Plaxedes Musademba[1], Joshua Simuka[2] and Tafadzwa Zimucha[2]

[1]School of Engineering and Technology Harare Institute of Technology, Harare, Zimbabwe
[2]School of Business and Management Sciences, Harare Institute of Technology, Harare, Zimbabwe

Email: pmusademba@hit.ac.zw

Abstract. Sustainable technologies play an important role in businesses by reducing negative environmental effects, avoiding depletion of natural resources whilst ensuring productivity. Zimbabwe is importing metal steel products that could be produced locally if local foundries adopt the rightful technologies. Most of Zimbabwean metal recyclers are using manual methods in the recycling process. The study looked at the negative effects of using manual production systems on the business performance of the Zimbabwean metal recycling industries. Qualitative and quantitative data collection techniques were adopted through the use of questionnaires and survey interviews. The researcher collected quantitative data through a questionnaire.77 out of 109 distributed questionnaires were returned and filled correctly by production personnel in the metal recycling industry. This translated to 70% response rate. Semi-structured interviews were conducted for the purposes of gathering qualitative data. Quantitative data revealed that metal recyclers are facing challenges of reduction in processing speeds, reduction in operation profits, poor product quality and high risk of getting injured due to the use of manual production methods. The study revealed that Zimbabwean metal recyclers are facing many challenges which to a greater extent are caused by their operation methods.

Keywords: *Sustainable technologies, Foundry, Scrap metal, Non-automated, Business Performance, Scrap metal.*

1. Introduction

Developing countries such as Zimbabwe deal with challenges in solid waste management such as insufficient waste recycling, hazardous wastes that are not separated for safe disposal, and landfills that are not properly engineered to prevent groundwater pollution (Teta and Hikwa, 2017). Zimbabwe has a lot of scrap metal and this to some extent is due to the fact that the country receives end of life vehicles from Japan, UK and other western countries. The availability of scrap metal in Zimbabwe is an opportunity to improve the country's economic situation. The utilisation of scrap metals using sustainable technologies can improve the profits margins in the local metal recycling industry.

Currently foundries and other informal metal recyclers are using unsustainable manual methods which reduce their competence and operational profits hence they fail to offer good prices for their main raw material (scrap metal). Zimbabwean foundries that are operating are facing a challenge of scrap metal shortage due to continued exports of the scrap metal to countries that pay more for the scrap as they have better technologies and recycling capacity. Zimbabwe could save at least $11 million per month and hundreds of jobs if it stops exporting scrap metal and beneficiate it locally thus according to ZIF (Chingwere, 2018).

Inefficient methods being used result in high usage of fossil fuels for heating, air pollution, hazardous operating method, less valued products and smaller product range of products from the recycled metal waste. The main objective of this research study is to analyse the impact of non-automated production methods used by Zimbabwean metal recyclers.

2. Literature Review

The literature review mainly focused on previous empirical studies on challenges faced by metal recyclers in general. There is a gap in published literature as no paper has been published concerning the impacts of the use of unsustainable manual technologies on the business performance of Zimbabwean metal recycling industries. A significant amount of research has investigated a range of e-waste recycling methods such as pyro-metallurgy, hydrometallurgy and bio-hydrometallurgy (Yken J, 2021).

A thesis for the degree of doctor of philosophy by Magnus Andersson was concerned with increasing the resolution of knowledge around opportunities for, and challenges of, recycling scarce metals and it aimed to identify measures that can raise recycling rates of such metals (Andersson, 2018). The thesis was mainly focusing on challenges of recycling scarce metal from dead motor vehicles e-waste. The conducted research highlights that for individual metals to be recycled, there is need for long-term, high impact and metal specific measures that target build-up of entire value chain (Andersson, 2018).

