Structure Integrity Assessment of a Cocoa Liquor Plant in Ghana*

[1]A. Simons, and [1]C. Addy
[1]University of Mines and Technology, Box 237, Tarkwa, Ghana

Simons, A., and Addy, C. (2019), "Structure Integrity Assessment of a Cocoa Liquor Plant in Ghana", *Ghana Journal of Technology,* Vol. 4, No. 1, pp. 1 - 6.

Abstract

In view of a projected re-opening of the liquor facility plant, a group of factory inspectors were assigned to carry out a technical audit on the equipment at the plant. The prime focus of the audit was to ascertain the prevailing technical state of the plant and make informed decision as to the type of maintenance required to make the system fully functional. Technical observations proved that most of the equipment are in good shape, however, some minor repair works were required to make them fully functional.

Keywords: Cocoa liquor plant, Audit report, Maintenance, Mechanical Issues, Electrical and Instrumentation

1 Introduction

In preparation for a potential re-start of production, of a cocoa liquor plant (Fig. 1) a team of inspectors were contracted to carry out a technical audit on the plant as a whole and equipment. In addition, the purpose of the audit was to assess the current technical state and functionality of the plant and equipment, and to state the repairs and rehabilitation needed immediately and for the next five (5) years. This is imperative to ensure that the plant operates at optimum level and at a minimal operating cost (Haasl, 1999). The audit highlighted among other things an in-depth assessment of condition of equipment and the plant.

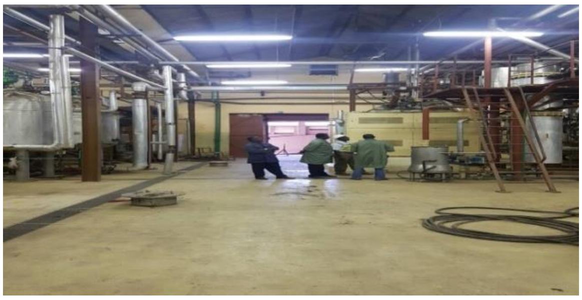

Fig. 1 Cocoa Liquor Plant

2 Resources and Methods Used

Risk assessment was carried out in accordance with Ministry of Employment and Labour Relations' factories, shops and offices act of the Constitution of Ghana.

The team of inspectors evaluated the plant safety and risk factor of the use of the Cocoa Liquor Plant and its emergent safety threats to the inspection team and the staff of the company. The entire plant was assessed and the key equipment such as the pumps, boiler, bean rooster, crushers, cooling tower, fuel tank and electrical connections and controls were inspected.

3 Results and Discussion

The scope of the work included the inspection of equipment in the process flow of liquor production and auxiliary equipment required to run the plant. It was observed that the liquor plant was in place but needed some maintenance and repair works. The inspection was carried mainly on tanks, pumps, roasters, boilers, chillers, crushers, cables, controls, building, hydraulic units, drag conveyor and cooling tower.

3.1 Observations

The plant had three (3) fuel tanks. Two (2) were badly rusted at the top. Whilst, one (1) had some repair works done on it and filled with fuel. Out of the two (2) chillers available, one (1) had been repaired, tested and was working alright but its general state was not good. Repair works were ongoing on the second chiller. The Boiler had two of its tubes punctured and was under corrective maintenance and being plugged. Experts were also on site to restore the Programmable Logic Control (PLC) system for the semi-automation of liquor processing, tempering and blocking. The company expects that the PLC experts will look at the calibration of the level gauges, flow meters and their transmitters. Other critical issues arising from field inspection which are of concern and require immediate attention of the management of the plant are summarised into mechanical, electrical and rust issues and structure assessment.

*Manuscript received June 20, 2019
Revised version accepted September 19, 2019

3.2 Mechanical Issues

The boiler and roasters were in good conditions as shown in Fig 2 and Fig 3. The forwarding pumps for the Cooling Tower were not mounted on their skids which secure the pump and the motor firmly to the foundation to allow for their smooth operation. The absence of skids in the assembly could lead to misalignment in bearings and couplings of the pump due to vibratory motion. One of the pumps was found lying close to the skid (Fig: 4), and, it was not functioning. It was found that the skids were not in place as a result of the frail nature of the bolts and nuts holding the pumps to the skids. Fig. 5 shows spaces meant for mounting of fans and four of such fans were in place. Three chiller condensers were inspected.

Fig. 2 Boiler

Fig. 3 Beans roasters

Fig. 4 Pumps Skid

Fig. 5 Structure for mounting of Fans

Fig. 6 portrays the rubber seals on the roaster doors which are hardened and peeling off. Roaster door rubber seals hold the doors firmly to the cabin of the roaster once closed. Worn out seals meant the roaster cabin door cannot be shut. The situation is undesirable since the preparation of cocoa liquor requires having the beans in the right state for an excellent blend. Thus, roasting is done to dehusk the beans, sterilize and develop for the right flavour. Therefore, the proper functioning of the beans roaster means a quality blend from the factory, hence, the roaster has to be in perfect shape for production. Due to the long absence in plant operation, the beans roasters after visual inspection were found to have decolourised with some level of rust on the roasters.

