Improving financial and environmental performance through MFCA: A SME case study

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by

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Motivation

- Small and medium scale enterprises (SMEs) around the globe significantly contribute to the economy (Revell et al., 2018).
- However, they are also significant contributors to environmental contamination. Compared to large scale industries, SMEs generally do not efficiently manage their waste.
- Their share in overall industrial waste generation is estimated to be about 70 %.
- According to a OECD (2018) report, worldwide consumption of raw materials will be doubled by 2060 due to expansion in the global economy and rise in living standards.

Study context: Indian Small and Medium Scale Enterprises (SMEs)

- In India, SMEs contribute around eight percent of the total GDP through production, export and employment generation (GOIMSME, 2016).

Table 1.1 Classification of small and medium scale enterprises in India (MSME Amendment Bill, 2018)

Category of industry	Criteria (Annual turnover)
Small enterprises	More than 50 million INR but does not exceed 750 million INR
Medium enterprises	More than 750 million INR but does not exceed 2500 million INR

- In recent years, with the launch of "Make in India" initiative, there has been substantial growth in manufacturing sector in India.
- The "Make in India" programme, started in 2014, supports SMEs with an aim to make India the world's largest manufacturing hub.

Question amongst SMEs in India:

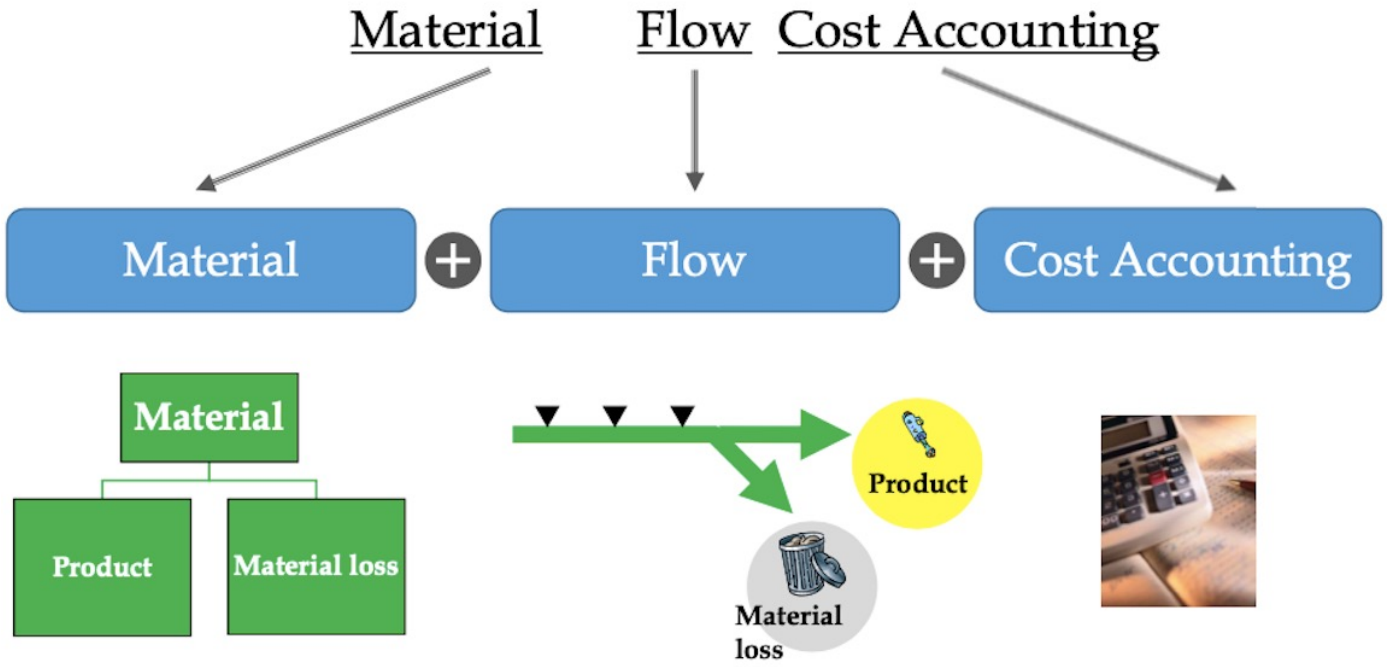
- How can we manufacture the goods while establishing environment and economic sustainability?

Answer:

