Theoretical Determination Of The Power Consumption Of The Universal Mounted Sprayer Of PJG'-10

Djuma Djuraev, Mukhtor Khalilov, Sunatullo Badalov, Matluba Nurmonova

Abstract: Current article describes the manufactured industrial sample of the universal mounted sprayer PJG'-0 of chemical treatment from pests and diseases of fruit orchards and vineyards of the Republic. With the construction of any sprayer designed to perform a specific job, individually for this purpose, a technological and kinematic scheme of its drive is developed. On the basis of the developed kinematic scheme, the authors used the article to determine the theoretical power consumption of a sprayer as a single dynamic system of moving parts and mechanisms. The power consumption of the universal mounted sprayer of PJG'-10 was determined by adding the power of the useful resistances expended in the extension of the air flow to the fan, the bearings and the vane-clamp gears, and when the pump moved, and the dependence for theoretical determination of the power consumption of the sprayer was derived on the basis of this. In this concern, the theoretical power consumption of the sprayer is determined, depending on the parameters of both the speed, pressure and airflow produced by the fan.

Index Terms: angular velocity, fan, garden, pressure, power, pump, sprayer, speed, productivity, torque.

1. INTRODUCTION

IMPROVING the yield and quality indicators of internationally competitive products through the introduction of new technologies and technical equipment in agricultural orchards and vineyards is important. According to the Food and Agriculture Organization of the United Nations (FAO), as a result of damage to plants by diseases and insects in the world, 20-25% of the crop annually dies [1,2,3]. Pest and disease control measures in vineyards and orchards are carried out using sprayers. A large number of sprayers of various brands are produced in the world, since scientific and practical work is underway to create new sprayer projects. Naturally, for the chemical treatment of a plant, based on its technology, the process of technological development of a specific and complete spraying is designed. The authors have developed a universal mounted sprayer for chemical treatment of orchards and vineyards to combat pests and diseases, based on this technology, theoretical studies have been carried out to determine its energy indicators. The purpose of this paper work is to analyze theoretical study of the relationship of the required energy during the operation of a universal mounted sprayer with the moment of rotation of the shaft, the number of revolutions of the fan shaft, productivity, speed and pressure of the flow of moving air and liquid

2 ANALYSIS OF RECENT STUDIES

Several scientific studies have been carried out to theoretically determine the required power of moving mechanisms and machines. [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15]. However, the sources cited are limited to determining the theoretical power of a particular mechanism, and not the whole machine. For example, the sprayer OVX-600, produced in the republic since 1980, is mainly used for defoliation and the control of pests and diseases of cotton [2]. Its theoretically required power has not been determined, but as a result of state testing carried out about 30 years ago by the method of tensometry, the actual value of the required power was determined [2]. When designing any sprayer, its technological and kinematic drawings are developed, but these drawings differ depending on the type of sprayer. In other words, the determination of the theoretical power of the sprayers is based on their exact kinematic drawings, and this problem is solved individually.

3 RESEARCH METHODS

It is important to determine the required power needed for chemical treatment of gardens using the PJG-10 universal sprayer, that is, its energy characteristics. Therefore, we present a kinematic drawing of the PJG-10 universal mounted sprayer designed and developed on its basis (Fig. 1). The universal mounted sprayer of PJG-10 consists of parts and mechanisms that are interconnected as follows: the front part of the cardan shaft is connected to the slot of the tractor power take-off shaft (PTO), and the rear part is connected to the drive mechanism of the sprayer. The shaft is attached to the sprayer frame using bolts with two bearing housings. A large pulley fixed by a nut is installed on the shaft with a keyed connection, a small pulley is mounted on the fan shaft, which are interconnected by V-belts. The fan wheel is mounted on the shaft using a one-way clutch. If the PTO shaft stops under the influence of the moment of inertia, the action arising from idling of the fan does not transfer to the PTO, which as a result releases the tractor engine from the load. In this case, the idle fan speed under the influence of the moment of inertia is maintained for a certain time.

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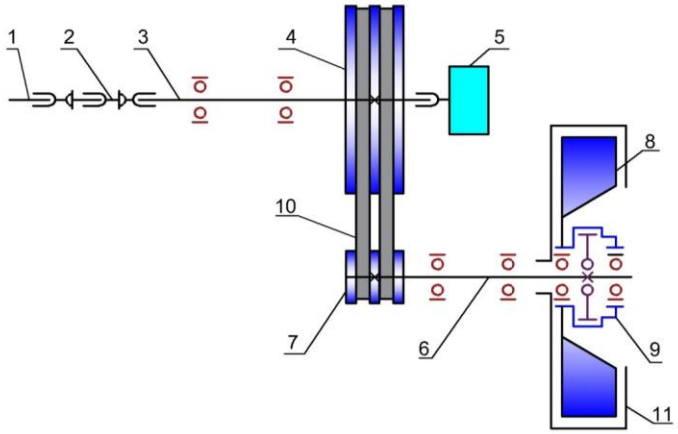

