

## PROCESS AUDIT, THE NECESSITY OF PROCESS FOR BETTER QUALITY PRODUCT

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### INTRODUCTION

Insulation is the most critical component for any electrical equipment even though it forms only 2-5% of cost /mass of electrical equipment. Any insulation failure of rotating machine is identified only after warrantee failure & that gives a dent to the product brand & its reliability. Hence proper adherence to impregnation process is critical for equipment reliability. It has been observed that there is a low awareness about this within the industry. The equipment manufacturers keep on building up the number of equipment's without any attention to the impregnation equipment capability. Selection of proper impregnating material & impregnation process is inadequate also once the impregnation process SOP is formed user does not review this process. Impregnation process audit provides a systematic approach to review the impregnation process while using, handling, storage & disposal of impregnating materials. The article provides the insight to the same.

#### Reasons of improper Impregnation process,

1. Higher production pressure leads to improper process.
2. Unnecessary stress on cost reduction.
3. Lower shop Floor awareness about impregnates
4. Selection of the wrong impregnation system gives insulation failure of the product.
5. Wrong impregnation cycle.

#### Reasons / effects of improper impregnation process give the following negative impact on product

1. Effect on performance of the electrical machine – low IR, low mechanical strength, failure within warrantee period
2. Due to continuous / regular imp. Cycle, long period experience/over confidence of an experienced worker leads to improper process for faster production, tends to become a reason for failure.

3. Misuse of the varnish / resin. Wrong curing conditions increase the cost of the product & improper performance of the machine.

#### Proper impregnation process / process audit gives following benefits

1. Proper secondary insulation, improves mechanical, electrical & chemical properties.
2. Savings in energy, cost, time & low wastage.
3. Increase in productivity with better quality.
4. Confidence on the product.

#### • Content for process audit

##### Process audit should cover following areas for impregnation.

1. Incoming store – These varnishes / resins are flammable materials & require storage in properly identified covered storage. These stores should have segregation as per hazards associated with the material based on compatibility of these materials. Proper hazard labelling system, Provision & use of suitable type of fire extinguishers, Flame proof electrical fittings, proper emergency exit, storage condition in line with supplier recommendations, Availability & display of MSDS, spillage prevention plan, awareness of PPE, training to the storekeeper, emergency preparedness in case of product behavior. Adherence to first come first out system (FIFO)
2. Operators' knowledge - Most of the times impregnation process is the responsibility with the contract laborer who does not have proper product knowledge and its safety aspects. This is a major concern for the impregnation quality & safety aspect related to impregnate. Operator should be confident / trained about VPI process. He should have impregnation process clarity such as –

#### - Why are we doing impregnation?

- Why we are applying vacuum & then pressure.

- What is the effect of correct Viscosity & Gel Time & why is it necessary to be maintained?
  - Role of temperature in VPI process as well as in curing process like storage temperature, viscosity at particular temperature, curing oven temperature etc.
3. Operators approach – cleanness, improper methods (short cut) etc. While doing VPI process operator's approach should be towards proper housekeeping. He has to take care while loading /unloading of job before & after impregnation, no spillage or droplet should fall down on VPI plant or shop floor. In case of varnish /resin spill he should immediately clean with proper method. Operator should not use any shortcuts in VPI process or should not follow any improper impregnation practice. To avoid this there is a need of proper training to operator so that he does not use wrong methods.
  4. SOP & execution of SOP – Standard Operating procedure for VPI process should be prepared in consultation with varnish / resin supplier & be explained to all concerned like shop incharge, supervisor, operators etc. & display near the VPI plant. To avoid shortcuts, mishandling of the material, proper process execution of SOP should be mandatory.
  5. Consumption of varnish / resin pattern - consumption of varnish / resin & addition of topping of the varnish / resin in storage tank has to be maintained in a proper format, which will give the following benefits–
    1. Quantity available in the tank can be traced at any time to adjust the viscosity & Gel time
    2. Addition of exact quantity of thinner, diluent & inhibitor is possible.
    3. Consumption pattern per job, which indicates price of resin / varnish per job.
  6. Maintenance of the health of the varnish / resin like store temp., maintenance of gel time viscosity, addition of varnish / resin in tank & addition of thinner / Diluent record etc.
  7. Mixing method after addition - after addition of any component in storage tank like thinner, diluent, hardener or resin / varnish to make the homogenous mixture, material should be stirred for at least 30 min. & this should be a part of SOP.

8. Available testing facility to maintain the health of the varnish / resin like viscosity cup (fig.1), Gel time equipment (fig.2) etc.