Material Flow Cost Accounting

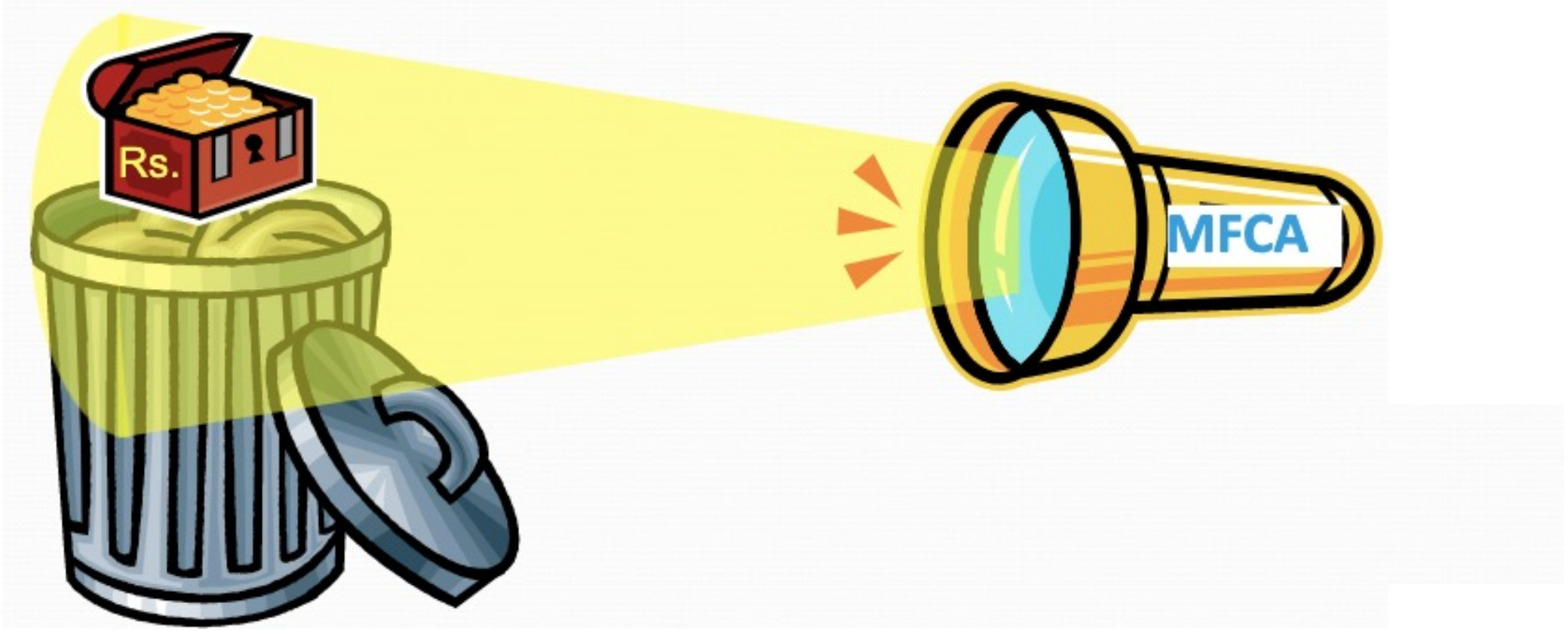
Introduction

- According to ISO 14051: (2011), Material Flow Cost Accounting (MFCA) is defined as a "tool for quantifying the flows and stocks of materials in the manufacturing process or production lines in both physical and monetary units".



- MFCA is an environmental management accounting tool that enables the organizations to effectively manage the use of both material and energy by improving the existing practices.

- MFCA focuses on wastes.
- MFCA makes losses visible.
- Finds out the profit hidden in wastes.



Who Implements MFCA?

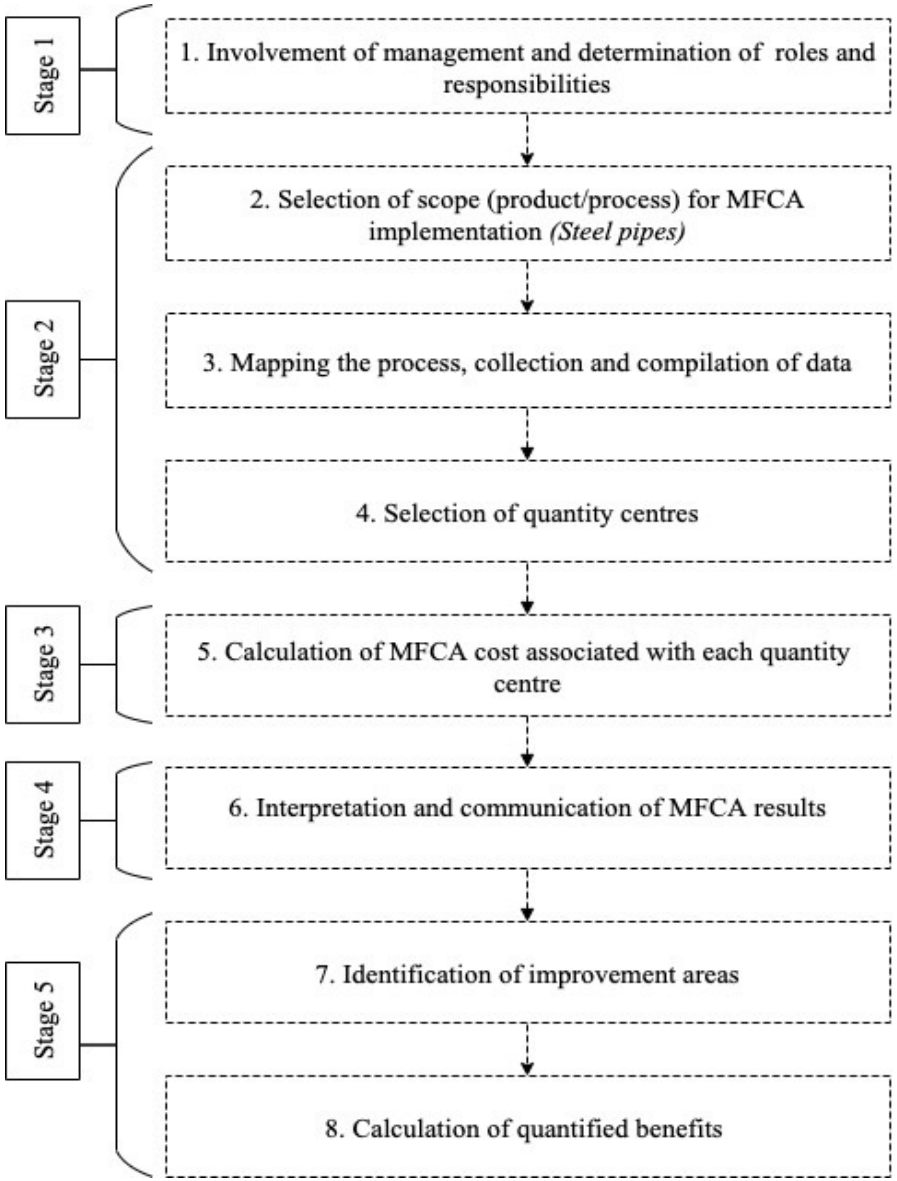
Author (year)	Application area	Country	Methodology used
Dekamin and Barmaki (2019)	Soyabean Production	Iran	MFCA
Dunuwila et al. (2018a)	Crepe rubber manufacturing	Sri Lanka	MFCA along with life cycle assessment (LCA)
Dunuwila et al. (2018b)	Crepe rubber manufacturing	Sri Lanka	MFCA along with life cycle assessment (LCA)
Wang et al. (2017)	Printed circuit board (PCB) manufacturing	Taiwan	MFCA
Zhou et al. (2017)	Iron and steel enterprise	China	MFCA along with 3R (reduce, reuse and recycle) concept of circular economy
Mahmoudi et al. (2017)	Oil refining company	Iran	MFCA
Jakrawatana et al. (2016)	Starch and ethanol production	Thailand	MFCA
Chompu-inwai et al. (2015)	Wood products manufacturing	Thailand	MFCA along with design of experiments
Fakoya (2015)	Micro brewery	South Africa	MFCA

