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Study Of Chemical Management System and Cost Reduction in Process

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Abstract : Cost reduction and increased productivity are required in today's world to maintain a competitive edge and ensure a company's success. There are three types of costs in any business: product costs, consumable costs, and tool costs. Consumable costs are heavily influenced by oil and grease. Coolants and oil are critical components of metal cutting machines, so managing, handling, and storing such chemicals is critical. There is a discrepancy between standard and actual machine consumption; this discrepancy must be closed in order to reduce consumable costs.

Using fundamental knowledge to reduce oil and coolant consumption, cut procurement costs, and improve product quality and productivity. The following methods and techniques were used to monitor and regulate coolant usage: Six Tools of Coolant Management, Why-Why analysis, Cause and Effect Diagram, Process Flow chart and the software used were Humentech, Minitab, and others. Founded a significant reduction in oil and coolant usage and procurement, resulting in a cost savings of 6% to 7.

Index Terms **- Chemical Management System, Cause and Effect Diagram, Cost Reduction, Minitab (I-MR chart), Cost Optimization, Design and Fabrication, Filtration Trolley, Process Charts.**

I. INTRODUCTION

In today's world cost reduction and increase in productivity is necessary to maintain competitive edge for the companies' success. In any company there are roughly three types of cost involved; namely: product cost, consumable cost and tool cost. In consumable cost, one of larger contributor is oil and grease. In industries coolants and oil are important ingredients for metal cutting machines and thus managing, handling and storage of such chemicals is important. Hence, Understand the chemical management system (coolant management system) for machinability and product life, Oil and Coolant application and monitor the consumption pattern and data analysis are important factors for consumable cost reduction.

Coolants influence machinability by providing an excellent surface finish, longer tool life, and a cleaner, hazard-free working environment. These are some of the desirable characteristics that have a direct impact on cost per component and productivity levels in metalworking operations (Manufacturing Processes). Thus, successful coolant selection and application results in high machinability (better material removal rate, easy chip ejection, better heat transfer, fewer built-up edges, and improved lubricity) and productivity, higher production and less break-down, improved tool life, and higher-quality product.

There is a discrepancy between the standard and actual consumption of equipment; this discrepancy must be overcome in order to reduce consumable costs. Using fundamental knowledge to reduce oil and coolant consumption, procurement costs, and product quality and productivity.

II. LITERATURE REVIEW

Thomas J. Bierma and Frank L. Waterstraat [1] states that there are some kinds of incentives in long run traditional supply relationship which lead towards promotion of wastes and expansion of hidden cost of the chemicals. The suggested substituted innovation is Shared Savings, to traditional chemical supply relationship. The suggested method has proven that it helps in reduction of both wastages and the overall costs involved in it. They have given a chart of 5 leading companies for the cost saving methods.

Amin El-khatib, Mohamed Ahli and Salesh Al Ameri [2] showed that as we know work safety is priority for any company thus any process related to safety measures taken for oil and gas is important. One of the barriers is internal corrosion in the chemical treatment, so controlling and monitoring of chemical life prevents loss of containment. There is chance for improvement in the area of chemical handling and monitoring. Some suggested areas improvement are proper planning and execution of chemical logistics, disorganized documentation of chemicals, shatter records for monitoring, gap between actual and procured consumption. Work in this area of improvement was carried out leading to benefits like new working process, innovation solutions for effective chemical monitoring, ensured improved quality assurance / quality control records, reduced chemical consumption and cost optimization.

Veer Shivajee, Rajesh Kr Singh, Sanjay Rastogi [3] suggested that in any manufacturing company there are roughly three types of cost involved; namely: product or waste cost, consumable cost and tool cost. The consumable cost consists other than the primary cost like raw materials such as fuel, filter units, filling components, required gases, various chemicals, oil and coolant, lubrication, etc. later the report highlights the importance of transformation cost for better improvement and competitive towards the market. Using, inspecting, and emphasizing lean tools decreased manufacturing conversion costs, according to the findings by like DMAIC (define-measure-analyze-improve-control) and quality control (QC) approaches such as the Pareto chart, Fish-bone diagram (Cause and effect diagram), and live data digitization are examples of DMAIC and quality control (QC) procedures.