Figure 1: Viscosity Cup



Figure 2: Gel Time Apparatus

9. Viscosity, Gel time testing method & knowledge
10. Curing oven conditions – Calibration, temperature, job temperature, Oven position near impregnation area, difference in job temp & display temp. etc. Curing oven should be placed in a corner of the shop floor with proper exhaust system, temperature controller & Individual Ammeters for each heating coil which will indicate proper working of each coil, proper fixture to load & unload the jobs safely. Oven calibration & cleaning should be done periodically & date

of next cleaning & calibration should be displayed near the oven so that the concerned person can plan for other activity.

11. Curing time – After attending job temp. /Other calculations oven should be stabilized first at the required temperature before loading the job. Curing time always starts after job attends the particular temperature; to measure the job temperature a separate thermocouple can be attached to the winding while loading the job in the oven.



**Figure 3: Curing Oven**

12. After curing testing to ensure the quality like – coating should be uniform, tack free without any lumps & bubbles to check the curing conditions MEK rub test.
13. Safety measures – PPE, Firefighting equipment & their usage etc. Power connections, periodic maintenances etc.



**Figure 4: Personal Protective Equipment's**

14. Summary of the process audit with suggestions.

- Format for process audit (Refer annexure 1)
- Implementation Effect of process audit
- Experience

We have conducted several process audits in all types of industries & observed that due to lack of training to actual operators & users they follow wrong methods in the process unknowingly.

**Actual Case:** at a vendor of renowned company while doing process audit it was observed that in impregnation plant as per SOP to vendor they adjust the viscosity & maintain the record & as per record the viscosity was correct BUT during interaction with the operator we asked them, "How much percentage of Varnish & thinner you are adding to adjust the tank level & viscosity?" Operator replied, "Normally we daily adjust the viscosity by only adding thinner" on that we asked them, "why only thinner?" he replied, "to adjust viscosity & as the varnish cost is higher than that of thinner, adding thinner reduces our impregnate cost. Then we checked the material inward record of their store & observed that on the basis of demand from production, store gives the order to manufacturers for varnish / thinner & when we saw the last few month's records it was observed that they had purchased only thinner.

Then we realized along with OEM QA head that currently they are impregnating with thinner only & Vendor always complains about smell & fumes on the shop floor.

We explained to all the production teams that our intention of impregnation is to apply varnish & not thinner. If you use more quantity of thinner you will not get the desired properties, in addition to that while curing, thinner will evaporate & higher percentage of thinner while evaporating gives smell & more fumes. So you have to use maximum 20% thinner every time & maintain the record of varnish & thinner addition so that at the end of the month we can get the exact quantity of varnish & thinner.

**Conclusion:** The operator's intention was to maintain the viscosity & save cost.

After giving training to all the operators & supervisors including store staff they

implemented the corrective action & hence OEM observed better impregnation quality & user vendor observed low fumes & less smell on shop floor.

This was observed & implemented because of process audit & hence we feel that PROCESS AUDIT, THE NECESSITY OF PROCESS FOR BETTER QUALITY PRODUCT.

### ANNEXTURE- 1

#### Process Audit Report Casting / Potting / Impregnation Process Verification

Customer	
Product	
Component being Potting / Casting / Impregnate	
Material consumption No of components per day	

#### Process Details:

#	Property	Unit	Spec	Observation
1	Storage of the resin			
2	Compatibility aspect of the storage			
3	Exhaust / fresh air provision			
4	Hazard labels at the storage			
5	FIFO is being followed			
6	Resin supply in packing of	Kg		
7	Hardener supply in packing of	Kg		
8	Supply of the R+H to the production	Kg		
9	Pre-inspection of Resin and Hardener			
	• Label checking for each container before use			
	• Viscosity @	Sec		
	• Density @	g/ml		
	• Any other			
10	Premixing of resin			
11	Charging of resin and hardener on dispensing tank			
12	Resin tank temperature (Preheating)	°C		
13	Degassing of resin (Vacuum)			
14	Hardener tank temperature	°C		
15	Degassing of hardener (Vacuum)			
16	Mixing Ratio (R:H), calibration	PBW		
17	Least count of weighing balance			
18	Mixing of the resin & hardener			

19	Application method (Manual/Metering mixing)			
20	Quantity of resin & hardener mixed			
21	Pot life of mixture	min		
22	Time required to consume mixed material (manual potting)			
23	Vacuum in chamber for vacuum Potting / Casting/Impregnation			
24	Curing cycle	°C / h		
25	Oven type			
26	Oven temperature	°C		
27	Quality of oven exhaust			
28	Test to check completeness of cure			
	• Hardness	Shore		
	• DSC analysis			
29	Method for shop floor condition monitoring			
30	Safety consideration			
	• Use of PPE			
	• Provision of Fire Extinguishers			
31	Insulation awareness			
32	Disposal of waste			

Process audit done by :

Date :