Objective

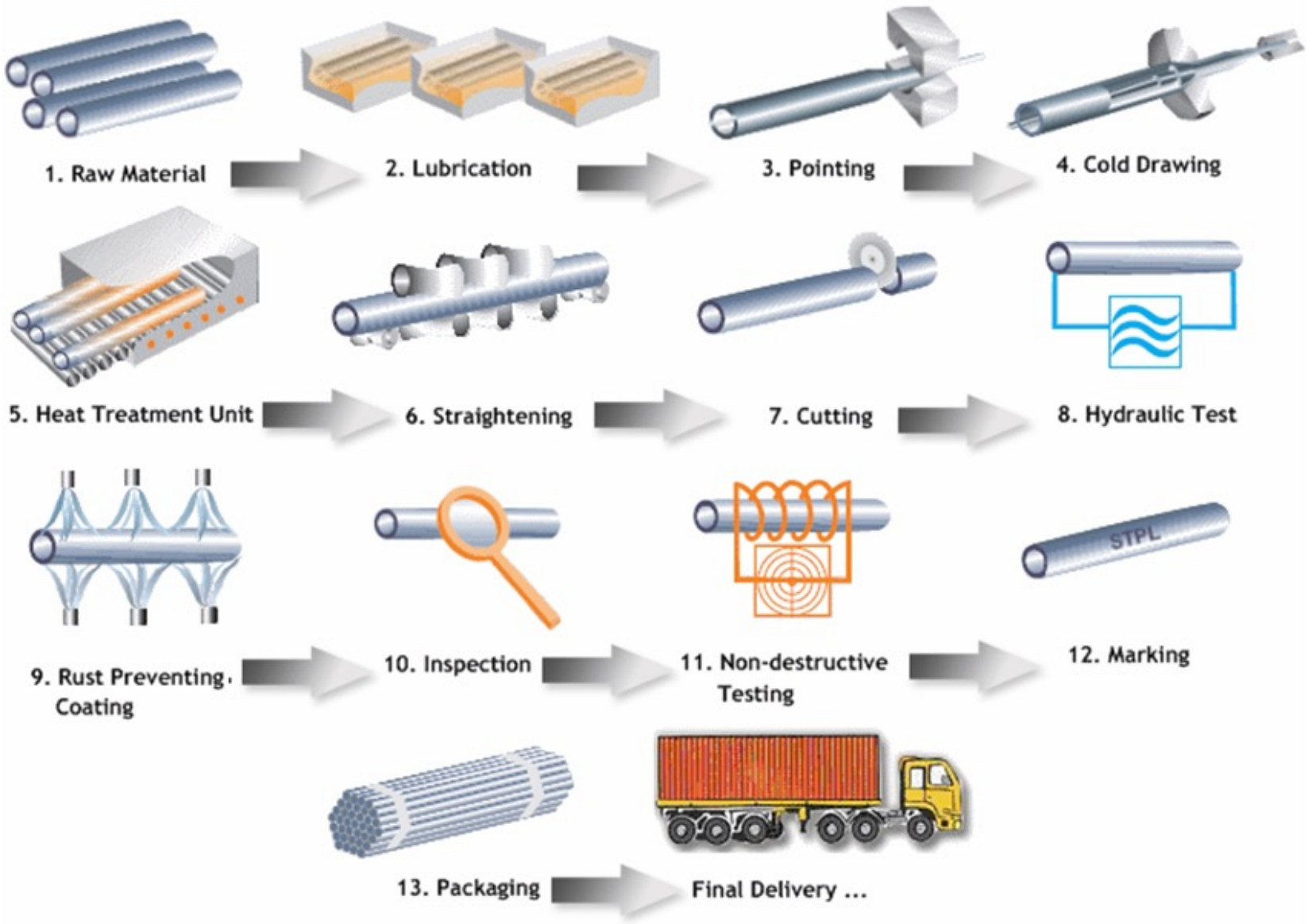
The case study was conducted in steel pipes and tubes manufacturing enterprise situated in the western part of India having nearly 250 employees.