Gavin Sinclair, Steven Klepper and Wesley Cohen [4] have found that Any company implements the research and development (R&D) for analyzing and monitoring the cost. There is a linkage between gathered output and cost reduction which is also known as learning curves. After accumulation of cost data, communication with the employee, data from R&D department they found that continuous cost reduction of bulk of the component were the examples of small technical changes in production process leading to large results, based on activities performed by R&D and related team.

K.S. Lee, D.B. Chaffin, G.D. Herrin and A.M. Waikar [5] have worked and study the effect on the lower back caused due to loading condition during pulling and pushing. The project was performed inhouse labs by construction of mobile trolley. The conditions for experiment were taken in six sets with parameter like weight ranging from 50 kg to 80kg, pulling and pushing forces ranging 98 N, 196 N and 294 N, various heights 600mm, 1090mm and 1520 mm and velocity of motion at 1.8 km/h and 3.6 km/h. The experiments show that more load is applied on lower back at pushing than in pulling and handle height of 1090 mm is more convenient for usage than remaining handle height. The 1520 mm handle height is best suited for pulling condition leading to the reduction of load on lower back.

Khaled W. Al-Eisawi, Carter J. Kerk, Jerome J. Congleton, Alfred A. Amendola, Omer C. Jenkins, WillGaines [6] have carried out various experiments were carried out on the physical force required to draw and push a mobile four-wheel trolley from a fixed position under various loading circumstances and with similar wheel sizes. The weights were loaded in sets of 36.3 kg and ranged from 0 to 181.4 kg. Smooth concrete, tiles, asphalts, and industrial carpets were among the materials evaluated, with two-wheel widths of 25mm and 38mm. The wheels were 51 mm, 102 mm, and 153 mm in diameter, with four different wheel orientations. In the first condition, the wheel orientation was F0R0 (F=Forward and R=Rear), meaning that all four wheels were pointing forward. F0R90 is the second condition (two wheels away from handle the were arranged in forward direction and wheel near to the handle were arranged in 90º to forward direction). F90R0 (two wheels distant from handle were organised in 90º forward direction and wheel near handle were arranged in forward direction) and F90R90 (all four wheels were arranged in 90º forward direction) were the third- and fourth-wheel orientation conditions, respectively. The tests found that wheel arrangement had no consistent influence on pulling and pushing force, except that the wheel put in front had the least pulling and pushing force, while the wheel organized with 90º toward forward direction had the highest pulling and pushing force. The testing indicated no significant variations in the pulling and pushing forces required when all four wheels were going forward.

P Chockalingam, K Kok, R Vijayaram [7] have comparatively studied the effect of dry and wet grinding on CMS glass fiber reinforced polymer laminate with systematic experimental analysis using pink aluminium oxide grinding wheel. The criteria utilised in this set of tests were grinding wheel speed, applied forces, feed and depth of cut, and surface polish. Cutting forces were reduced and surface quality was enhanced when the proper coolant was used. The forces are less at low feed and high speed due to the poor chip formation in dry grinding. Grinding forces in synthetic coolants are lower at high feed and low speed due to enhanced cutting and lubrication, but in emulsion coolants, low forces are produced at low speed, feed, and higher depth of cut due to increased cutting and lubrication. Dry grinding has a better surface finish at high feed and low speed, synthetic coolant grinding has a better surface finish at high speed and deeper depth of cut, and emulsion coolant grinding has a better surface finish at high speed and high feed.

III. METHEDOLOGY

3.1 Chemical Management System

Chemical management system (CMS) is a formalized process for leading machines to safe and long life. The goal is to increase the life of coolant and reduce the cost during the crucial period of transition. A properly implemented CMS system prevents increased risks for Quality of Product and coolant change. Inadequate CMS can increase foaming, smell, lack of surface finish, reduce tool life and some health hazards like itching and small swelling on hand. Effective CMS involves review of all significant changes in coolant and oil to ensure that all are at acceptable level and to be maintained after the change had been implemented. Different parameter selected for effective CMS is viscosity, PH value, Hardness, Smelling, Refractive index, lubrication and Millipore value.

