Design of a Tool for Ensuring Complete Deaeration in the Cooling System of Generator

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***Abstract* – In this paper, we present our observations about Design of a tool for ensuring complete deaeration in the cooling system of generator. Deaeration is the process of complete removal of air from the system. The present method used is of a glass tube fitted between the pump and radiator which is a part of close circuit (comprises with cooling water jacket- radiator- glass tube -pump). The diameter of the glass tube varies as per the pipe diameters of generator sets. The problem with the present method used is the frequent breakage of the glass tube due to improper handling. The project aims at designing of such equipment which can be used for various diameters and which is sturdy and handy. The design FMEA will represent the modes of failure and there remedies.**

Keywords – cooling system , system components, generator set, Deaeration

I. INTRODUCTION

Diesel engine of Generator is cooled by the cooling system. Liquid-cooled engines are cooled by pumping a coolant mixture through passages in the engine cylinder block and heads by means of an engine-driven pump. All engines utilize a jacket water cooling system for cooling the cylinder block and heads. The Engines used in generator sets are of a varied capacity. The closed system is pressurized system with pressure as 10-14 psi. Treated water is used for the cooling to avoid corrosion. The engine along with the cooling system of generator is tested mainly for unwanted air entrapment. The closed circuit of cooling system must include deaeration and venting provisions to prevent buildup of entrapped air. If any amount of air is present in the system then it may lead to formation of hotspot or cavitations. For this process of deaeration, vents are provided in the system which will enable the trapped air to exit from the system. Hence to ensure the complete removal of air from the system company undergoes in to the process of deaeration by using glass tube. Glass tube is fitted to the suction side of the pump. Effect of temperature and pressure during the test is negligible.

The existing method used for the process of deaeration includes a glass tube, torch and a set of clamps. The testing of the generator sets is done before it is dispatched to the market. The method includes the use of water as a coolant for testing purpose but in actual cooling system ethylene glycol is used. The system needs to be checked for the process of deaeration so a portion of the pipe is cut in between the pump and the radiator and a glass tube is clamped between the pipes with the help of manual clamping. The generator is then started for testing and checked for any air entrapment through the glass tube. It is done by observing the bubbles flowing along with the water through the glass tube. The system is run for 25 minutes and within this stipulated time the system should be deaerated completely. The deaeration takes place through the vent holes provided in the system. But this process facing some difficulties such as breakage of glass tube, use of different glass tube for different gen-set. Hence we developed equipment which will ensure deaeration and came up with all the shortcomings.

II. EXISTING METHODOLOGY

The existing method used for the process of deaeration includes a glass tube, torch and a set of clamps. The testing of the generator sets is done before it is dispatched to the market. The method includes the use of water as a coolant for testing purpose but in actual cooling system ethylene glycol is used. The system needs to be checked for the process of deaeration so a portion of the pipe is cut in between the pump and the radiator and a glass tube is clamped between the pipes with the help of manual clamping. The generator is then started for testing and checked for any air entrapment through the glass tube. It is done by

observing the bubbles flowing along with the water through the glass tube. The system is run for 25minutes and within this stipulated time the system should be deaerated completely. The deaeration takes place through the vent holes provided in the system.

III. OBJECTIVE

The method used earlier had shortcomings such as frequent breakage of the glass tube while clamping, handling etc. The discoloration of the glass tube after using for number of times. The concept generation is to avoid these difficulties.The basic motive was to reduce the number of glass tubes used. The concept is to design the whole set of diameters into ranges and having a single glass tube for each range. The concept was divided in three ranges as the diameters were varying from 25mm to 90mm. Accommodation of all the diameters in a single range was inconvenient because of the pressure drop. Also the length available for fitting of glass tube for small capacity gen-sets is less than those for higher capacity engines. Hence the need for dividing the diameters was required. Also the problem of turbulence was erased with the range concept.Asthe apparatus will be at suction side of the pump the pressure won't play a role in creating problems in the system.

IV. SOLUTION PROVIDED

➢ *Design of the testing equipment*

- *Components* - Glass tube of required length, Flanges, Inserts,U-Seal,Gasket, studs and Tie rods.