The objective of this research is to apply the MFCA tool in an Indian SME for improving its environmental and financial performance.

Steps for MFCA Implementation in an Indian SME



Step 3: Mapping the process, collection and compilation of data

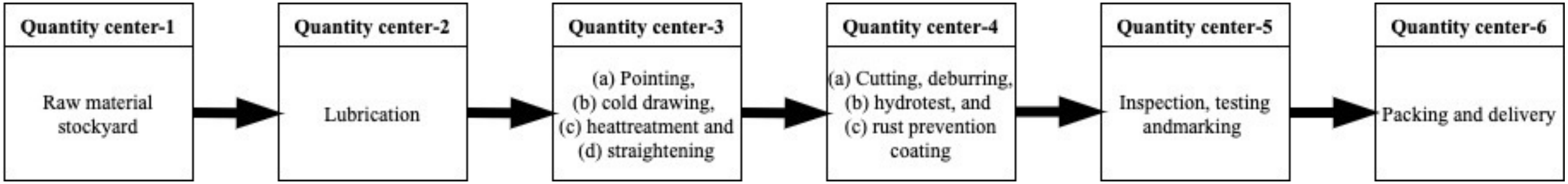


Material flow details at individual manufacturing sub-process

Sub-process number	Manufacturing sub-process	Number of input raw materials (Quantity)	Cost of current input raw materials (INR)	Cost of consecutive waste (INR)	Weight of current input raw materials (Kg.)	Weight of consecutive waste (Kg.)
1	Raw material stockyard	1	23,003,736	956,040	371,028	15,420
2	Lubrication	5	2,660,036	2,553,957	98,532	94,591
3	Pointing	2	124,000	124,000	880	880
4	Cold drawing	2	349,500	337,860	1,400	1,380
5	Heat treatment	3	285,478	299,924	6,818	7,051
6	Straightening	0	0	0	0	0
7	Cutting and deburring	2	145,284	389,254	741	4,676
8	Hydro test	3	139,442.45	159,887.45	1,417.88	1,836.23
9	Rust prevention coating	2	556,968	529,248	7,697	7,312
10	Inspection, testing and marking	3	43,527	576,501	900	9,708
11	Packing and delivery	8	981,384.35	6,805	5,015.05	82

Step 4: Selection of Quantity centers

- Total six QCs were formed to implement MFCA in the SME.



Step 5: Calculation of MFCA cost associated with each quantity center

Table 6.1. MFCA material balance (based on material cost)

Data period	(1 month)
Type of product	Steel tube

No.	Input	Quantity (Kg)	Material Cost (INR)
1	Packed steel pipes and tubes: 62 INR/kg	371,028	23,003,736
	Total (A)	**371,028**	**23,003,736**

Quantity Center 1

Name of process: Raw material stock yard

Material loss			
No.	**Type of Material loss**	**Quantity (Kg)**	**Material Cost (INR)**
1	Material waste (steel strips, tubes etc): 62 INR/kg	15,420	956,040
	Total (B)	**15,420**	**956,040**

Negative product %	4.16%
Positive product %	95.84%

No.	Input	Quantity (Kg)	Material Cost (INR)
1	**Previous process positive product (A-B)**	355,608	22,047,696
2	HCL: 25 INR/kg	93,723	2,343,075
3	Metcot 220: 65 INR/kg	2,860	185,900
4	Steric acid: 69 INR/kg	1,663	114,747
5	Metcot 210: 82 INR/kg	120	9,840
6	Caustic: 39 INR/kg	166	6,474
	Total (C)	**454,140**	**24,707,732**

Quantity Center 2

Name of process: Lubrication

Material loss			
No.	**Material loss**	**Quantity (Kg)**	**Material Cost (INR)**
1	Waste acid (chemical sludge): 27 INR/kg	94,591	2,553,957
	Total (D)	**94,591**	**2,553,957**

Negative product %	10.34%
Positive product %	89.66%

No.	Input	Quantity (Kg)	Material Cost (INR)
1	**Previous process positive product (C-D)**	359,549	22,153,775
2	Pointing die: 150 INR/kg	80	12,000
3	Grippers: 140 INR/kg	800	112,000
4	Cold drawing die: 80 INR/kg	150	12,000
5	Drawing oil: 270 INR/kg	1,250	337,500
6	Ammonia: 41 INR/kg	6,533	267,853
7	Descaling chemical: 95 INR/kg	60	5,700
8	MS-wire: 53 INR/kg	225	11,925
	Total (E)	**368,647**	**22,912,753**

Quantity Center 3
Name of processes: (a) Pointing, (b) Cold drawing, (c) Heat treatment and (d) Straightening

