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AN ANALYSIS OF RESIN WASTE REDUCTION IN THE INDUSTRY OF RESIN CAST TRANSFORMERS

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ABSTRACT

Global market rivalry is becoming more intense. A number of organisations have come to understand how important it is to raise their own game. The resources that are available may be used to do it. In the sector, cutting waste is crucial to increasing efficiency. This article examines a case study of a resin cast transformer manufacturing firm where the monthly financial loss to the business is around 3,40,000 rupees due to 8.87% of the resin waste. Additionally, there is an increase in cycle time, which raises lead time and causes customer discontent as well as a competitive disadvantage. Analyse the existing scenario using various lean tools. Broken casting, bucket waste, and drum waste all significantly contribute to resin waste, according to an examination of the existing state of affairs using several lean tools, such as the Pareto chart, fishbone diagram, why-why analysis, and process flow diagram. We were able to cut resin waste by 44.19% and rejection by 39.64% by consistently implementing the PDCA cycle to every part of the process. The industry's monthly savings by cutting resin waste from 8.87% to 4.95% is 1,52,880 Rupees.

INTRODUCTION

Development of the industries is significant in today's competitive market. There are a number of companies making the same product. To be competitive in the market, the company has to make desire quality products in the shortest possible time. Therefore to fulfill the customer demand and business goal need to utilize available resource properly. One of the most efficient approach to utilize resource is lean manufacturing. Lean manufacturing is a production system that focuses on reducing waste, creating customer value and seeking continuous process improvement. [1] there are several advantages of lean manufacturing [2] Waste minimization is greatly encouraged by the operational and cultural environments created by lean manufacturing. [3] waste is any expenses and costs that your company has that do not become or help the business process or the organization become more valuable and relevant. [4] there are 8 types of waste generated in the industry 1. Defects 2. Overproduction 3. Waiting 4. Non-utilized talent 5. Transportation 6. Inventory 7. Motion 8. Extra processing [5]

Resin is used for making dry type of resin caste transformers and it is an essential part of the resin cast transformer making industry. [6] wastages of resin is the most crucial part of this type of industry. It gives financially big impact on the industry it reduces the profit of the company, increase inventory related to resin, and increase manufacturing time that directly affects the delivery

time of product. This all factors give a competitive disadvantage in the market. As there is no usage of solid waste resin it directly affects the environment too. We studied the condition and analyze the waste of resin in one of the cast resin manufacturing company located near Vadodara, Gujarat, India. And also implemented some of the solutions regarding the reduction of resin waste according to the condition

METHODOLOGY

There are different lean tools that help to improve the efficiency of the procedure like PDCA, Poka-Yoke, Kaizen, 5S, 7 Muda, Kanban, Takt Time, JIT, OEE, VSM, TPM, SMED, Andon, Visual Factory SMART Goals, Bottleneck Analysis, etc.[7] one of the efficient tools for continuous process improvement is PDCA(plan do check act) cycle. [8]

PDCA Cycle

The PDCA method is the foundation of TQM. PDCA methodology is used to improve performance continuously through the performance management system. [9] It is also known as Deming cycle and Shewhart cycle. The PDCA principle was first proposed by Walter A. Shewhart in 1939. [10] The manufacturing sector benefits from the proper use of the PDCA cycle in the following ways: 1. Reduce Losses 2. Lower Defect 3. Minimize the Lead Times 4. Shorten Idle Time 5. Qualitative analysis 6. Enhance Quality 7. Reduce Energy Consumption 8. Make Stability Stronger [11] There are 4 Phase of PDCA cycle [12]

1 Plan.
- Step 1: Determines the problems that are already there by analyzing the current situation.
- Step 2: Discover the different root causes of those issues.
- Step 3: Determines the key elements from various causes.
- Step 4: Develop an improvement plan and a solution based on the crucial criteria.

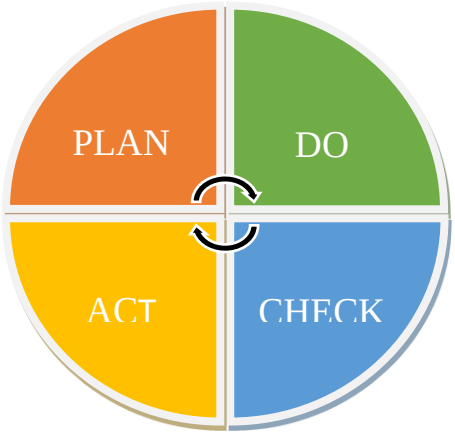
2 Do.
- Step 5: Execute the plan and the measures.

3 Check.
- Step 6: Verify that the implements comply with the requirements of the plan.

4 Act.
- Step 7: Compile achievements and summarize experiences.
- Step 8: Creates the next cycle out of unsolved or recently developed issues.

FIGURE 1. PDCA Cycle

CASE STUDY



A resin based transformer making industry was taken as a case study. To be competitive in the market need to utilize available resources for that we need to eliminate generated waste in the industry. To find and eliminate waste in the company first is to observe what are actual processes in the company. The data was taken of all the processes, it is observed that the company is facing the problem of excessive use of resin. So to eliminate or reduce this waste it is needed to implement PDCA in the different areas where waste is generated. Improve the procedure according to the root cause of that waste.