Mulaudzi et al. (2017) conducted a study on challenges faced by local authorities in solid waste management. The solid waste included scrap metal hence it was also analysed. Mulaudzi concluded that solid waste management in Zimbabwe, particularly Beitbridge is poor and ineffective, due to challenges such as poor community engagement; lack of machinery such as refuse trucks, compactors, there is also poor waste management practices such as burning of municipals and illegal dumping, poor enforcement of the legislations(Kaushik and Walsh, 2019)(Kaushik and Walsh, 2019) (Mulaudzi 2017).

(Adanu, Gbedemah and Attah, 2020) investigated why sustainable technologies are not used to collect, dismantle and sell e-waste given the risk of injury and extensive environmental pollution associated with handling of electronic waste. The research was mainly aimed at assessing the type of technologies that were currently used in managing e-waste. The study also looked at challenges that are faced when adopting sustainable technologies. The use of unsustainable technologies to manage e-waste contributed to physical injuries to workers and pollution of the environment (Adanu, Gbedemah and Attah, 2020). A major challenge limiting the use of sustainable technologies is lack of financial resources to acquire modern equipment despite the laborious nature of the work. The paper concludes that sustainable solutions to electronic waste management requires support from government to subsidize the cost of sustainable technologies in e-waste management.

Secondary data was collected from online newspapers and metal industry inventory data. According to data reported in November 2020, Zimbabwe's scrap metal industry has a monthly scrap metal shortfall of 17 000 tonnes. The scrap metal industry in the country demands a monthly supply of 27 000 tonnes which is currently not being met. At the time of the release of the data in November 2020, the industry could only access 10 000 tonnes of scrap metal having to import the balance of 62%. Scrap metal is a critical input in some domestic manufacturing businesses (Van Beukering and Bouman, 2001) (The Periscope Report Quick Stats, 2020)

The shortage of scrap has further been compounded by continued exports mainly to South Africa despite local foundry men's willingness and capacity to consume all the available scrap metal at competitive prices compared to what is obtaining across the border (Chingwere, 2018).

From the literature gathered the main challenges that are being faced by local recyclers include; quality of steel products produced from the scrap

- Minimizing contamination with other metals.
- Energy sources as they typically rely on coal or electricity for heating
- Lack of efficient refining technologies to recycle future scrap feed.

3. Methodology

The research design adopted was that of a mixed method approach, the researcher used survey questionnaire and interview to collect the data. Some of the sections in the research instrument are shown in Table 1.

One of the objectives of the research study was to examine the current production methods being used in the Zimbabwean recycling industry. Participants were asked to indicate the level of automation in their industry by ticking an appropriate box. The participants were required to indicate the source of energy required in the melting stage.

The research questions used are described in the table 1 below as qualitative or quantitative.

Table 1: Sample research question, type of research and data collection method.

Research Question	Type of research	Data collection method
1. Briefly describe the current metal recycling production methods that your firm uses.	Quantitative	Survey
2. To what extent do you agree or disagree that using unsustainable manual methods causes challenges in process operation.	Quantitative	Survey
3. Are there any strategies that your organization have put in place to address the challenges being faced during your operation process?	Qualitative	Interview
4. How do your products and process compare to those produced by international companies that are highly automated and use sustainable technologies?	Qualitative	Interview
5. In your own opinion why are metal scrap dealers opting to sell scrap metals to companies outside Zimbabwe	Qualitative	Interview
6. What are the main factors that affects the adoption and use of sustainable technologies in the Zimbabwean metal recycling industries?	Quantitative	Survey

Qualitative and quantitative methods was mainly used to collect both primary and secondary data. The survey was done using questionnaires. The quantitative approach used managed to provide information on the main challenges that the Zimbabwean metal recyclers are facing.

The main characteristic of qualitative research is that its outcomes are not measurable and quantifiable, however its basic advantage is that it offers a complete description and analysis of a research subject, without limiting the scope of the research and the nature of participant's responses (Collis & Hussey, 2003). The researcher used interviews which mainly gave a qualitative analysis and survey questionnaires which contributed majorly to the quantitative analysis. The interviews helped the researcher to get to know the challenges that the local recycling industries are facing. The questions in the interview guide were explanatory and descriptive. The researcher also managed to get more information regarding the study as the interview was interactive and, in some organizations, informal giving the respondents freedom to express their views.