The CMS System consists of 6 steps namely: Circulation, Controls, Contaminants, Cleanliness, Commitments and Recycling, to achieve it different process are followed like Coolant Filtration and Refilling Process (Tank cleaning), Change of Coolant Process, Millipore testing process for product quality, Maintaining the coolant level and maintaining the RI value for the coolant, Leakage arrest and break down supportive activity related to coolant and oil.

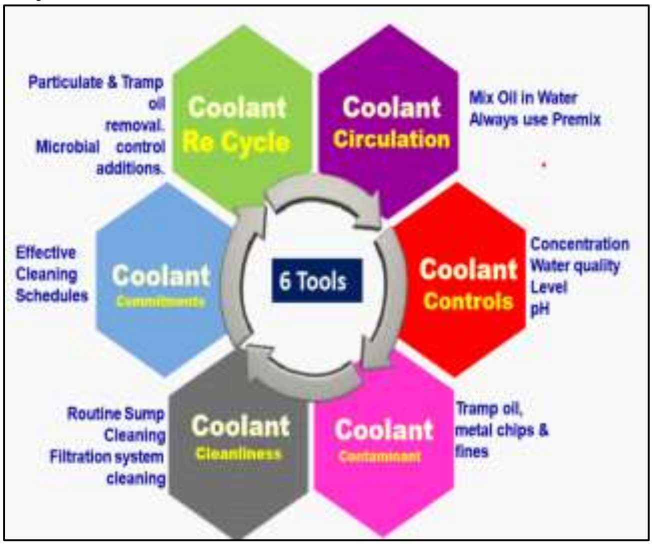


Figure - 1: 6 Tools for Coolant Management

The difference between standard and actual consumption was discovered after a thorough examination and understanding of the CMS process. For this study, data from the year 2020 was gathered. This is the project's baseline data, which will be compared to actual consumption in 2021. For the year 2020, the data gathered represents the average trend in consumption and procurement.

POLYCUT CONSUMPTION	
Jan-20	2665
Feb-20	2150
Jun-20	2720
Jul-20	640
Aug-20	1088
Sep-20	956
Oct-20	2550
Nov-20	3885
Dec-20	2198
AVERAGE IN LITRES	2095

Table - 1: Polycut Consumption

ETP DISPOSAL	
Jan-20	27000
Feb-20	22000
Mar-20	18090
May-20	21000
Jun-20	39000
Jul-20	21000
Aug-20	31000
Sep-20	24000
Oct-20	18000
Nov-20	15500
Dec-20	42500
AVERAGE IN LITRES	25372

Table - 2: ETP Disposal

METAFIN 40 CONSUMPTION	
Jan-20	835
Feb-20	635
Jun-20	1315
Jul-20	745
Aug-20	929
Sep-20	830
Oct-20	573
Nov-20	665
Dec-20	545
AVERAGE IN LITRES	707

Table - 3: Metafin 40 Consumption

METAFIN 40 PROCUREMENT	
Jan-20	1260
Feb-20	420
Mar-20	630
Jun-20	840
Jul-20	840
Aug-20	630
Sep-20	1260
Oct-20	630
Dec-20	630
AVERAGE IN LITRES	793

Table - 4: Metalfin 40 Procurement

TECHNICLEAN SF CONSUMPTION	
Jan-20	357
Feb-20	171
Mar-20	35
Jun-20	259
Jul-20	104
Aug-20	205
Sep-20	176.5
Oct-20	49
Nov-20	109
Dec-20	44
AVERAGE IN LITRES	151

Table - 5: Technaclean SF Consumption

MUSCULCOOL - 744 PROCUREMENT	
Jan-20	2100
Feb-20	1890
Mar-20	2100
Jun-20	2730
Jul-20	2940
Aug-20	2730
Sep-20	1890
Oct-20	2310
Nov-20	3150
Dec-20	3150
AVERAGE IN LITRES	2499

Table - 6: Musclcool-744 Procurement

3.2 COST REDUCTION:

To monitor the consumption pattern and identify areas for improvement, tools such as Why – Why analysis (5 whys), Cause and effect diagrams (Fish-bone), Process flow charts, and Individual-moving range charts were used. A trolley was manufactured at the Cummins workplace for the re-use method, which was discovered to be effective.