***Fig 1**. Kinematic diagram of a universal mounted sprayer.*

1-tractor power take-off shaft (PTO); 2- cardan shaft; 3-sprayer shaft; 4- large pulley; 5- pump; 6- fan shaft; 7- small pulley; 8- fan wheel; 9 - one-way transmission clutch; 10-V-belt; 11- fan cover. Current fan wheel is mounted on the sprayer frame using bolts. The pump is mounted on a spline at the end of the shaft with an axle inserted using bolts. The main function of the pump is to suck in the working fluid from the tank and direct it to the pressure of the regulator under a certain pressure, thus spraying the working fluid in the air stream with a certain dispersion content. The PJG-10 universal mounted sprayer works as follows: the extension is transmitted from the tractor PTO via the driveshaft to the sprayer shaft, through the large pulley mounted on it, by means of V-belts to the small pulley and fan wheel, while the pump is being sucked in. Therefore, the air flow from the sprayer fan, directing the spray liquid, carries out the chemical treatment of orchards and vineyards.

4 RESULTS

If we analyze determining the theoretical power required for the PJG-10 universal mounted sprayer, we consider its moving parts and mechanisms as a dynamic system [1,2,3,4,5]. The required power of the universal mounted sprayer N is equal to the sum of the consumed power when moving the mechanisms:

kW (1)

At the same time: N1 is the power consumed in overcoming the useful resistance arising in the process of air flow from the fan, kW; N2 - power consumed in overcoming the harmful resistance arising from the action of bearings and V-belts in the sprayer mechanisms, kW; N3- Power consumption in the process of bringing the pump into action, kW; The moving parts and mechanisms of the PJG-10 universal mounted sprayer are symmetrical cylinders and move around a fixed axis. In general, the power of moving mechanisms and machines is determined by the following expression. A power unit is measured in two dimensions: horsepower and kilowatts. Therefore, in general, we present the power transition in both units of measure and from one unit of measure to another.

The power measurement formula is generally expressed in units Вт:

$N = M \cdot \omega$, Вт (2)

Here: M – mechanism torque, H м ;

ω – angular velocity,1/c ;

Below are the power units necessary for a theoretical study of power and their relationship, as well as the necessary physical dimensions, a unit of 1 horsepower is briefly denoted as 1 hp.:

1Вт = (1Н ˙1м) / 1с; 1кГ = 9.80665 Н; 1Н = 1/ 9.80665 кГ; 1о.к. = (75 кГ м)/ с; 1о.к. = 735.5 Вт; 1Вт = 0.0013596 о.к.; 1кВт= 1.36 о.к.

applying the following parameters to the above expression, we obtain:

$$\mathbf{75 \cdot N = M \cdot \omega}, \text{1 о.к} \quad (3)$$

The angular velocity ω is determined by the following expression:

$$\omega = \frac{\pi \cdot n}{30}, \text{ 1/c} \quad (4)$$

Where: n – shaft revolutions, rpm.

we calculate the expression (2) with respect to the moment M, substituting the angular velocity ω we obtain the expression (4)

$$M = \frac{75 \cdot N}{\frac{\pi \cdot n}{30}} = 1762.2\frac{N}{n},$$

$$\frac{N}{n}$$

кГм; or M = 716.2 , кГм (5)

we calculate expression (5) with respect to the power N and obtain the following:

$$N = \frac{M \cdot n}{716.2}, \text{о.к} \quad (6)$$

The power determination formula is expressed in kW;

$$N = \frac{M \cdot n}{716.2} \cdot \frac{1}{1.36} = \frac{M \cdot n}{974}, \text{кВт}$$

or

$$N = \frac{M \cdot n}{974}, \text{ кВт ;} \quad (7)$$

At the same time, we determine the amount of rotation of the fan wheels using the following expression in accordance with the kinematic diagram of the atomizer (Figure 1):

$$i = \frac{n}{n_1} \quad (8)$$

Here: i- transmission amount;

n_1- transmission amount BOM, its values are associated with the tractor brand “Belarus” and TTZ 80.10, equal to n1 = 540 rpm;

The number of gears i is expressed through the diameters of the moving pulleys (9):

$$i = \frac{D}{d} \quad (9)$$

Here: D diameter of a large pulley, м;

d- diameter of a small pulley, м;

Substituting expression (8) into expression (9), calculating the equality, we determine the number of revolutions of the fan wheel n:

$n = \frac{D \cdot n}{d}$, per/min,

The power consumed to overcome the effective airflow resistance of the fan N_1, depending on the performance and pressure of the air flow, is as follows

$$\boldsymbol{N = Q \cdot H}, \text{ кg м/s} \quad (10)$$

Here: Q - air flow rate, м^3/ s

H - air flow pressure, кg/м^2

In accordance with the above units in the formula (10) we express in kW;

$$N_1 = \frac{Q \cdot H}{75 \cdot 1.36}$$, kw;

or

$$N_1 = \frac{Q \cdot H}{102}$$, kw;

(11)

Therefore, the consumed power that arises to overcome the useful resistance in the event of an air flow from the fan of a universal sprayer is associated with the air flow and pressure performance, which is expressed in expression (11).