3.1 Ethical consideration

The researcher asked for permission first from the recycling companies before getting information from their employees. To gain access to the targeted respondents, the researcher indicated to them about their freedom to respond or not. To ensure confidentiality and credibility all the information that was collected was used for academic purpose only. As a result, no information derived from this research will be passed to a third party without the permission of the researcher.

4. Presentation of Results

The research study focused on ascertaining the challenges or impacts of using manual production methods in the Zimbabwean metal recycling industries.

Participants were first asked to indicate the level of automation and source of heat energy in their industry by ticking an appropriate box. The detailed production methods were explained by respondents who were interviewed and the details are described under the qualitative analysis.

Table 2. Current Metal Recycling Production Methods

Manual (only 1 or no automated stages)	Semi-automated (at least 2 stages are automated)	Fully Automated (all stages are automated)	Source of heat	
			Renewable (solar or biomass briquettes)	Non-Renewable (coke or coal)
69	8	0	0	77

The results indicate that 90% of the respondents have highly manual processing methods, whilst 10% have some stages automated. No respondent indicated that their process is fully automated. All the respondents indicated that they are using non-renewable energy sources

Participants also indicated the extent to which they agree or disagree to challenges that the researcher indicated were caused by using manual production methods. The responses were indicated using a 5-point Likert scale. The results are presented in table 3 below.

Table 3: Challenges of Using Manual Production Methods

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	**Mean**
Reduction in processing speeds	89.6%	10.4%	0.0%	0.0%	0.0%	**4.90**
Reduction in operation profits	79.2%	13.0%	5.2%	2.6%	0.0%	**4.69**
Reduction on product quality	66.2%	24.7%	6.5%	1.3%	1.3%	**4.53**
Low price offers to scrap metal dealers	39.0%	28.6%	20.8%	6.5%	5.2%	**3.90**
Lack of scrap metals	36.4%	24.7%	26.0%	9.1%	3.9%	**3.81**
High risk of getting injured during operation.	84.4%	13.0%	2.6%	0.0%	0.0%	**4.82**
Product contamination	64.9%	22.1%	10.4%	2.6%	0.0%	**4.49**
Flue gases that affect the operator and environment	71.4%	13.0%	15.6%	0.0%	0.0%	**4.56**

According to table 3, the majority of the respondents strongly agreed that they were facing challenges from using manual processing methods. The major challenges were reduction in operating speeds, profit, product quality and high risk of getting injured during operation. A sizeable number of respondents (39%) did not agree that the challenge of offering low prices to scrap dealers is due to the use of manual production methods. Figure 1 below shows a graphical presentation of the challenges of using manual production processes in recycling industries.