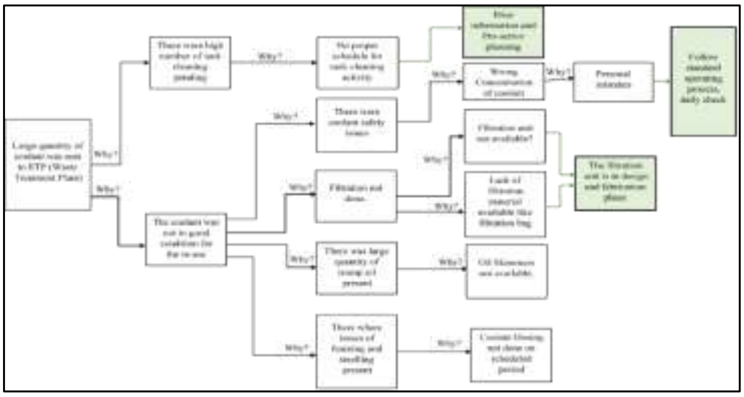


Figure - 2: Why – Why Analysis (Root Cause)

Change of Coolant Process: The coolant is changed when there is quality issue about the product, or we get lower cost alternative coolant. The quality issues are like bad surface finish, smell and odour, rusting of product and lack of tool life. Health related issue like hand itching, rash etc.

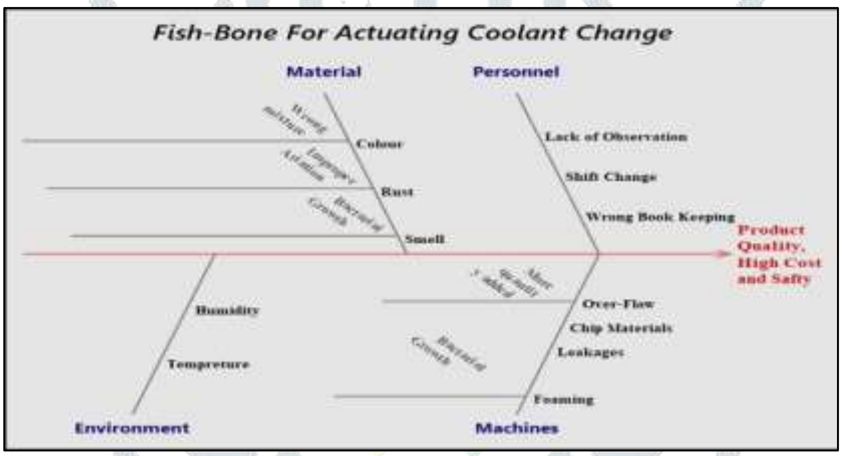


Figure - 3: Cause and Effect Diagram

3.3 Designing and Fabricating of Filtration Trolley for Re-Use of Coolant:

The ergonomic parameters taken into consideration while designing the trolley are Trolley load, Push/pull force, Trolley height, Handle height, Handle diameter, Distance of travel, Frequency of travel etc.

1. Trolley load: The total load inside the trolley should be optimum. Pushing and pulling force increases if load increases.

2. Push/pull force: The pushing and pulling depends on the weight inside the trolley or vehicle. Various parameters are considered for the design of trolleys such as pull or push force at start, pull or push force during motion, load carrying capacity of trolley, types of wheels & wheel material, ergonomics consideration, travel distance of trolleys, trolley material, etc. The operational efficiency of process is improved by proper design of material handling trolleys. Here operational efficiency of process is concerned with reducing human effort, optimize material flow, improve work efficiency, increase safety etc.

3. Trolley height: The trolley height should not be more than human height since it may cause accidents. If the trolley height is more the person who is pushing the trolley is unable to observe the objects in front hence it should be optimum.