RESIN WASTE

Brainstorming regarding resin waste:

After brainstorming with the team below point is raise about the wastage of resin

- Not knowing about the actual size of the mold
- Mixing of access material
- Mold leakage
- Bucket bottom stickled waste
- Asking for extra (more than requirement) material
- Starring waste
- Access material poured into top cup
- Drop waste during handling/pouring and bucket refilling
- After finishing waste
- Due to failure of the coil while doing pouring
- Rework and rejection waste

Fish Bone diagram

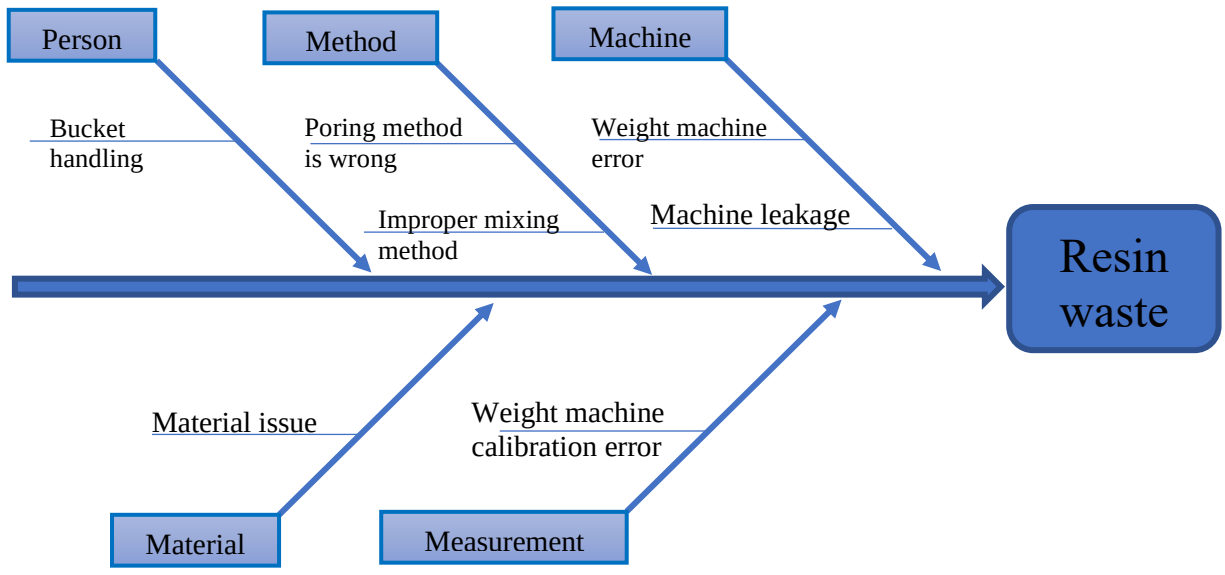


FIGURE 3. Fish bone diagram

Photos of resin waste

FIGURE 4(a). After pouring bucket waste

FIGURE 4(b). Mold leakage waste

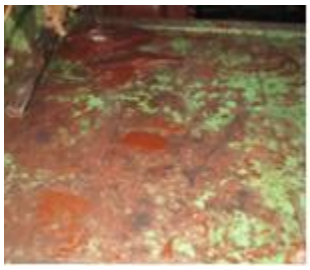


FIGURE 4(c). Dry casting material

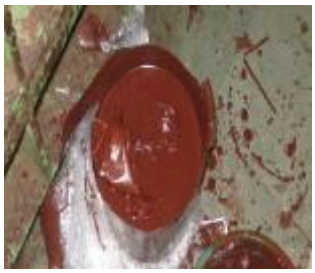
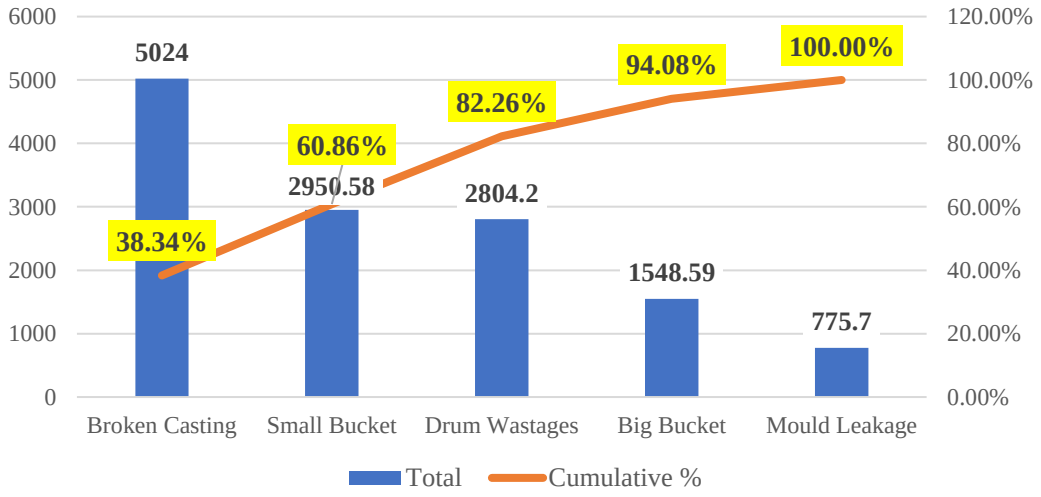


FIGURE 4(d). After mixing material

FIGURE 4(e). Broken casting



- Below is the Pareto chart for the resin waste data of May-July 2022

FIGURE 5. Pareto chart for the resin waste

- From the above pareto chart we can clearly say that the main cause of resin waste is Broken casting, Bucket waste and Drum Waste