Material loss			
No.	**Material loss**	**Quantity (Kg)**	**Material Cost (INR)**
1	Rejected tubes: 62 INR/kg	135	8,370
2	Sample tubes taken out for quality check: 62 INR/kg	128	7,936
3	Used Pointing die: 150 INR/kg	80	12,000
4	Used grippers: 140 INR/kg	800	112,000
5	Used cold drawing die: 80 INR/kg	150	12,000
6	Used Drawing oil: 270 INR/kg	1,200	324,000
7	Used ammonia: 41 INR/kg	6,533	267,853
8	Used descaling chemical: 95 INR/kg	60	5,700
9	Used MS-wire: 53 INR/kg	225	11,925
	Total (F)	**9,311**	**761,784**

Negative product %	3.32%
Positive product %	96.68%

No.	Input	Quantity (Kg)	Material Cost (INR)
1	**Previous process positive product (E-F)**	359336	22,150,969
2	Abrasive cutter: 133 INR/kg	704	93,632
3	Deburring tool: 1396 INR/kg	37	51,652
4	Jigs tool: 45 INR/kg	495	22,275
5	Rubber seals: 780 INR/kg	7.65	5,967
6	Hydralic oil: 121.50 INR/kg	915.23	111,200.45
7	Pressure gauge: 1000 INR/kg	3	3,000
8	Rust preventing oil: 72 INR/kg	7694	553,968
	Total (G)	**369,191.88**	**22,992,663.45**

Quantity Center 4
Name of processes: (a) Cutting, deburring, (b) Hydro test and (c) Rust prevention coating

Material loss			
No.	**Material loss**	**Quantity (Kg)**	**Material Cost (INR)**
1	Rejected tubes: 62 INR/kg	2,206	136,772
2	Pointed end cuts of tube: 62 INR/kg	2,155	133,610
3	Used abrasive cutter: 133 INR/kg	704	93,632
4	Used deburring tool: 1396 INR/kg	37	51,652
5	Used jigs tool: 45 INR/kg	495	22,275
6	Used hydralic oil: 121.50 INR/kg	915.23	111,200.45
7	Used pressure gauge: 1000 INR/kg	3	3,000
8	Ued rust preventing oil: 72 INR/kg	7,309	526,248
	Total (H)	**13,824.23**	**1,078,389.45**

Negative product %	4.69%
Positive product %	95.31%

No.	Input	Quantity (Kg)	Material Cost (INR)
1	**Previous process positive product (G-H)**	355,367.65	21,914,274
2	Cotton material: 27 INR/kg	831	22,437
3	Marking slate: 327.50 INR/kg	2	655
4	Marking chemical: 305 INR/kg	67	20,435
	Total (I)	**356,267.65**	**21,957,801**

Quantity Center 5
Name of process: Inspection, testing and marking

Material loss			
No.	**Material loss**	**Quantity (Kg)**	**Material Cost (INR)**
1	Rejected tubes: 62 INR/kg	8,862	549,444
2	Cotton material: 27 INR/kg	831	22,437
3	Marking slate: 327.50 INR/kg	2	655
4	Marking chemical: 305 INR/kg	13	3,965
	Total (J)	**9,708**	**576,501**

Negative product %	2.63%
Positive product %	97.37%

No.	Input	Quantity (Kg)	Material Cost (INR)
1	**Previous process positive product (I-J)**	346,559.65	21,381,300
2	Wooden box: 291.45 INR/kg	2,550	743,197.50
3	Hession cloth: 130 INR/kg	463	60,190
4	HDPE: 60 INR/kg	698	41,880
5	Plastic sheets: 99 INR/kg	496	49,104
6	Steel strips: 95 INR/kg	614	58,330
7	Packing clip: 56 INR/kg	18	1,008
8	End caps: 120 INR/kg	154	18,480
9	Adhesive tape: 417 INR/kg	22.05	9,194.85
	Total (K)	**351,574.70**	**22,362,684.35**

Quantity Center 6
Name of process: Packing and dispatch

Material loss			
No.	**Material loss**	**Quantity (Kg)**	**Material Cost (INR)**
1	HDPE: 60 INR/kg	31	1,860
2	Plastic sheets: 99 INR/kg	25	2,475
3	Steel strips: 95 INR/kg	26	2,470
	Total (L)	**82**	**6,805**