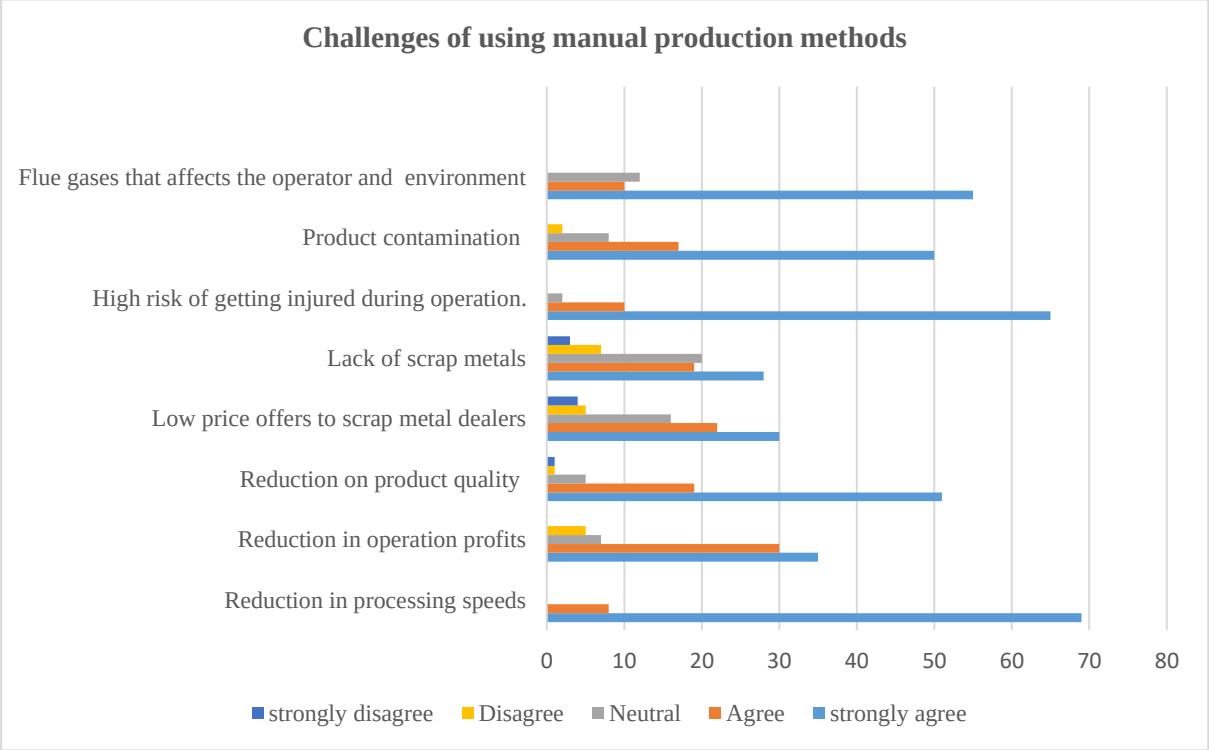

Figure 1. Challenges of Using Manual Production Methods

The graphical presentation clearly indicates that a greater percentage strongly agreed that using manual production processes have negative impacts. The above quantitative findings reveal that there are negative impacts caused by using manual processing methods in Zimbabwean recycling industries. The major challenges are reduction in processing speeds, poor quality products, high injury risks and high production costs. These findings show that manual production methods have a negative impact on the profitability of the industry. The findings are also supported by literature found on news websites and local newspapers.

4.1 Reliability of the Questionnaire

The reliability of the questionnaire was tested using the Cronbach's Alpha to ascertain if the findings obtained are reliable. The reliability test run in the SPSS produced results presented in the table below.

Table 4: Questionnaire reliability

Variable	**Cronbach's Alpha**	**N of Items**
Current Production Methods	0.981	5
Challenges of using manual production methods	0.943	8
Factors affecting adoption of technologies	0.955	7
Overall Cronbach's Alpha	0.979	20

A score of .979 for the 20 items entered in the SPSS software was produced. According to Meyer (2010) an overall Cronbach's Alpha of more above .600 is recommended which shows that the questionnaire was reliable

4.2 Qualitative data analysis

Interviewees were asked to describe their process as either automated, semi-automated or highly manual. The participants were also asked to describe their process operation in terms of sustainability. None of the participants said their process was fully automated and/or sustainable. The majority of the participants said their processes were highly manual with some pointing out that they have make shift locally made crushing machines. One interviewee response is provided below;

Our processes are very simple and not automated. We use jack hammers to crush the scrap metal that we would have selected using the handpicking methods. We remove plastics and some type of metals that will not be fit for that particular feed stream. We use plastics and papers and wood sticks to start the fire which will heat up the coal ashes that will melt our scrap metal. For now, sustainability is not much an issue as we are just looking at providing for the family

The respondent stressed the point that the process is highly manual and for now they just want to have a minimum profit to fend for their family

The study also looked at the safety of the current operating process in most local metal recycling processes. Participants were asked about the injury risks associated with the operation processes. One operator that owned a make shift grinder had this to say;

There are a lot of risks in our industry but due to experience fatalities only happen once in a while. There is a high risk in operating the semi-automatic make shift grinder as it is open on top, any mistake my hand or finger may be grinded. We also have healthy risk of contracting diseases as we do manual separation the clean the scrap metal. There is high risk of being burnt by the fire we make using charcoal, we also inhale a lot of gases from the heating processes that put us at risk of contracting respiratory diseases.