❖ Broken Casting

➢ PLAN

MVCT Process flow chart

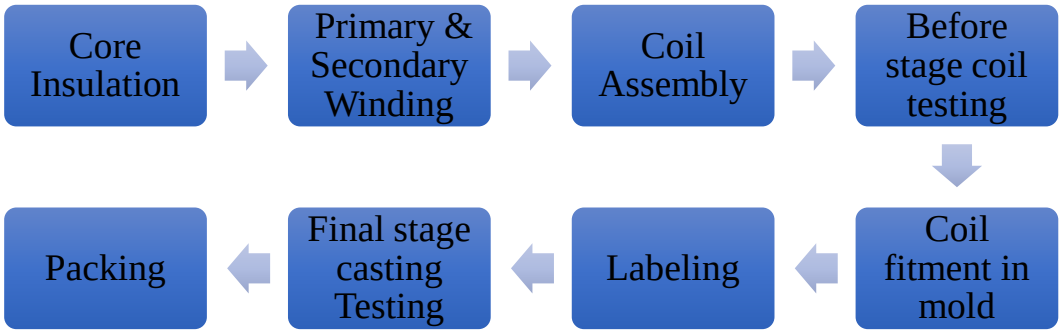
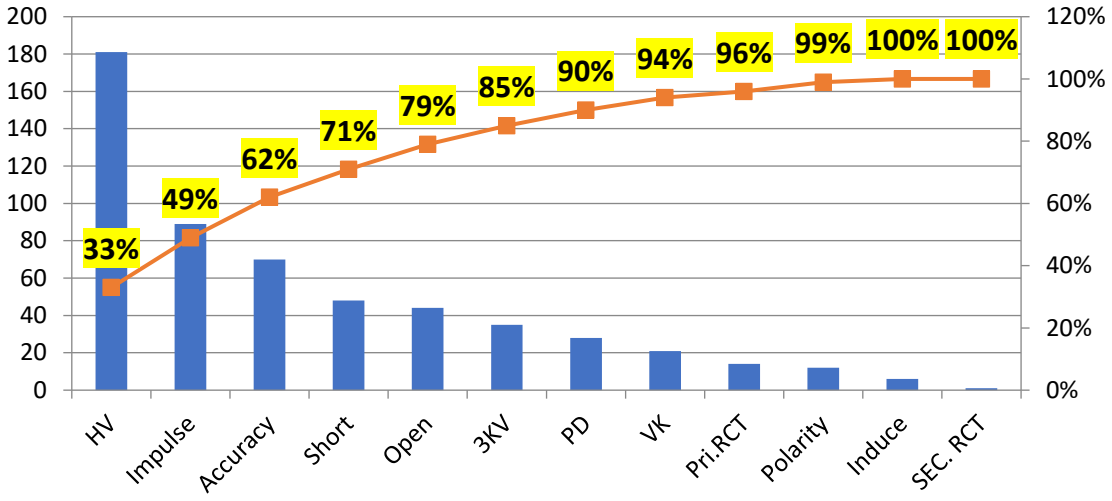


FIGURE 6. MVCT Process flow chart

➢ Rejection Data from May-22 to Nov- 22

Rejection type	NC QTY	Cumulative %
HV	181	33%
Impulse	89	49%
Accuracy	70	62%
Short	48	71%
Open	44	79%
3KV	35	85%
PD	28	90%
VK	21	94%
Pri.RCT	14	96%
Polarity	12	99%
Induce	6	100%
SEC. RCT	1	100%

Table 1. Rejection data



➢ Pareto chart

FIGURE 8. Pareto chart of rejection

From the data, we observed that HV Failure is a major defect of an overall rejection

