Study on Analysis of Penetration Forces by Drilling and Fungicide-liquid Flow Behavior by Injecting on Oil Palm

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Abstract—.

Disease on oil palm trees cause by G. boninense may lead to rotting and eventual death to the trees. This is considered as a major loss to plantation operators. Currently, one of the methods in treating the disease is through injection of solution that consists of hexaconazol or tetraconazol as the active ingredients. While the type of effective solution may have been identified, the application technique can be simplified much further. At the moment, once the effected tree has been recognized, the next step is to drill the tree and then the driller is taken out and an injected is put forward. The paper presents the study and analysis of penetration forces by drilling and fungicide-liquid flow behavior by injecting on the oil palm trees. The results will influence the direction of a new mechanism design to implement the solution.

Keywords— G. boninense; drilling; injecting; treatment.

I. INTRODUCTION

Basal stem rot (BSR) is one of serious diseases that caused by Ganoderma boninense. Since this pathogen attacks young palm as lower as 5 years old, many oil palm researcher and farmer have to take this issue as their major problem to prevent and overcome the disease [1]. In 2010, the result of BSR survey in oil palm estates was about 3.71% incidence of the disease recorded where 59148 ha affected area out of 1594286 ha that causes yield losses about RM1.5 billion [2][3].

There are several methods to control Ganoderma such as culture practices, good land preparation, soil mounding, biological control, integrated sanitation by deboling and applying fungicide into the affected palms by trunk injection [2]. Various fungicides have been made to control this disease in plantation although the results are still inconclusive but some systemic fungicides seem to be effective [4]. Such fungicides that have been tested as drazoxolone, cycloheximide, triadimefon, carbonix, benomyl, hexaconazol, penconazol and tetraconazol [5]. The fungicides application includes soil drenching, trunk injection, or combination of both methods [6].

Ineffective fungicide control of BSR in oil palm is the major problem that caused by failure to deliver chemical to infected Ganoderma infected area in the oil palm. Besides, the deliver failure can generate chemical waste issue that affect operating cost and environment [4][9].

This paper discusses the concept of drilling and injecting oil palm trees for optimum delivery of fungicide specifically to kill Ganoderma boninense.

II. MATERIALS AND METHODS

A. *General drilling concept*

Drilling is one of machining processes that involving a work of forming or altering the object by removing material in the form of chip. Drilling is a combination process between rotating movement and linear feed. There are a few methods of drilling such as solid drilling, trepanning, counterboring and reaming. The drilling methods are chose as the hole type desired.

B. *General injection concept*

Injection is a process to infuse liquid into body. The process is often using pressure as actuate factor to deliver the liquid through a hollow tube such as syringe, needle and nozzle that passing skin or outer layer of materials being injected directly into targeted zone with sufficient depth. Basically injection pressure do has relationship to flow rate, length and pipe diameter which are important factors in injecting calculation using Darcy-Weisbach equation as Equation 1.

$$h_f = f_D \,.\, L/D \,.\, V^2/2g \qquad \text{(Equation 1)}$$

where h_f (m) is the head loss due to friction, L (m) is the length of pipe, D (m) is the internal diameter of the pipe, V (m/s) is the fluid flow velocity, g (m/s^2) is gravitational acceleration and f_D is Darcy friction factor.

C. Study of drilling oil palm tree

The basidiomata of Ganoderma appear at the stem base, or originating from infected roots. The position of basidiomata on the stem usually reflects the position of the infected area within stem [5][7]. BSR involves decay of the bole, lower stem and the root system on the infected palm that can eventually decay and collapse [9].

Malaysian Palm Oil Board (MPOB) is Malaysian government agency that leads oil palm technology in way to control BSR in Malaysia where has developed and disseminated 34 technologies that related to biology, detection and control and management [2]. MPOB's pressure-injecting fungicide (PIA) is one of technology that currently used in plantation to deliver fungicide into oil palm tree. PIA is certainly used for research benchmark in order to compare the efficiency by specification of machines as in Table 1.

Table 1. Specification of PIA equipment

Specification of PIA equipment	
Drill: -Type of drill -Drill bit diameter -Drill length	 Gasoline engine drill 11 mm 400 mm
Injector: -Material -Injector diameter -injector length -Pressure	 Stainless steel 120 mm 500 mm 20 bar pressure

Since Ganoderma live in within oil palm lower stem and bole, 300mm of test rig high is should be competent. The motion concept of the platform as in Fig. 1 takes three stages where at first the force gauge is initially pushing the drill and moving towards sample as oil palm trunk. In the second stage, it starts to drill the trunk and the force gauge will start to record a data in unit of Newton force (N). Lastly the drill will be stopped as it reaches a certain displacement or penetration depth.