4. Handle height: The handle height should range between 910-1200mm.

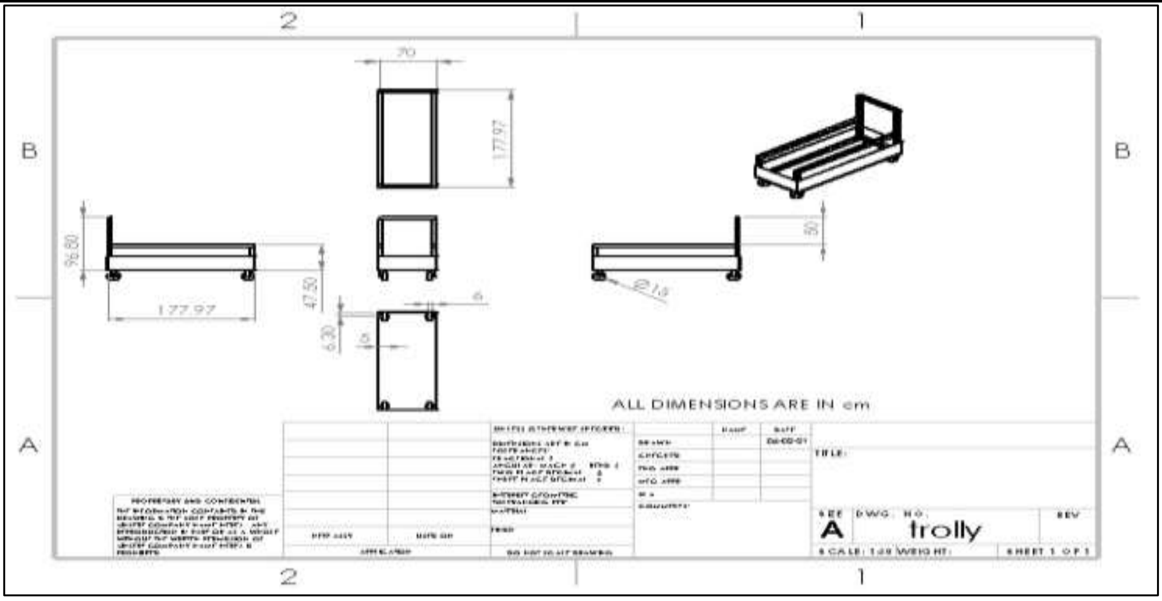


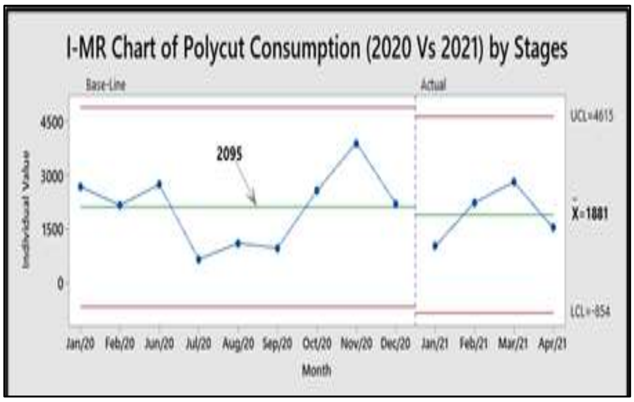
Figure - 4: Filtration Trolley Design

Figure - 5: Filtration Trolley for Coolant Re-Use

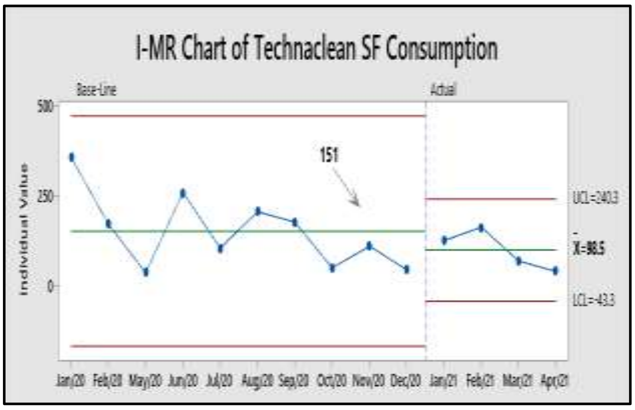
IV. RESULTS AND DISCUSSION

4.1 Results

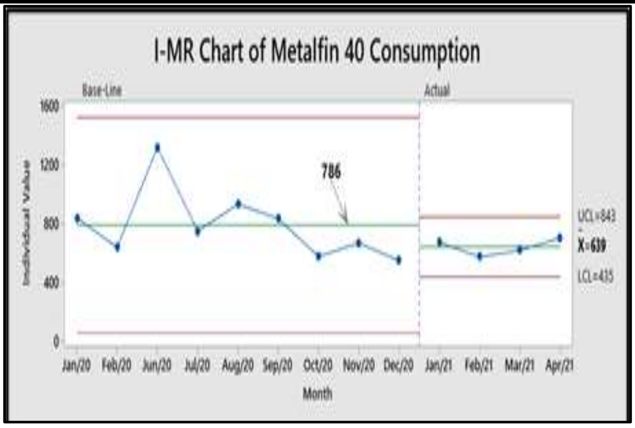
Mini tab software was used for the comparation between base-line 2020 and actual 2021 Individual Moving Range (I-MR) chart preparation.