HV FAIL

➢ All Possible Causes

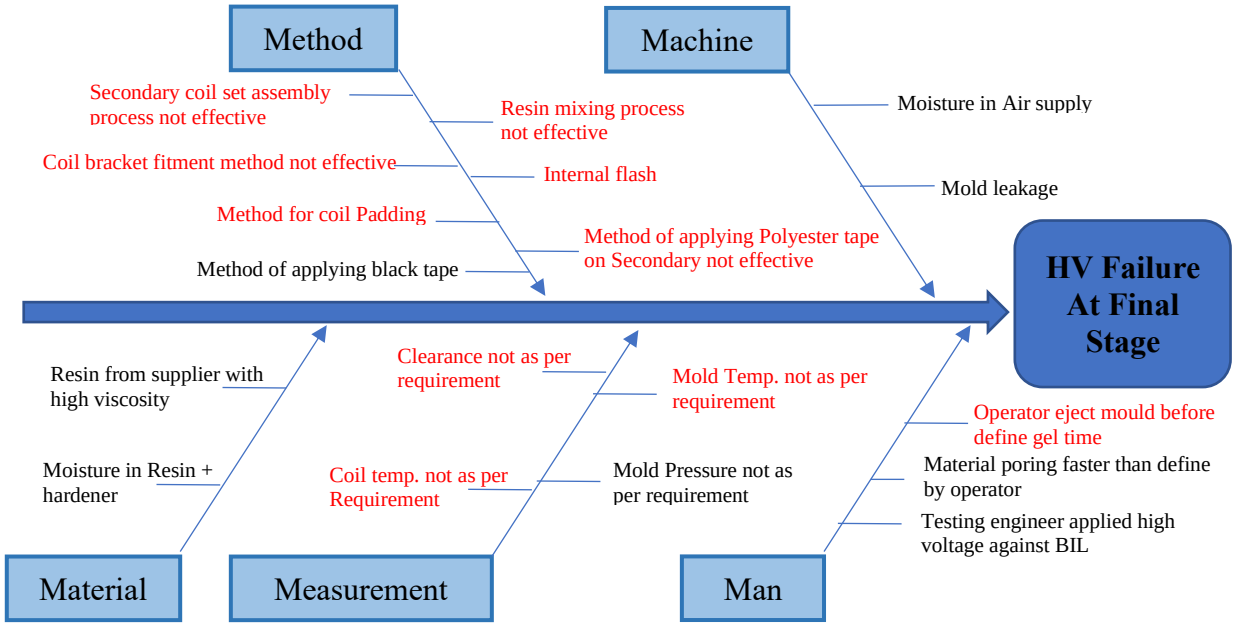


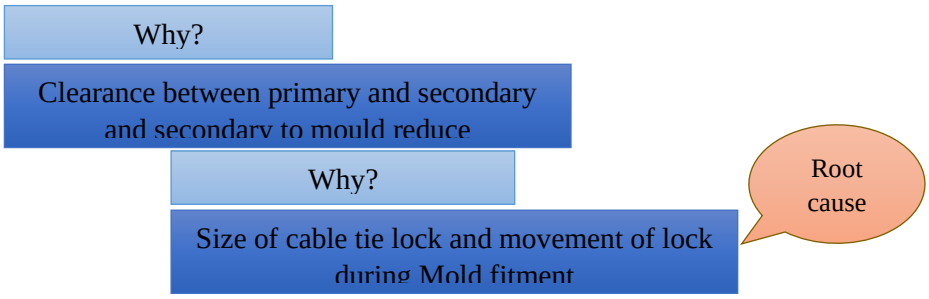
FIGURE 9. Fishbone diagram of Possible HV fail Causes

1. **Secondary coil set assembly process not effective**

➢ PLAN

Multiple secondary coils are assembled by using a cable tie. The use of cable tie is good for fitting but a lock of cable tie reduces the required clearance between the primary and secondary coil and secondary to mould.

- WHY-WHY Analysis



- DO

BEFORE
Multiple coils wound with cable tie as shown in photo

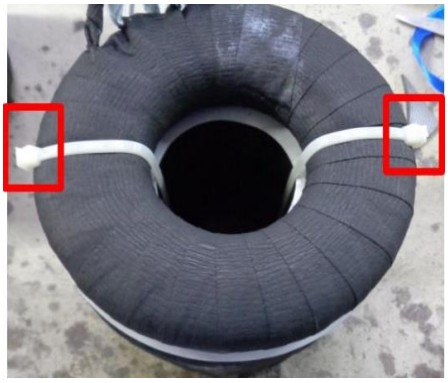


FIGURE 10(a). Secondary coil with cable tie

AFTER
Multiple coils wound with ribbon as shown in photo

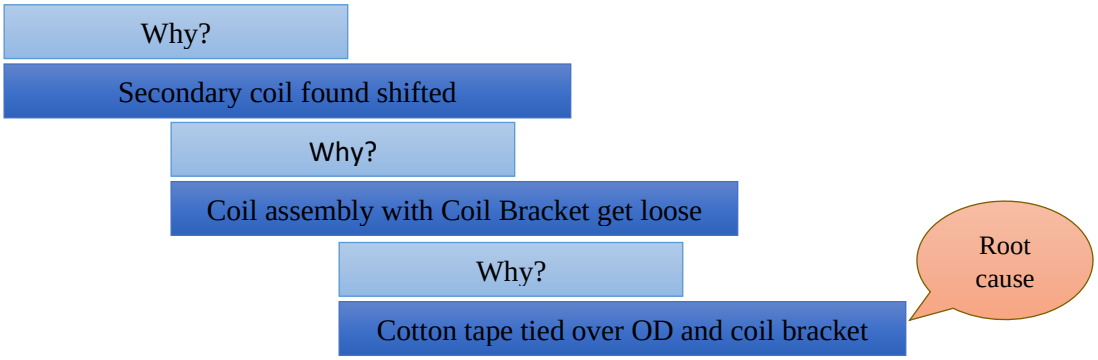
FIGURE 10(b). Secondary coil with ribbin

2. Coil bracket fitment method not effective

- PLAN

In the Analysis of HV Failed CTs, the secondary coils found shifted or moved from its place and further observing coil fitment in mould, it is observed that secondary coils are moved from their place and the cotton tape used to tie the coil and bracket is found loosen.

- WHY-WHY Analysis



➢ DO

BEFORE

Multiple coils wound with cable tie as shown in photo

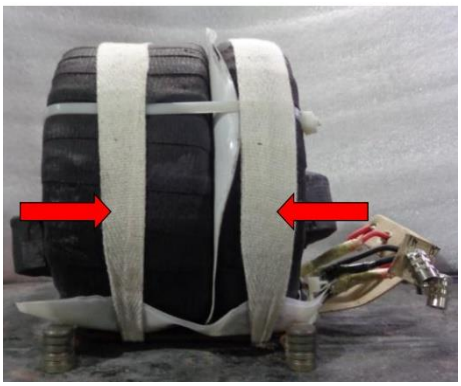


FIGURE 11(a).