The performance of the air flow arising from the fan Q is determined by the following expression:

$$\boldsymbol{Q = S \cdot \vartheta},$$ м^3/s

(12)

Here: S– surface of two side windows of the fan casing with outflow of air,м^2;

h - скорость потока воздуха , м/s

The area of the two side output windows of the fan casing of the universal mounted sprayer is determined by the formula (13):

$$S = 2a \cdot h,$$ м^2;

(13)

Here: a- air outlet window width, м;

h- air outlet window height,м ;

Substituting the air flow performance from the two output windows of the fan casing Q (13) into expression (12), we obtain the following:

$Q = 2a \cdot h \cdot \vartheta$, м^3/s

(14)

The pressure and speed of the air flow through the windows of the fan casing, directed into the open atmosphere, is determined by the formula of the Italian scientist Evangelista Torricelli (1608-1647) [6]. In the seventeenth century, Evangelista Torricelli created a formula for the relationship between speed and pressure created by the movement of air and liquids. The basic formula for determining the speed and pressure of air and liquid:

$$\vartheta = \varphi\sqrt{\frac{2g \cdot H}{\gamma}}$$, м/s

(15)

Here: ϕ – air flow output coefficient, its value is taken as φ=1 [6].

g – acceleration of gravity, g=9.81 м/с^2 .

γ- specific gravity of air, γ=1.22 кГ/м^3.

Taking into account the above parameters, expression (15) is equal to:

$\vartheta = \sqrt{16.04H}$,м/s

(16)

From the alignment (16) we determine the air pressure:

$$H = \frac{\vartheta^2}{16.08}$$, кg/м^2

(17)

Substituting the values of Q and H defined above into expression (11), we obtain the following:

$$N_1 = \frac{2ah\vartheta^3}{1640.16}$$, kw;

(18)

In the analysis of expression (18), the power spent to create the air flow varies depending on the cubic speed. We determine the power necessary to overcome harmful resistance when moving bearings and V-belts in a universal mounted sprayer PJG'-10:

$N_2 = (1-\eta) \cdot N_1$, кВт

(19)

It is important to determine the efficiency of the drive to determine the power of the spent harmful resistance when driving the bearings and V-belts of the mechanisms of the universal mounted sprayer of PJG-10.

The drive efficiency is determined in accordance with the kinematic scheme of the universal mounted sprayer shown in Fig.1.

$$\eta = \eta_1 \cdot \eta_2$$

(20)

Where: η_1 - Bearing efficiency;

η_2– V-belt efficiency;

Substituting expression (18) into expression (19), N2 becomes equal:

$N_2 = (1-\eta) \cdot N_1 = (1-\eta) \frac{2ah\vartheta^3}{1640.16}$, kw

or

$N_2 = (1-\eta) \cdot \frac{2ah \cdot \vartheta^3}{1640.16}$, kw

(21)

The power N_3 required for the operation of the pump installed in the PJG-10 universal mounted sprayer, in relation to the fluid flow rate (capacity) Q_1 and fluid pressure H_1, is determined in accordance with expression (11):

$$N_3 = \frac{Q_1 \cdot H_1}{102}$$, kw;

(22)

The theoretical power required for a universal mounted sprayer N is the sum of the energy used to give the following air flows, mechanisms and movements of the pump in accordance with the expression (1):

$$N = \frac{2ah\vartheta^3}{1640.16} + \frac{2ah\vartheta^3}{1640.16}(1-\eta) + \frac{Q_1 \cdot H_1}{102}$$

, kw

or

$$N = \frac{2ah\vartheta^3}{1640.16}(2-\eta) + \frac{Q_1 \cdot H_1}{102}$$, kw

(23)

Based on a certain theoretical power of the PJG-10 universal mounted sprayer, we determine the torque M (7) driving the drive shaft from expression; (7)

$$M = \frac{974 \cdot N}{n}$$, кГ м;

(24)

Based on the expression (24), the shaft of the universal mounted sprayer is calculated for strength and reliability. We will continue the study to determine the actual power required for the PJG-10 universal mounted sprayer. In the future, it is planned to conduct tensometric tests in conjunction with research institutes.

5 CONCLUSION

Finally, current research has been expressing mathematical calculation on determine the theoretical power of the PJG'-10 universal mounted sprayer, equal to the sum of the consumed power arising from the useful resistance of the emerging air flow from the fan. Main outcomes on harmful resistance when moving bearings and V-belts of mechanisms and resistances

arising from the pump. In this case, the theoretical power of the sprayer is determined in the relationship of the parameters of speed, pressure and productivity of the emerging fluid flows from the pump and the air flow from the fan.

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