The interviewee basically explained more on the challenges that face especially as small-scale recyclers.

5. Discussion of results

The study established that there are negative impacts that affect the local metal recycling industry. Both qualitative and quantitative data revealed the negative impacts of operating manually. The impacts found were reduction in processing speeds, reduction in operation profits, and reduction on product quality. The other impacts include low price offers to scrap metal dealers, lack of scrap metals, high risk of getting injured during operation, product contamination and flue gases that affects the operator and the environment. Prasanna 2022 indicated the negative effects of manual processes by indicating advantages of automated technologies over manual processes. Unlike non automated recycling systems, automation helps businesses stay profitable by increasing output, reducing errors, and saving time and resources, also in a time of economic crisis, automation is a cost-cutting tool that can also help increase productivity and profit (Prasanna 2022).

The findings revealed that manual processing methods negatively affect operation speeds. The time taken during manual crushing and manual selection processes is long and it has an effect on the overall operation process. This results in less products being produced per day as compared to automated systems. The separation process takes a lot of time and sometimes due to error operators' end up leaving non-metals in the feed stream resulting in poor quality. Manual operation means more human resources which increases the production costs. Negative impacts of manual processing methods were also explained by Granta (2017) who indicated that unlike manual methods, automated machines do not have breaks, sick leave or holidays, and therefore even if they are only running during normal shift hours. This alone can often lead to a production increase of 140%+, automated machinery can also typically run faster and produce more accurately made products with fewer defects (Granta 2017).

The study established that there are a lot of risks in the local metal recycling industry. The risks include being accidentally crushed by hammers. Other risks include healthy risk due to inhaling flue gases from the heating processes. The gases also contribute to climate change as they are greenhouse gases meaning they also affect the environment. There is also high risk of being burnt by the fire the

recyclers make using charcoal. OSHA (2008) also indicated that employees involved in manual metal recycling activities may be exposed to metal fumes, smoke, hot environments, and hot material when working near furnaces, and may come in contact with metals that present hazards through both skin contact and inhalation.

The research findings also revealed that the recyclers are also facing challenges of scrap metal despite the high quantities of scrap metal in the country. The products produced by local recyclers are of poor quality and are sold at low prices. This makes the recyclers offer less price on scrap metals resulting in scrap metal dealers exporting scrap to get more money. Literature revealed that the government has put a ban on metal exports but companies apply for waivers which is sometimes abused. The continued export of scrap metal is resulting in shortages of scrap. Similarly, Chitaka's study (2014) the export of scrap metal was viewed as a great concern to recyclers as it reduces the chances of local beneficiation

6. Conclusion and recommendations

Zimbabwe has a lot of scrap metals which could be locally processed and improve the country's GDP. Most of the local metal recyclers are operating manually and are facing many challenges which contributes to the reduction of profits and high risk of human and environmental health. The major challenges that the study found include reduction in processing speeds, poor quality products, high injury risks and high production costs. These findings show that manual production methods have a negative impact on the profitability of the industry.

Recommendations

The researcher recommends the use of automated technologies in the Zimbabwean metal recycling industry which increases convenience, operation speeds, product quality and profitability. Adoption of technology in the recycling industry has been employed to increase recycling rates, keep up with changing materials and products entering the waste stream and improve profitability for scrap metal recyclers (ScrapWare, 2021). Automated technologies reduce health risks and reduces environmental pollution. New recycling technologies, which arimproving, are one means of addressing current low metal recycling rates (Reck B, 2012). There are many automated technologies available for use by the metal recycling industry.

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