AFTER

Multiple coils wound with ribbon as shown in photo

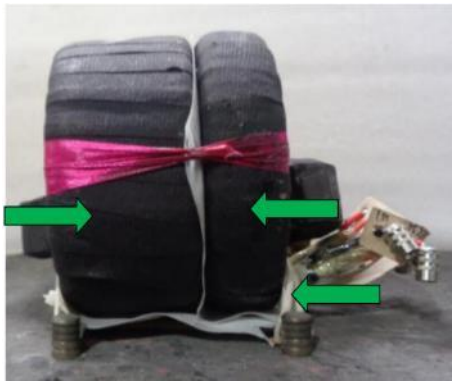
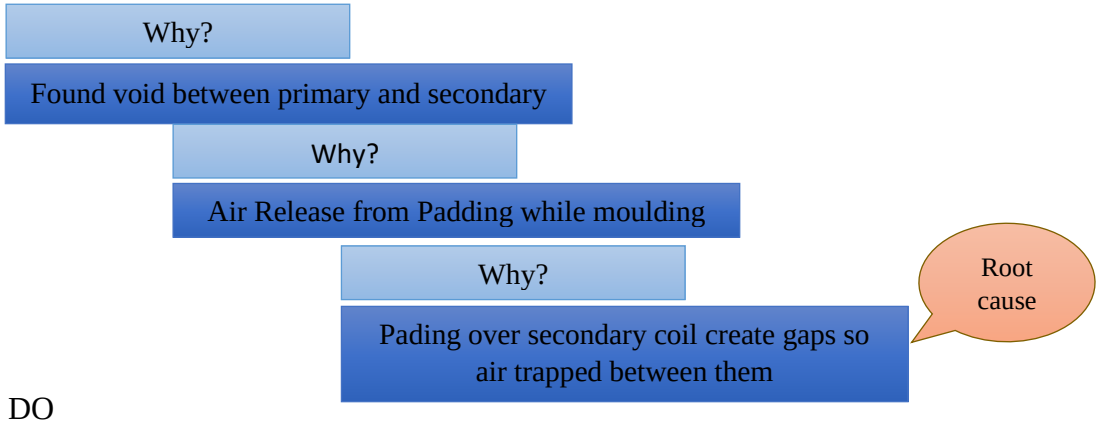


FIGURE 11(b).

3. Method for coil Padding

➢ PLAN

- In Analysis of HV Failed CTs, some coils are found with voids between primary and secondary and further observing it is found that during the moulding process air release in padding create voids
- WHY-WHY Analysis



➢ DO

BEFORE

Padding on coil after coil winding during coil assembly

AFTER

Padding on core in stand of coil to eliminate air gape create

FIGURE 12(a). Padding on coil

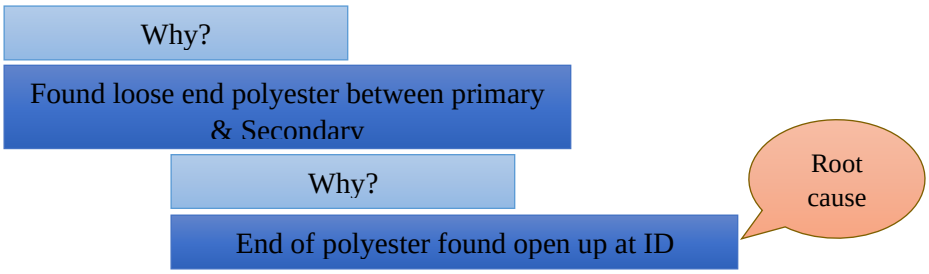
FIGURE 12(a). Padding on coil

4. Method of applying Polyester & Adhesive tape between primary & secondary is not effective

➢ PLAN

Observed polyester tape between primary and secondary in the analysis of HV failed CTs. Around 31 CT found out of 50 CT with polyester tape observation between primary and secondary during broken casting analysis