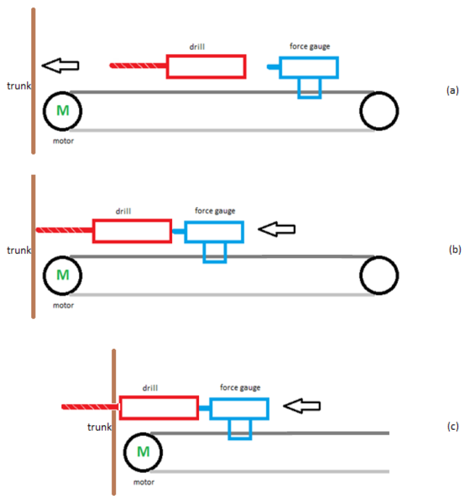

Fig. 1. General test rig motion concept

III. RESULTS AND DISCUSSION

A. Development of drilling test rig concept

In order to measure penetration forces on oil palm drilling process, suitable drilling test rig needed to be developed. The drilling test rig is designed based on constraints and constructed experimental variables studied. Spindle speeds, feed rates, drill bit diameters, drilling angles and drill bit types are importantly considered for variables in drilling test in way to get penetration forces as main result. Thus the drilling test rig can be controlling all the variables together to measure desired result.

Overall dimension of this drilling test rig as in Fig 2 is 500mm length, 300mm width and 400mm height. This platform uses the 16mm inner diameter linear bearing that fitted through 500mm stainless steel shaft of 16mm diameter. The linear bearing is used for reducing the friction force in the drill motion. Therefor the friction force of the drill platform motion can be negligible. The main platform can be rotated 45 degree at most in order to meet the requirement of one of experimental variables which is drilling angles.

The test rig can be divided into two systems which are drilling system and feeder system. Drilling system consist a platform of 220V AC motor with speed controller that be fitted of a drill chuck for 10mm to 25mm drill bit diameter. The AC motors are used because of high torque and power stability as the motors can be powered by conventional 220V plug or 220V generator set for outdoor used. While the test rig feeder system is using the linear screw drive system to control force gauge platform motion and hence push along the drill platform. 200N force gauge is used to measure penetration forces on live oil palm.

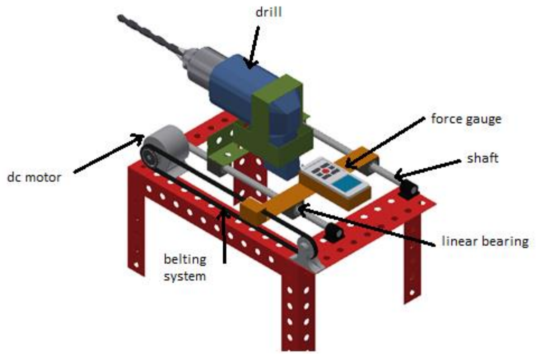

Fig. 2. Proposed penetration drill force test rig concept

B. Development of nozzle design concept

The vital component in the design of this device is the nozzle that resembled a hybrid between a driller and a hollow rod. The purpose is to perform drilling and injecting in one pass, hence simplifying the procedures on delivering the solution for treatment. One of the design constraints considered was the diameter of the nozzle, whereas smaller size was preferred in order to inflict minimal damage on the trunk. Fig. 3 shows two types of proposed nozzle designs. Both (a) and (b) are hollow cylinders with 5 mm diameters and two 3 mm apertures. In (a) the apertures are perpendicular to the axis of the drill tip, while in (b) the apertures are angled at 45° from the axis of the drill tip.

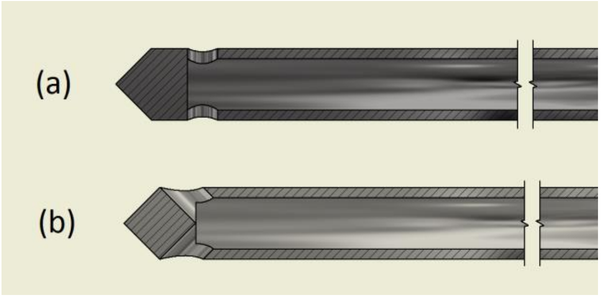

Fig. 3. Two 3mm apertures perpendicular to axis of the tip (a) and two 3mm apertures angled as 45^o from tip axis (b).

Since the drilling would reach a depth of between 20 to 30 cm, it is important that the material for making the nozzle should be able to withstand the loading requirement and durable enough for long period and repeatable usage. Table 2 lists three industrial materials for preliminary studies, namely titanium, alloy steel and silicon nitride. Finite Element Analysis (FEA) was performed based on axial stress on both designs, using Autodesk Inventor. In this preliminary analysis the resistance force was assumed to be 10 N. The results are shown in Fig. 4 for type A (Fig. 3) and Fig. 5 for type B (Fig. 3). In type A, based on Von Misses stress, all three materials showed very slight variations in terms of maximum stress, with titanium (1.843 MPa), steel alloy (1.852 MPa) and silicon nitride (1.864 MPa). Similarly for type B, the order is the same with titanium (2.475 MPa), steel alloy (2.677 MPa) and silicon nitride (2.899 MPa). Between the two types, apertures for type B has at least 30% higher maximum stress for a given condition.