The team observed that foams have been used to seal the openings of the winnower crusher instead of the required tarpaulin-like material (Fig 7). The winnower is very essential in the initial process of the beans refinement in the entire cocoa liquor production processes. Winnowing is done to separate the hay of the cocoa beans from its fruit after crushing of the beans. The operation of the winnower is based on agitation which enables the smooth separation, these agitations results in vibrations. These vibrations have led to the removal of the bolts and nuts holding the winnower to the base and have further damaged the winnower rubber seals interfacing between the winnower and the base.

Fig. 6 Seals peeling off Roaster Door

Fig. 7 Winnower Crusher seals

3.3 Electrical and Instrumentation Issues

All the controls were in good shape, however, they were covered with dust. The cables and trays were covered with a lot of dust which needs to be cleaned. Cables around the cooling tower have been exposed to harsh weather conditions for long, to the extent that the colour of the outer sheath has changed (Fig. 8). In industrial settings such as a cocoa liquor plant where heavy equipments such as boilers and roasters are used; it is certain that heavy duty electrical cables would used. Due to the high voltage ratings of those cables it is essential to store them safely. For electrical safety, the cable tray system is encouraged for industrial setups. This system helps save space, material and cost; and makes it easy for maintenance and extension of cable tray installation (Anon., 2009). It was observed that the tray system was in place, howbeit, the tray was not covered, hence exposing the cables to the harsh weather conditions. In spite of the fact that most cables are designed to function at specific temperature conditions, prolonged exposure to high temperatures will damage them. Research findings from Mani, S *et al* (Mani *et al.*, 2018) suggest that there is a limit of the thermal tolerance of each cable hence if exceeded deteriorates the insulation sheath around the cable and puts the system at risk of fire outbreak; there is the need for total burial of the cables to avoid human contact. The 1000 kVA generator was found to be operating below it rated capacity at an estimated 40% amounting to 400 kVA. The level transmitter was found wornout and suspected to be defective and some switches were also found broken.

Fig. 8 Cables exposed to harsh Weather Conditions

3.4 Structure Assessment

Structural integrity assessment was done on the factory building. The team of inspectors made the following observations on cracks and leakages.

Cracks

The main entrance to the factory possesses a serious threat to both workers and passers-by. The entrance walls have developed some cracks and appear weak. According to Kunal and Killemsetty (2014), cracks usually result when the prevailing stress on the building exceeds the designed strength of the building. This stress is classified into two types namely, externally applied stress and internally induced stress. The externally induced stress includes dead, live, wind or seismic loads, whilst the internally induced stress is due to thermal variations, moisture changes and chemical actions (Kunal and Killemsetty, 2014). During the inspection cracks were observed at certain parts of the building, the cracks were seen to be growing in thickness and in depth. Based on the gap classifications of Kunal and Killemsetty(2014), the crack can be classified as medium crack.

Fig. 9 Crack at the Main Entrance

Leakages

There were two types of leakages observed during the inspection; water and oil. Leakages were observed from the roof into buildings spaces as a result of chocked gutters on the roof. These could be attributed to the non-maintenance of drainage for rainwater, open penetration which could be vents for pipes or chimneys, and aged roof (Moore, 2019). A critical look at the roofing system pointed to aged roofing system to be the principal cause of the leakages. This can result in electric shocks taken congnisance of the fact that the plant has a lot of electrical connections and life threatening. There is also the possibility of rusting of wall mounted frames and peeling off of wall coatings (Fig. 10).

Fig. 10 Leakage of Water Causing the Painting of the Tempering Room to Peel Off

Concerning the oil leakages, it was observed that the gearboxes for the tubular drag conveyors leak badly as well as the hydraulic unit for the cooler and this can be seen in Fig 11 and Fig 12. This is as a result of aged seals and/or gaskets in the unit. According to Gawande, (2019), the seal performance of gearbox flange assembles has direct correlation with the selection of the right gasket thickness of the gearbox. Ensuing from the prevailing conditions, these gaskets need replacement to avoid damage to the gears and injury due to slippage.

Fig. 11 Tubular Drag Conveyor Gearbox

Fig. 12 Cooler Hydraulic Unit

3.5 Rust Issues

One of the critical observations made was on the issues of rust. It was found that the structure of the cooling tower had been attacked by rust (Fig 13). An impeller of one of the cooling pumps which was on the skid was found rusted. The fuel tank that serves the plant was found in a deplorable state, in fact the roof was totally rusted (Fig 14) and put workers at risk when working with such structures (Singhania and Sanyal, 2013).