- WHY-WHY Analysis



➢ DO

BEFORE

Polyester tape start-end point position not defined

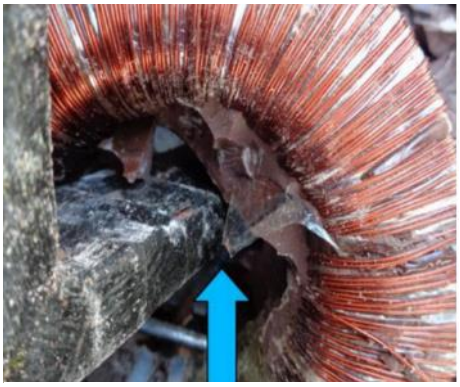


FIGURE 13(a). Open polyester between coil

AFTER

Polyester tape start-end point position defined

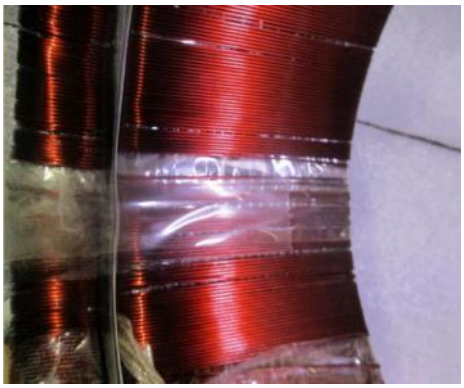


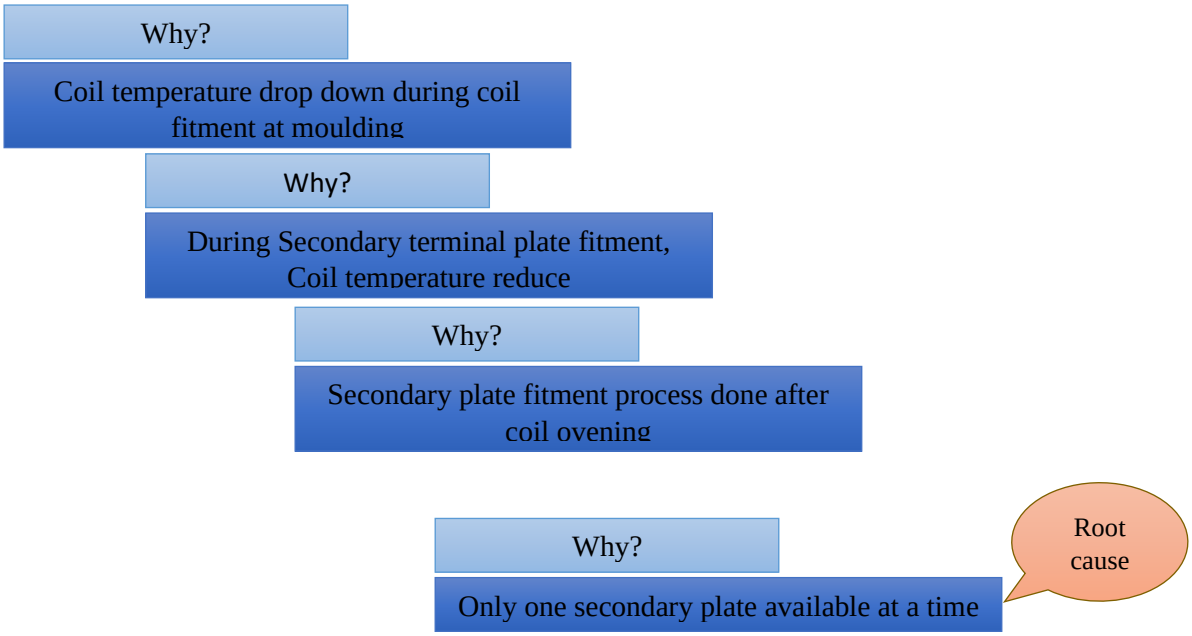
FIGURE 13(b). Close polyester between coil

5. Coil temp. not as per Requirement

➢ PLAN

Observed that temperature of the coil get decreased during the coil fitting in the mould.

- WHY-WHY Analysis



BEFORE

Coil heating in oven without secondary plate

FIGURE 14(a). Coil without secondary plate in oven

AFTER

Coil heating in oven with secondary plate

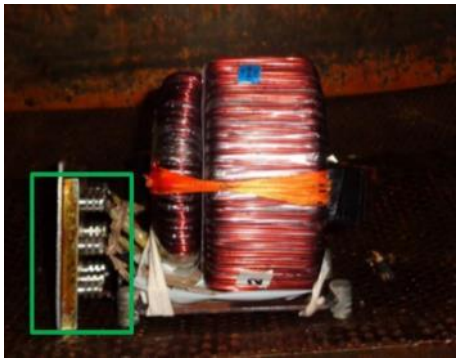


FIGURE 14(b). Coil with secondary plate in oven

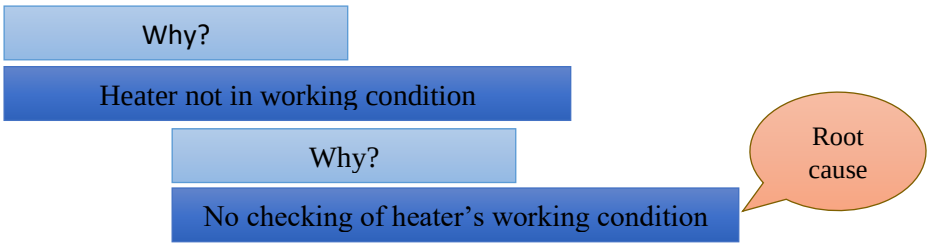
➢ DO

6. Mould Temp. not as per requirement

➢ PLAN

From the analysis we found that in some case mold temperature is less than require temp

- WHY-WHY Analysis



➢ DO

LED CTs are provided to heaters, if the LED do not glow then the heater is not working

FIGURE 15. Heater with LED

➢ CHECK
- Earlier 25-30 CT was found Fail on a monthly basis due to HV fail
- In the last month we found only 8 CT fail due to HV fail
- Around 68% reduction in HV fail

➢ ACT
- Update Work instructions for the change process
- Made Do & Don't of process

❖ STIRRER TIMER

➢ PLAN

Proper mixing of material is not done due to this error sometimes PD fail occur after casting

➢ Do

A stirrer is operated by a combination of PLC and timer due to this mixing of resin and hardener Occur in require manner.

FIGURE 16. Stirrer timer

➢ CHECK

- As stirrer is operate by combination of PLC and Timer there is proper mixing of resin and hardener.
- It helps to reduce PD fail.
- Taking avg 5 CT fail every month due to PD fail.
  Taking avg 15 kg resin use in one CT
  5*15=75 kg every month
  75*78=5850 Rs/month
  5850*12=70200 Rs/year

We will save around 70,000/- Rs every year by using a stirrer timer

➢ ACT

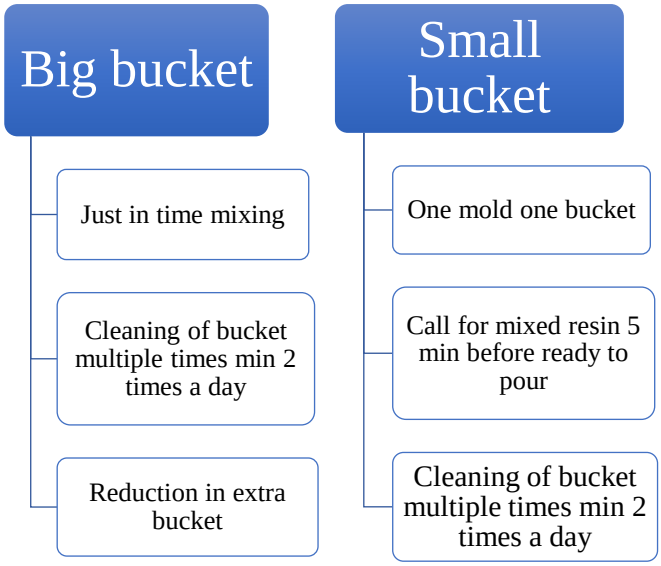
- Operating button of the stirrer is directly connected to stirrer timer
- By Default timer is operated and proper mixing of resin and hardener in min. time
- Timer timing change according to the weather

❖ BUCKET WASTE

➢ PLAN

Bucket waste is the waste generated during the process. There are two types of bucket waste big bucket waste and small bucket waste. Below is some of the scope of improvement point.