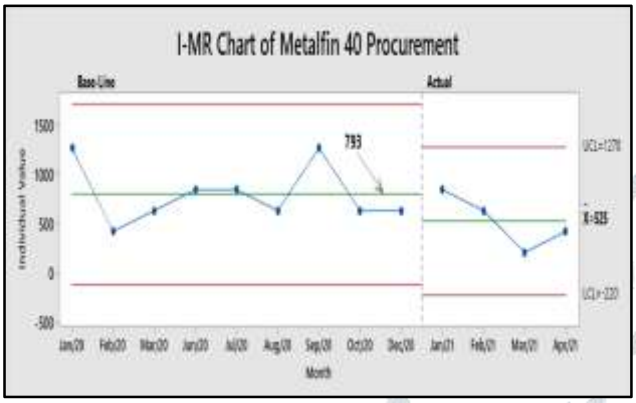
Result - 1: Polycut Consumptions



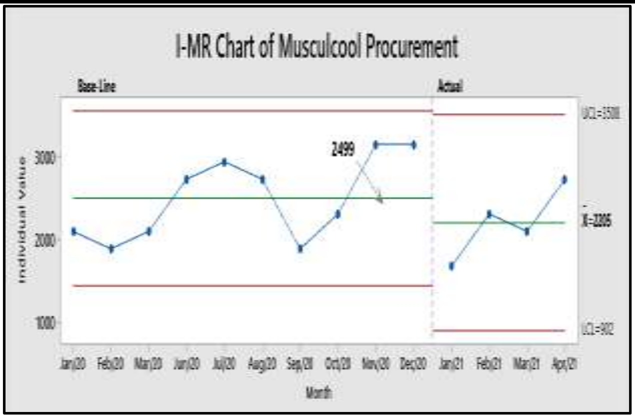
Result - 2: Technaclean SF Consumption



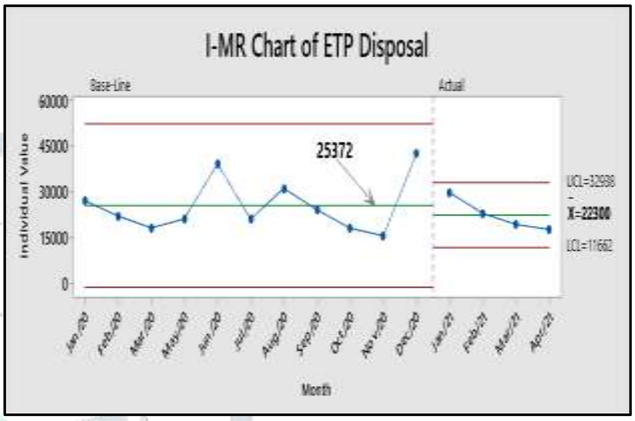
Result - 3: Metalfin 40 Consumption



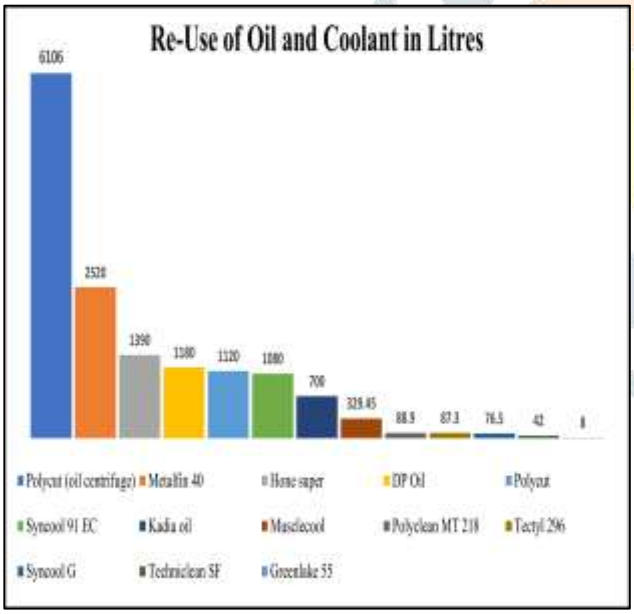
Result - 4: Metalfin 40 Procurement



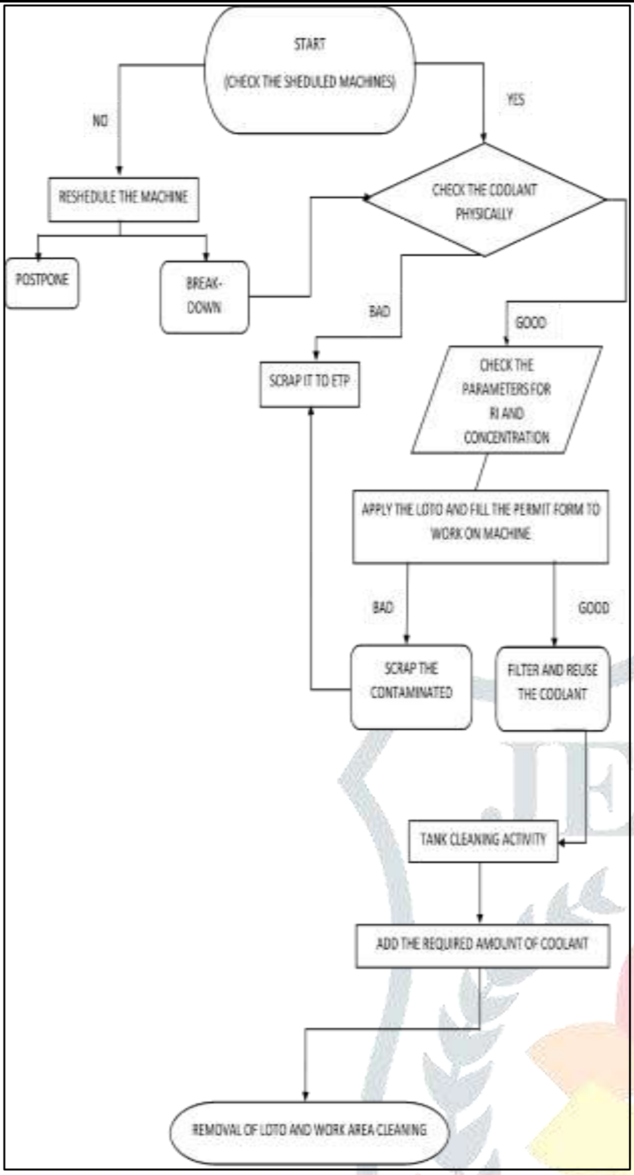
Result - 5: Musculcool Procurement



Result - 6: ETP (Waste Treatment Plant) Disposal



Result -7: Re-Used Coolant



Improved Process Flow : Filtration and Tank Cleaning

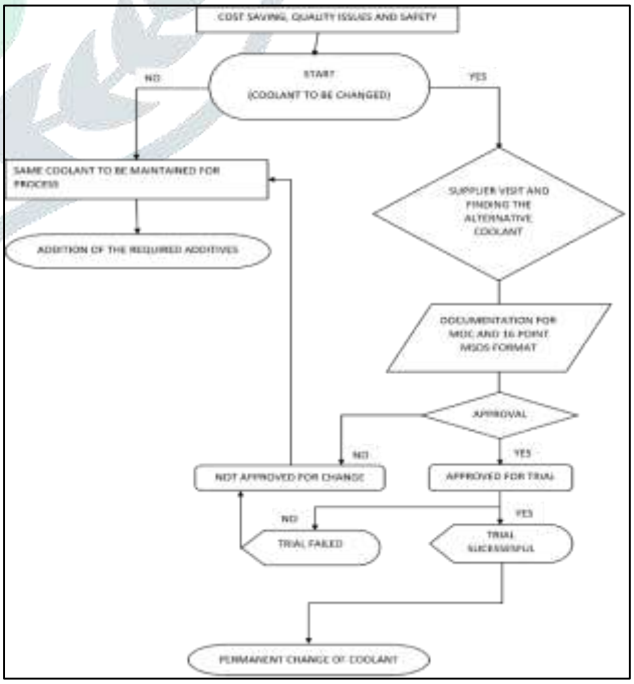
1. Result: MUSCLECOOL 744

Test (Unit)	Recommendations	Actual Results
Appearance (Visual)	Fluorescent Green Liquid	Pale Yellow Milky Emulsion Liquid 
pH (Units)	8.5 to 10.0	9.7
R.I. (Brix)	3.0 to 7.0	6.3 (Fade)
Conductivity (μs/cm)	< 5000	5650
Bacteria Test	$< 10^5$	10^2
Fungi Test	Passes	Passes
Tramp Oil (%)	<1.5 ml	1 ml
Oven Stability (2 Hrs) @60°C	No Separation	No Separation
Cast Iron Corrosion Test	No Rust Spots	No Rust Spots

2. Analysis Summary:

1. The pH & RI is OK.
2. The Electrical Conductivity is little higher than the recommendations.