Negative product %	0.03%
Positive product %	99.97%

INR- Indian National Rupees

Fig. 6.1. MFCA cost calculations

Quantity Centers → / Cost items ↓	Quantity center 1	Quantity center 2	Quantity center 3	Quantity center 4	Quantity center 5	Quantity center 6
	Raw Material Stockyard	Lubrication	(a) Pointing, (b) Cold drawing, (c) Heat treatment and (d) Straightning	(a) Cutting, deburring, (b) Hydro test and (c) Rust prevention coating	Inspection, testing and marking	Packing and delivery
Total new input cost						
Total	23,313,084	2,813,076	4,143,128	1,432,194	504,327	1,467,384
New Input MC	23,003,736	2,660,036	758,978	841,694.45	43,527	981,384.35
New Input SC	245,700	140,400	210,600	175,500	280,800	351,000
New Input EC	63,648	12,640	3,173,550	415,000	180,000	135,000
Total cost handed over from previous process						
Total	0.00	22,344,175.12	22,556,813.85	25,812,423.17	25,966,811.53	25,775,936.74
MC from previous process	0.00	22,047,696.00	22,153,775.00	22,150,969.00	21,914,274.00	21,381,300.00
SC from previous process	0.00	235,478.88	337,013.00	529,432.25	671,870.93	927,615.68
EC from previous process	0.00	61,000.24	66,025.84	3,132,021.92	3,380,666.60	3,467,021.06
Process total input cost						
Total	23,313,084.00	25,157,251.12	26,699,941.85	27,244,617.62	26,471,138.53	27,243,321.09
Input MC	23,003,736.00	24,707,732.00	22,912,753.00	22,992,663.45	21,957,801.00	22,362,684.35
Input SC	245,700.00	375,878.88	547,613.00	704,932.25	952,670.93	1,278,615.68
Input EC	63,648.00	73,640.24	3,239,575.84	3,547,021.92	3,560,666.60	3,602,021.06
Percentage quantity of negative product	**4.16%**	**10.34%**	**3.32%**	**4.69%**	**2.63%**	**0.03%**
Percentage quantity of positive product	**95.84%**	**89.66%**	**96.68%**	**95.31%**	**97.37%**	**99.97%**
Total positive product cost						
Total	22,344,175.12	22,556,813.85	25,812,423.17	25,966,811.53	25,775,936.74	27,233,719.71
Positive product MC	22,047,696.00	22,153,775.00	22,150,969.00	21,914,274.00	21,381,300.00	22,354,547.15
Positive product SC	235,478.88	337,013.00	529,432.25	671,870.93	927,615.68	1,278,232.10
Positive product EC	61,000.24	66,025.84	3,132,021.92	3,380,666.60	3,467,021.06	3,600,940.46
Total negative product cost						
Total	968,908.88	2,600,437.28	887,518.67	1,277,806.10	695,201.78	8,269.19
Negative product MC	956,040.00	2,553,957.00	761,784.00	1,078,389.45	576,501.00	6,805.00
Negative product SC	10,221.12	38,865.88	18,180.75	33,061.32	25,055.25	383.58
Negative product EC	2,647.76	7,614.40	107,553.92	166,355.33	93,645.53	1,080.61

MC = material cost (in INR), SC = system cost (in INR), EC = Energy cost (in INR)

Step 6: Interpretation and communication of MFCA results

Figure 6.3. The MFCA cost allocation (positive vs. negative)