1. Mold chart –No of kg Resin require for 1 type of casting
2. Replace the bucket which has low viscosity compare to plastic
3. Use of resin spacer instead of pressboard.
4. Use a wiper in the bucket for extraction of resin after pouring
5. Coating in Bucket Which make Bucket surface Non-stick with resin



- DO

FIGURE 17(a). Plastic bucket

FIGURE 17(b). SS bucket

Replacing the conventional plastic bucket with stainless steel bucket

- CHECK

Sr.no	Plastic Bucket	Steel Bucket	Casting material save difference
1	1.350	1.110	0.24
2	0.610	0.440	0.17
3	0.640	0.600	0.04
4	1.062	0.760	0.30
5	1.250	0.900	0.35

TABLE 2. Comparison of plastic and SS bucket waste

- Resin save: -
  After 4 pouring on and avg 150-200 gram
  One mould 12 pouring/Day: - 450-600 grams/day
  12 mould 12 pouring/Day: - 5400-7200 grams/day

400-500 Rs/day and 12000 Rs/month can be save but this has limitations too as the bucket is lost, damage or operator forgot to clean the cost of ss bucket become costlier than its advantage.

- DO

Wiper applied in the small bucket for extraction of resin which stuck in the bucket after pouring.

After pouring 1 After pouring 2 After pouring 3

- CHECK
- Result of experiment

Sr no.	Bucket use for no of kg mold (in kg)	No of time bucket use	Total resin extracted (in gram)
1	10	1	150
2	14	2	153
3	14	2	160

TABLE 3. Result extraction of resin using wiper

From the experimental data we can say that

- after 3 pouring and 6 times using same bucket by applying a wiper after each pouring around 463 g resin saved.
- By taking an approximate quantity around 150 g per pouring
- Avg. 4500 casting per month
- We can save 4500*150=675000 grams/month
  =675 kg/month

It is a good idea but it has some limitations too. As solidification time of resin is less and the operator need to do other value added activity at the same time, sustenance of this method is lesser.

- DO

- Teflon coating inside the SS bucket

FIGURE 19. Coating bucket

➢ CHECK

- We got success as the coating in the bucket is Non-Stick with resin but there are some limitations too as the material has low viscosity last stage material start to solidify before it

drained from the bucket.

FIGURE 20. Coating bucket with resin

❖ RESIN SPACER

➢ PLAN

Pressboards are use to maintain height in assembly which is use in between coil bracket and coil. Planning to use resin spacers instead of a pressboard which has a thickness of 1 mm weight of 8 grams.

➢ DO

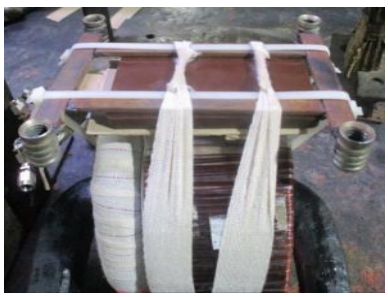


FIGURE 21(a). Resin spacer

- At Assembly, for maintaining height used Resin Spacers.
- Spacers thickness = 7 MM
- Pressboard weight =77 grams.

➢ CHECK

- Resin spacer has a glossy surface
- After made spacer, surface found uneven.
- Spacer thickness not standardize

➢ ACT

- Modification in spacer

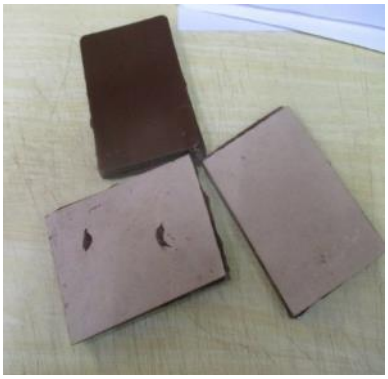


FIGURE 21(b). Resin spacer

- Developed spacer by sticking one Press board for eliminating the glossy surface.
- After modification of spacer

  1) Thickness=8 mm
  2) Weight= 85 grams.

- After modification in manufacturing of resin spacer it is easy to use and easy to handle
- Everyday around 110-120 spacers are produce

❖ POURING CUP

➢ PLAN

- Length of the cup was near about 1 fit & when we have to pour resin from this cup at that time resin was jammed at ID of the cup and that jammed resin was going into waste / scrap. This waste resin was 0.3 KG per pcs.

➢ DO

- New cup introduce in which length of the cup was reduced which is 0.5 fit.

FIGURE 22(a). 1 ft Pouring cup

FIGURE 22(b). 0.5 ft Pouring cup

➢ CHECK

- In a month we saved Rs. 35,100/- from resin waste reduction by modifying cup size.
- Calculation as per the below.
  Total Production in last month = 4500.
  Resin waste save per pcs = 0.100 KG.
  Resin cost per Kg = 78

Total cost save = 4500 x 0.100 x 78 = 35,100/-

➢ ACT

- Replace all the pouring cups from 1 fit height to 0.5 fit height.