Table 2. Materials specification comparison

	Titanium	Alloy steel	Silicon Nitride
Density	4.51 g/cm^3	7.73 g/cm^3	3.18 g/cm^3
Yield strength	275.6 MPa	250 MPa	610 MPa
Tensile strength	344.5 MPa	400 MPa	610 MPa
Young' Modulus	102.81 Gpa	205 GPa	427.18 GPa

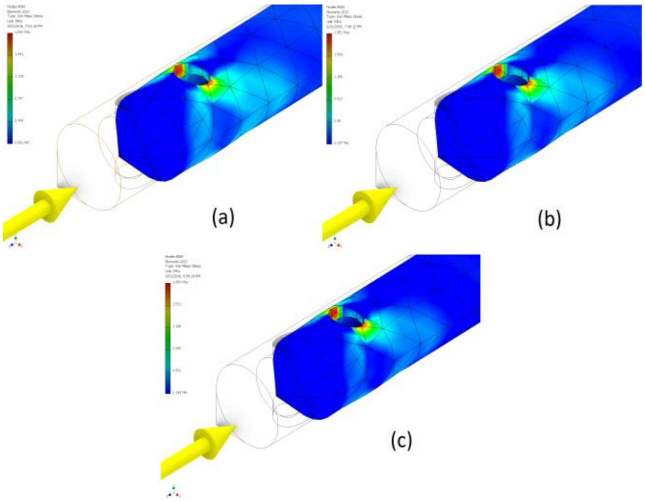

Fig. 4. Stress analysis of 5mm diameter nozzle with two separated perpendicular holes at tip by using three different types of materials; titanium (a), alloy steel (b) and silicon nitride (c)

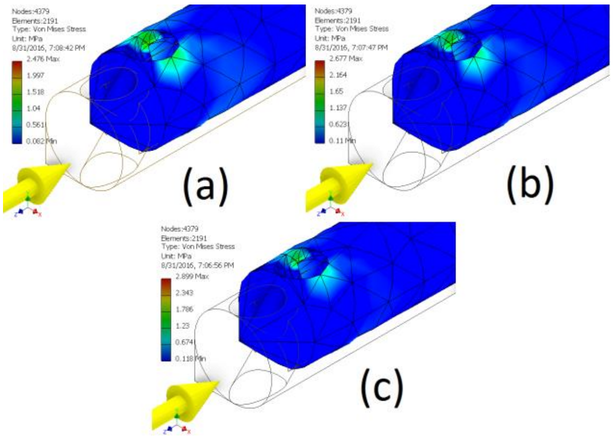

Fig. 5. Stress analysis of 5mm diameter nozzle with two separated 45^{o} apertures at tip by using three different types of materials; titanium (a), alloy steel (b) and silicon nitride (c)

IV. CONCLUSIONS

In conclusion, the preliminary analysis did not show any significant difference between the proposed materials. However this was based on axial stress which considered only the penetration. Further analysis will be considered in terms of torsion and also thin wall pressures due to the fluid flow in order to optimize the design.

REFERENCES

[1] S. Basu, A. C. Odena, I. F. J. Vankelecom, "MOF-Containing Mixed-Matrix Membranes for CO_2/CH_4 and CO_2/N_2 Binary Gas Mixture Separations", *J. Separ. & Purif. Tech*., vol. 81, pp. 31-40, 2011.

[2] MPOB, Malaysian Palm Oil Board-Biological Research Division. March 10, 2016. Research and Management of *Ganoderma* Disease in Oil Palm. Retrieve from: http://bio.mpob.gov.my/download/Research%20and%20Management%20of%20Ganoderma%20Disease%20in%20Oil%20Palm.pdf

[3] H. Ikmal, J. Razak, S. Rahim, M. Aminulrashid, I. Fauzi, A. Rizal and A. S. Idris, Tractor mounted trunk injector for control of basal stem rot (BSR) disease, MPOB Information Series No. 546, 2014.

[4] A. S. Idris, S. Ismail, D. Ariffin and H. Ahmad, Control of *Ganoderma* – infected palm – development of pressure injection and field applications, MPOB TT No. 131, 2002.

[5] N. Laila, S. Shafiquzzaman, K. Y. Umi, M. M. A. Mondal, Issues of *Ganoderma* spp. and Basal Stem Rot Disease Management in Oil Palm, *American Journal of Agricultural Science*, Vol. 2, No. 3, 2015, pp. 103-107, 2015.

[6] J. Razak, H. Ahmad, K. Ramdhan, A. S. Idris, S. Rahim, M. Aminulrashid, I. Fauzi, Mechanical trunk injection for *Ganoderma* control, MPOB Information Series No. 215, 2004.

[7] Plantwise Knowledge Bank, March 10, 2016. Basal Stem Rot of Oil Palm (Ganoderma boninense), Retrieve from: http://www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=24924

[8] R. M. Cooper, J. Flood, R. W. Rees, *Ganoderma boninense* in Oil Palm Plantations: Current Thinking on Epidemiology, Resistance and Pathology, The Planter, Kuala Lumpur, 87 (1024): 515-526(2011), 2011.

[9] K. Michael, Getting Chemical into Trees Without Spraying, *UtahState University Cooperative Extension*, NR/FF/020(pr), 2011.