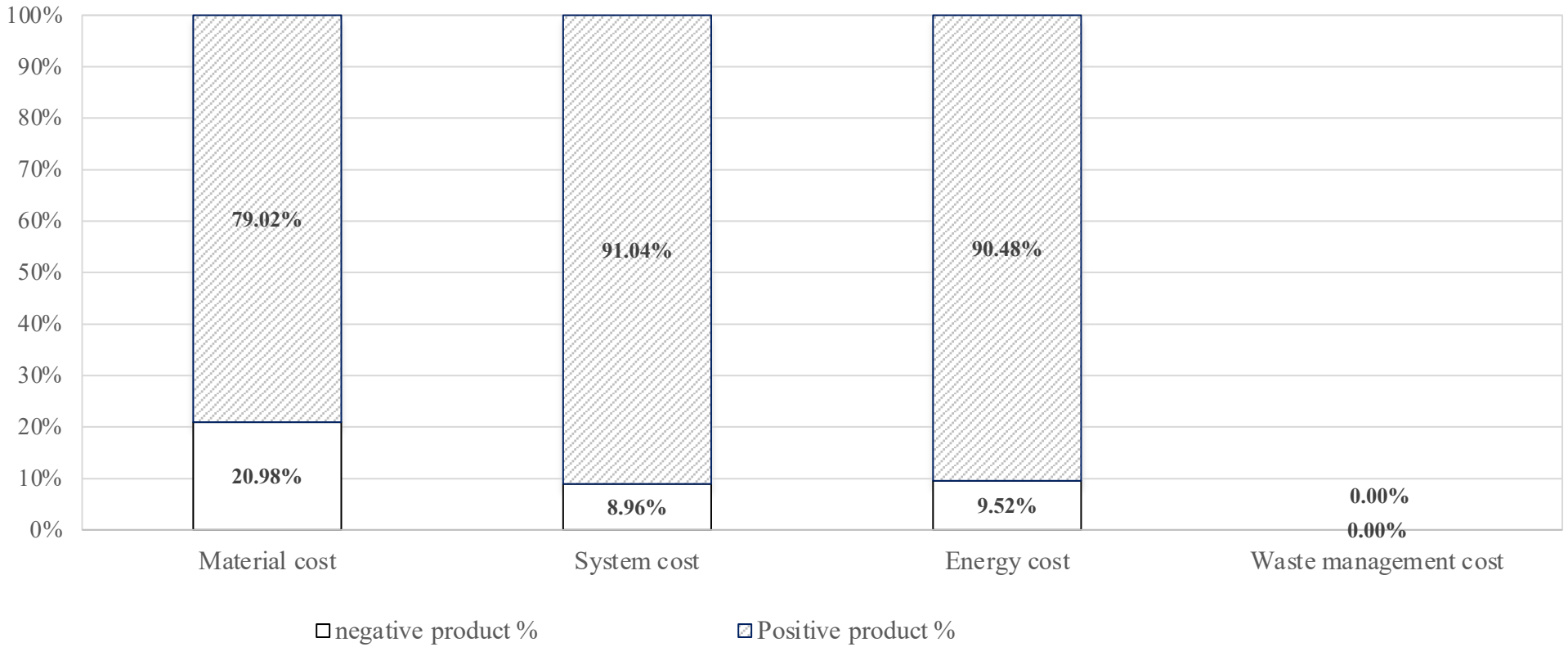


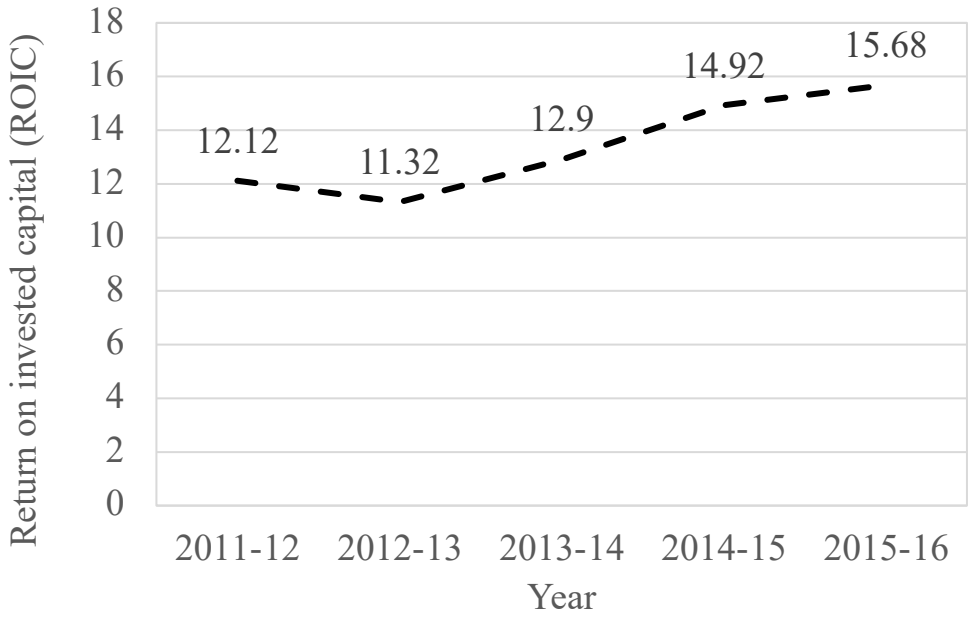
Table 6.2. Summary of the positive and negative costs in MFCA

	Material cost (INR)	System cost (INR)	Energy cost (INR)	Waste management cost (INR)	Total cost (INR)
Positive Product	22,354,547.15 (79.02 %)	1,278,232.10 (91.04 %)	3,600,940.46 (90.48 %)	(---)	27,233,719.71 (80.88 %)
Negative product (loss)	5,933,476.45 (20.98 %)	125,767.90 (8.96 %)	378,897.55 (9.52 %)	(---)	6,438,141.90 (19.12 %)
Total	28,288,023.60 (100 %)	1,404,000 (100 %)	3,979,838.01 (100 %)	(---)	33,671,861.61 (100 %)

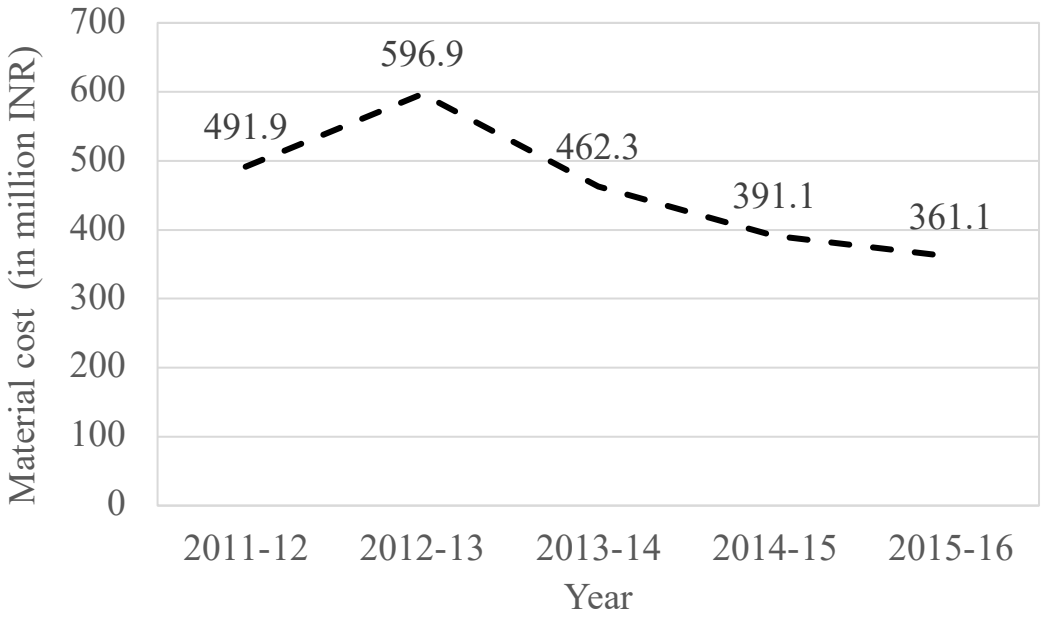
7. Results and Discussions

- Step 7: Identification of improvement areas

Before MFCA implementation	After MFCA implementation
The wall thickness eccentricity of mother tube used was 0.4 mm. 	The wall thickness eccentricity was reduced to 0.15 mm. 
Fully covered wooden box used earlier with 1-inch thickness. 	Redesigned wooden box with 0.75-inch thickness. 