❖ DRUM ROLLER

➢ PLAN

- After extraction of all the resin from the drum still 6-7 Kg resin is stuck in the drum which is not accessible that resin goes to waste. The resin stick inside the surface and freezes at bottom of the drum. Waste
  Kg of resin depends on the weather condition if the weather is cold then more resin freeze in the drum.
- For extraction of more amount of usable resin roller type mechanism is place to rotate the resin drum

➢ DO

FIGURE 23. Drum roller

➢ CHECK

- We can say that using of drum roller can help to reduction in wastages of resin
- It is found from the experiment that Around 2-2.5 kg lesser resin stuck in the drum in normal working condition
- Also found that extraction of resin from the drum depends on weather conditions and time of rolling

➢ ACT

- Rolling of Drum 50-60 min.
- Made checklist for Rolling of Drum
- Made S.O.P. for use of Resin Drum

RESULT & DISCUSSION

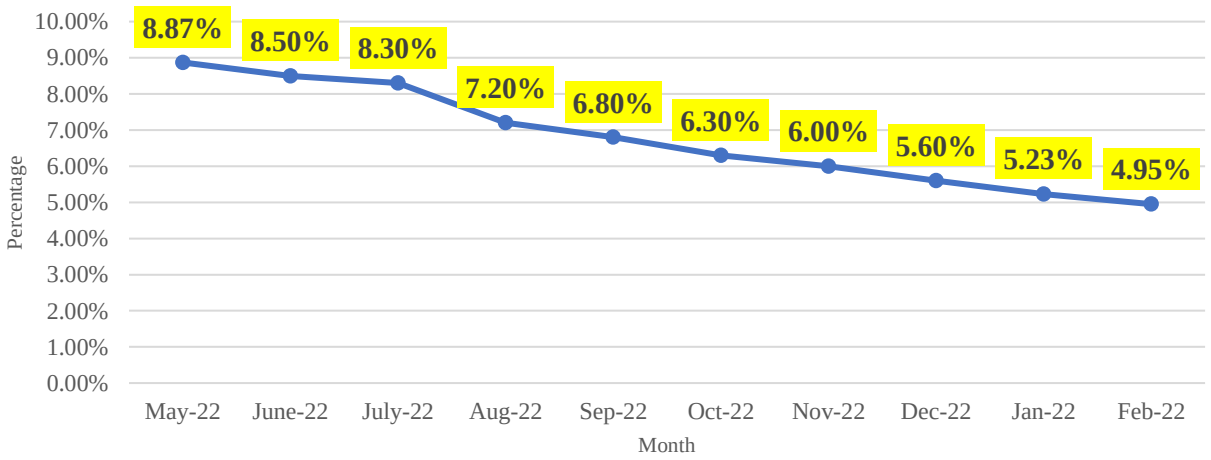
Different lean tools are used to reduce resin waste. By continuously applying the PDCA cycle in the process we got the tremendous result as wastage of resin reduce by 44.19%. Waste reduce from 8.87% to 4.95 %

Analyze the situation and implement the solution according to the condition. The pareto chart shows that broken casting, small bucket and drum wastages are the main reason for the resin wastage. Around 38.34% of waste comes from broken casting, so targeted the rejection waste and reduced that by 39.64%. Reduce the rejection from 1.69% to 1.02.

The second largest waste comes from Bucket waste. We have done many experiments for reduction of bucket resin waste. (1)Replace the small bucket with ss bucket and got the positive result as resin is less waste in ss bucket than plastic but it has some limitation too as the bucket is lost, damage or operator forgot to clean the cost of ss bucket become costlier than its advantage. (2) After pouring use wiper in the bucket for extraction of resin and save avg. 150 gram resin in one time due to operators unavailability and less solidification time this method cannot sustain for a very long period of time (3) Use PTFE coating inside bucket for less chemical reaction of resin and bucket as a coating in the bucket is Non-Stick with resin but there is some limitation too as the material has low viscosity last stage material starts to solidify before it drained from the bucket. (4) Resin spacers are made from waste resin which will use in manufacturing daily around 120 resin spacers are manufacturing (5) Pouring cup is a redesign from 1 fit height to 0.5 fit height and save around 100 gram of resin from every pouring. Through all the above action bucket resin waste reduce by 50.48% and reduce the bucket resin waste from 1016.3 to 503.2 kg/month.

Drum waste is also very critical for resin waste it generally depends on weather condition if weather is cold than more amount of resin is stick inside resin drum for reduction of this waste drum roller type mechanism is placed drum is rotated on this due to this proper mixing of resin done in drum and more amount of resin can be extracted by using this mechanism. Around 2-3 kg lesser resin is stuck in the drum. Due to this resin waste from the drum is reduce from 934 kg/month to 588.1 kg/month. Around 37.03% reduce found.

From all the above actions we got tremendous results as overall resin waste reduce by 44.19%



Saving around 1,52,880 Rs per month by reducing resin waste from 8.87% to 4.95%.

FIGURE 24. Resin waste chart

CONCLUSION

The purpose of this research was to lower the resin waste from 8.87% to 5%. to optimise the resin cast transformer's production process. Waste resin is an essential component of the sector. The firm loses around 3,40,000 rupees per month as a result of resin waste. Additionally, there is an increase in cycle time, which raises lead time and causes customer discontent as well as a

competitive disadvantage. Resin waste is mostly caused by fractured casting, bucket waste, and drum waste, according to a lean analysis of the existing state of affairs. By consistently implementing the PDCA cycle in all areas of the process, we managed to decrease rejection waste by 39.64% and resin waste by 44.19%. The industry's monthly savings by cutting resin waste from 8.87% to 4.95% is 1,52,880 Rupees.

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