1. *Glass Tube* - The basic designing of the glass tube included determining the diameters for the three ranges of the tubes that are needed for the apparatus.In each range we consider glass tube of maximum diameter.As far as the length of the glass tubes is considered the allowable length is considered and the length is decided accordingly. For the first range the length is 75mm whereas for the remaining range the length taken is 100mm.The thickness of the glass tube varies between 4mm to 5mm.
2. *Flanges* - The number of flanges required for an apparatus are two, one on each side. The flange is provided with a groove on the side where glass tube is going to be attached to it. The groove is given so that the glass tube can be accommodated. Also on the pitch circle diameter (PCD) of the flange, 6 holes, 3 of which are for tie rods and the others are for studs. For one of the flange, 3 holes for tie rods are blind on one side and for the other flange the holes are through. Also the other three holes are for studs which are through holes for both flanges.The thickness of flange is 25 mm each.
3. *Inserts* - The three ranges in which the diameters are divided are all required for different generator sets. For each apparatus 1 set of inserts are required. The diameters for the inserts are according to the requirement. The thickness of the inserts are 15mm.For range 1 having glass tube of 38 mm we use 3 set of inserts. For range 2 having glass tube of 59 mm we use 2 set of inserts. For range 3 having glass tube of 90 mm we use 2 set of inserts.
4. *U-Seal* - The of purpose U-seal is to prevent leakage from glass tube and flange assembly also it provides cushioning effect to glass tube.It is made of Teflon and it is fitted in the groove which is provided on the flange.
5. *Gasket* - The purpose of Gasket is to prevent leakage from insert and flange assembly.

V. USE OF MATERIAL

The material selection for the apparatus was based on the constraints like weight,strength, effectiveness and durability.

• *Delrin:-* The material used for the flange and inserts was delrin. Delrin is a general purpose medium viscosity black acetalhomopolymer resin for injection molding. It has good thermal stability. It offers an excellent balance of desirable properties that bridges the gapbetween metals and ordinary plastics. Properties of the material delrin are:-

- High mechanical strength, rigidity and light in weight.
- Toughness and high resistance to repeatedimpacts
- Long-term fatigue endurance
- Excellent resistance to moisture, gasoline,Solvents, and many other neutral chemicals
- Excellent dimensional stability
- Good resilience and resistance to creep
- Natural lubricity
- Wide end-use temperature range
- Good electrical insulating characteristics.

These properties make the material suitable for the use in the instrument.

• *Mild Steel:-* The material mild steel is used for the tie rods and studs. It has properties which makes it suitable for the application. Mild steel can be machined and shaped easily due to its inherent flexibility. It can be hardened with carburizing, making it the ideal material for producing a range of consumer products. Steel is any alloy of iron, consisting of 0.2% to 2.1% of carbon, as a hardening agent. Besides carbon, many other metals are a part of it. They include chromium, manganese, tungsten and vanadium. Also the material is readymade available it became easier for the choice.

- *Teflon:-* Polytetrafluroethylene (PTFE) is a synthetic fluro polymer of tetrafluroethylene. It is best known as Teflon. The sealing arrangement required a material that would long last. Also the manufacturing of the material should be easy. The reason because of which the material Teflon was used is it can be machined easily though the material cost is high. The sealing for the glass tube and flange needed the use of Teflon.

VI . TESTING

The testing of the apparatus involves cutting of the pipe connecting radiator and pump similar to the procedure before. As per the diameter of the pipe the range is chosen and the inserts are assembled. The problem of clamping in earlier design which leads to breakage of the glass tube is eliminated by clamping the hose pipe on inserts, instead of directly on glass tube. The coolant used normally is ethylene glycol, but for testing procedure water is used. It is ensured that the apparatus does not have any leakage which will hamper the overall working of the generator. The generator is turned on and the coolant starts flowing through the closed circuit. Formation of bubbles implies the air entrapment in the system. The system is run for period of 25 min within which the system needs to be completely deaerated. If the bubbles vanish then we can conclude the system is completely deaerated.

VII. ANALYSIS

The design FMEA of the apparatus is prepared.Refer to the Appendix A at the end of the paper.

VIII. CONCLUSION

The apparatus proved to be rigid, portable and overcame the problems faced in the previous design.