Impact on ROIC through MFCA implementation

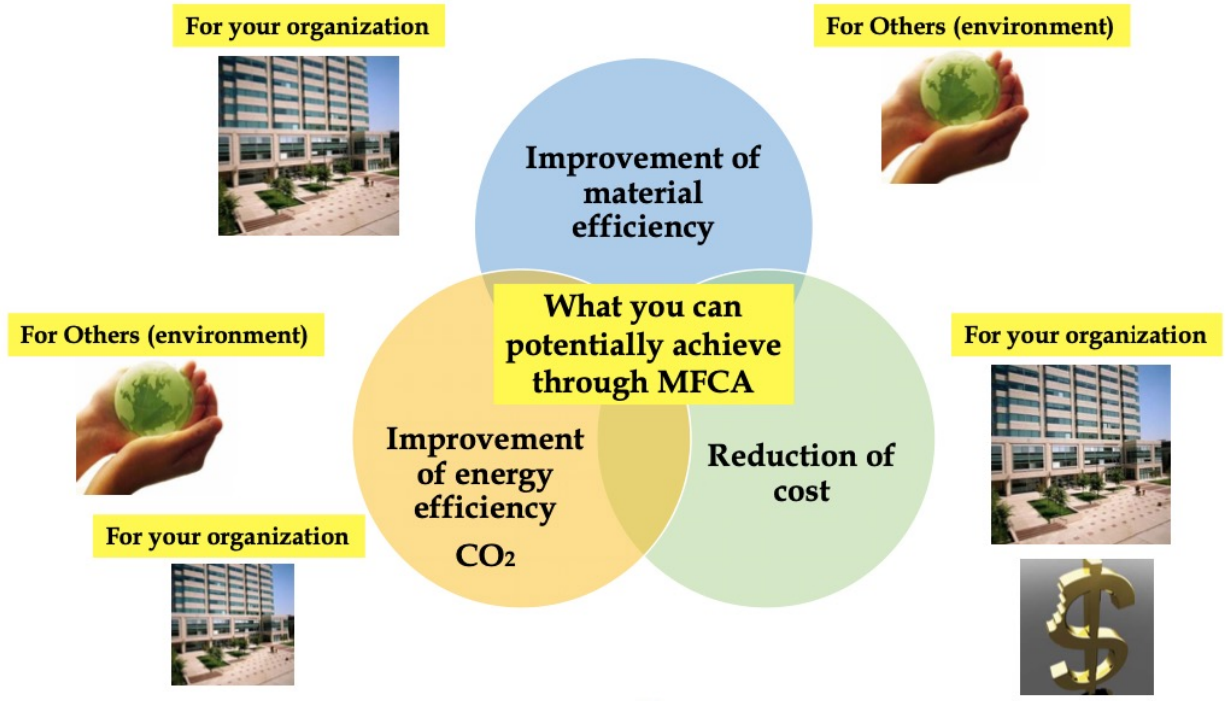


Impact on material usage through MFCA implementation

Summary of implemented solutions and quantified benefits obtained after MFCA implementation.

8. Conclusions

- We focused on action research based case study and presented the implementation of MFCA in an Indian manufacturing SME.
- With an investment of USD 7123, the case company had an overall annual savings of USD 302,350.



Practical implications

- The implementation steps demonstrated in the study will help the SME managers and practitioners to understand the effective implementation of MFCA tool.
- The results of this study will promote the adoption of MFCA in developing or low-income countries to show their contribution towards cleaner production.
- Set avenues for implementing MFCA in a supply chain level (ISO 14052).

- Software

Umberto

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Improving financial and environmental performance through MFCA: A SME case study

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ABSTRACT

SMEs around the globe are often challenged by the issues related to productivity enhancement, material usage, waste management and sustainability. Material flow cost accounting (MFCA) is considered as a green productivity tool that can be utilised by SMEs to overcome these challenges. Despite the benefits, its adoption among SMEs, especially in developing countries, remains low. The purpose of this research is to examine how MFCA can be suitably implemented in an SME set-up to improve the financial and environmental performance of the enterprise. This study utilises case based research methodology to exemplify the application of MFCA tool in an Indian steel pipes and tubes manufacturing SME. As a part of MFCA analysis, material cost, system cost and energy cost at each quantity center was calculated to identify inefficiencies in the production process of the SME. Thereafter, several solutions were implemented to address these inefficiencies. The result of the MFCA implementation showed an overall annual savings of 21,028,452 INR (USD 302,350) through an investment of 495,400 INR (USD 7123). The present study reveals that the application of MFCA tool leads to higher productivity, better energy efficiency and improved environmental performance. The SME's performance was also monitored for five years to study the long-term benefits of MFCA implementation. The findings suggest that, post MFCA implementation, the return on invested capital of the SME increased by 29.37% and the material usage cost reduced by 26.58%. This research would be beneficial to managers, practitioners, and policymakers for effectively implementing MFCA in SMEs.


Thank you