3. Some Bacteria are present, If required add biocide at 0.1% of sump size.
4. In Stability test in oven at 50 deg cel, did not found any phase separation layer, which found OK.
5. Also suggested to remove contaminations, dust & fine chips are present inside the coolant tank, then remove it & filter the coolant
6. Floating tramp oil present, suggested to remove the floating Tramp oil regularly with Oil Skimmers or Manually.
7. There are No any rust spots observed on the filter paper in Cast Iron Chip test.
8. Rest other parameters are OK. Closely monitor pH & Conc. of the coolant regularly

Result - 8: Sample Test Result for Filtered Coolant.



Process Flow : Process for Coolant Change

4.2. CONCLUSIONS

- The proper deployment of a chemical management system or a coolant management system resulted in high product quality. Filtration, monitoring, and maintenance of the coolant and oil reduced machine/product issues, resulting in improved machinability and shorter cycle times.

- Coolant-related issues such as product stains, coolant smell, and skin irritation were significantly reduced when the Chemical / Coolant management system was properly implemented.
- We were able to reduce activity time, save money by reusing coolant, have easy and stress-free mobility, and reduce the burden on the ETP plant by designing and fabricating a coolant filtration trolley.
- Re-use of coolant and oil, as well as proper execution of chemical / coolant management system via filtration for coolant and centrifuge unit for oil recovery, result in fewer chemicals being sent to the ETP. (i.e. 25kl to 22kl).
- Cost Reduction (6-7%).
- Overall Effective Efficiency (OEE) increased by 10% as a result of the project (5 percent OEE improvement due to Machinability and 3 percent improvement due to coolant system related).
- Consumption / Procurement reduction:
  - Polycut Consumption = 34 %.
  - Matelfin 40 consumption = 18 %.
  - Metalfin 40 Procurement = 33 %.
  - Technaclean SF Consumption = 34 %.
  - Musculcool Procurement = 11 %.
- The project initiative not only saved money, but it also improved the final product's quality by improving the surface finish, extending tool and coolant life, adhering to strict time constraints, and increasing overall operational efficiencies.

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