4 Conclusion and Recomendations

Structure integrity assessment was carried out on the plant and based on the technical observations made on issues on mechanical, rusting, electrical and instrumentation fire hazard and general housekeeping, the team found the plant to be repairable and useable. Some technical recommendations were made by team and if these are fully implemented it would ensure the availability and reliability of the plant.

4.1 Recommendations

Based on the findings made, the key recommendations are stated in Table 1.

Fig. 13 Rusted Cooling Tower

*

Fig. 14 Rusted Fuel Tank Roof

Table 1 Recommendations

Mechanical Issues	I. II.	All the belts of the mechanical drives need to be replaced. The chiller meant for tempering and blocking needs to be replaced immediately. Spares of the main transfer pumps (gear and rotor) and their parts should be procured.
Electrical & Instrumentation Issues	I. II. III.	Check all the level transmitters on the product vessels and if defective replace them. An immediate action should be taken to fix all the broken switches of the control panel for the roasters. The 1000 kVA generator which cannot generate 40% of its rated capacity needs an immediate repair and a plan should be in place for procuring a new one. New batteries must be procured for starting of the generators.
Fire Hazard	I.	Expedite action to refill all the fire extinguishers and restore them to their designated locations.
Rust Issues	I. II.	All the screw conveyors attacked by rust should be rust treated. Two new screw conveyors should be procured as a spare to help in reducing down-time. An immediate rust control action should be carried out to curtail the rapid deterioration of the cooling tower and the fuel tank roof.
General housekeeping	I. II.	An immediate housekeeping should be carried out at the following areas; (a) Boiler house (b) Chiller room (c) Beneath the fuel tanks (d) Areas around the cooling tower Also, Check and repaint deteriorated painting peeling from the wall of the buildings to maintain good housekeeping

References

Haasl, T. (1999), "Operation and Maintenance Assessments: A Best Practice for Energy-Efficient Building Operations", *Portland Energy Conservation, Inc*, 54 pp.

Anon., (2009), "Method Statement For Installation of Cable Tray or Trunking", *www.electricva-da.com/building-services/ method-statement-for -installation of-cable-tray-or-trucking,* Assessed: 9th September, 2019

Mani, S., Kafil, M. & Asadi, E. (2018), "Best Practice Condition Monitoring Framework for 63kV Cable Networks entailing Power Quality, Insulation Degradation and Thermal Inspection"; A Case Study, *12th Condition and Monitoring & Fault Diagnosis Conference* February, 2018, Sherif University of Technology, Iran, pp. 1 – 13.

Kunal, K., and Killemsetty, N. (2014), "Study on Control of Cracks in a Structure through Visual Identification and Inspection", *IOSR Journal of Mechanical and Civil Engineering*, e-ISSN:2278-1684, P-ISSN: 2320-334X, Volume 11, Issue 5, Version VI, pp. 64-72.

Moore, J. (2019), "Why is My Commercial Roof Leaking? 5 Common Causes of Commercial Roof Leaks", *www.westroofingsystems.com/why -is-my-commercial-roof-leaks,* Assessed: 9th September, 2019.

Gawande, S. (2019), "Study of the Effect of Gasket Thickness for Bolted Gearbox Flange Joint*", SN Applied Sciences*, 1.10.1007/s42452-018-0030-y, pp. 1-7.

Singhania, G. K., and Sanyal, B. (2013), "Behaviour of Rust and Rusted Steel Surfaces" *British Corrosion Journal*, Volume 8, 1973 – Issue 5, pp. 1 – 7.

Authors

A. Simons is an Associate Professor of Mechanical Engineering and a Consulting Engineer currently working at the University of Mines and Technology, Tarkwa, Ghana. He holds the degrees of MSc from the Belarusian-Russian University, Magilev, Belarus, PhD from St. Pertersburg State Mining Institute (Technical University) St. Petersburg Russia and NDT Level II from Trinity NDT College Bangalore, India. He is a member of America Society of Mechanical Engineers. He is also a Professional Engineer of Ghana Institution of Engineering. His research and consultancy works cover Heat Transfer, Fuels and Internal Combusting Engines, Machine Design, Maintenance Engineering, Accident Vehicle Assessment, Factory Technical Audit and Non Destructive Testing (NDT).

C. Addy is PhD Mechanical Engineering student at University of Mines and Technology, Tarkwa Ghana. He holds the degrees of MSc from Newcastle University, UK and BSc from the University of Mines and Technology. His research areas are Thermodynamics, Fluid Mechanics, Heat Transfer, Thermal Management in Electronics, Electrical Power and Maintenance Engineering.