IX. ACKNOWLEDGEMENT

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APPENDIX A

FAILURE MODE AND EFFECTS ANALYSIS
(DESIGN FMEA)

SYSTEM :- COOLING SYSTEM
SUBSYSTEM:- DEARATION TOOL

DESIGN RESPONSIBILITY: AKSHAY OKA
CORE TEAM: POURNIMA JAGTAP, ASHISH MOGHE, SOURABH KARLEKAR, AKSHAY OKA

COMPONENT :- GLASS TUBE, FLANGE, U-SEAL, GASKET, INSERTS

(9) ITEM / FUNCTION	(10) POTENTIAL FAILURE MODE	(11) POTENTIAL EFFECTS OF FAILURE	(12) Severity of Effect(s) of Failure	(13) Class	(14) POTENTIAL CAUSES OF FAILURE	(15) Probability of Cause Occurring	(16) CURRENT DESIGN CONTROLS P:PREVENTION D:DETECTION	(17) Probability Controls Will Detect or Prevent Failure	(18) RPN	(19) RECOMMENDED ACTION	(20) RESPONSIBILITY AND TARGET COMPLETION DATE	(21) ACTIONS TAKEN	Action Results (22) Severity of Effect(s) of Failure	Probability of Cause Occurring	Probability Controls Will Detect or Prevent	RPN
Glass Tube	No Function	Breakage	8		Excessive Clamping Pressure	9	No control	6	432	specific torque should be applied		Torque Chart	8	3	2	48
			6		Transport	7	No control	6	252	Packing case		Concept of packing	6	2	2	24
			8		Handling at assembly	8	No control	6	384	SOP for assembly		SOP	8	4	3	96
			5		Crack / manufacturing defect	4	No control	5	100	supplier certificate		supplier certificate	8	1	2	16
			3		Excessive water pressure	3	Partial Control	3	27	Appropriate selection of glass	TEAM	thickness of glass tube is 5mm	3	1	2	6
			3		Temperature of water	3	Partial Control	3	27	Appropriate selection of glass		thickness of glass tube is 5mm	3	1	2	6
			5		Misalignment in tool assembly	4	Partial Control	3	60	SOP for assembly		SOP for assembly	5	3	2	30
	Partial function	Leakage	8		Air gap due to variable thickness	6	Design Control	6	288	Manufacture glass tube with uniform thickness		supplier certificate	8	4	3	96
			8		Less clamping pressure	6	No control	6	288	Clamp with sufficient force		Torque Chart	8	2	2	32
Flange	Partial Function	Fitment	6		Improper machining	4	Design Control	3	72	Supplier Certificate		Supplier Certificate	6	2	2	24
			6		Misalignment	4	Design Control	3	72	GDT to be provided		Inspect and check.	6	2	2	24
			4		Breakage	2	Design Control	2	16	Supplier Certification		Supplier Certification	4	1	1	4
		Short life span	8		Corrosion	7	No control	6	336	Low corrosion material to be selected		Use of Delrin	8	1	2	16
			4		Defect in Material	4		3	48	Supplier Certificate		Supplier Certificate	4	2	2	16
Insert	Partial Function	Fitment	6		Improper machining	4	No control	3	72	Supplier Certificate		Supplier Certificate	6	2	2	24
			6		Misalignment	4		3	72	GDT to be provided		Inspect and check.	6	3	2	36
			4		Breakage	2		2	16	Supplier Certification		Supplier Certification	4	1	1	4
		Short life span	8		Corrosion	7	No control	6	336	Low corrosion material to be selected	TEAM	Use of Delrin	8	1	2	16
			4		Defect in Material	4		3	48	Supplier Certificate		Supplier Certificate	4	2	2	16

Sealing	Partial Function	Leakage	8	Improper way of sealing (O-Ring)	6	Oring	6	288	Selection of appropriate seal	use of U-Seal	8	2	3	48
			7	Absence of seal in Glass tube and flange	7	No control	6	294	Follow assembly procedures	Follow assembly procedures	7	4	2	56
			7	Absence of seal in insert and flange	7		6	294	Follow assembly procedures	Follow assembly procedures	7	4	2	56
			6	Defect in seal	4		3	72	select after inspection	Supplier Certificate	6	2	1	12
			6	High temperature	4		3	72	Select material (neoprene/silicon)	Teflon seal	6	1	1	6
Tie Rod and Studs	Partial function	Short life span	8	Corrosion	6	No control	6	288	Avoid contact with water	assure absence of moisture	8	3	2	48
			7	Breakage due to defect in material	5	No control	5	175	select after inspection	supplier citificate	7	3	2	42
		Bending	7	Excessive clamping pressure	6	No control	5	210	specific torque should be applied	Torque charts	7	2	2	28
System	Partial function	vibrations	8	Loosening of assembly	6	No control	6	288	Periodic tightening	Periodic tightening	8	3	3	72
		Pump failure	8	Leakage	6	Partial control	5	240	Use of seals and proper clamping	U Seal ang gasket	8	1	1	8
		Leakage	7	Improper clamping in hose and insert	5	Partial control	5	175	Appropriate clamping	Use of clamping equipment	7	3	3	63

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