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THE DESIGN OF UTMAS-1 SPRAYING MECHANISM FOR MICROLIGHT

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Abstract. CGS Hawk-1 microlight has been identified as a suitable light aircraft for aerial spraying in Malaysia due to its easily operable, relatively cheap overhead and maintenance costs. A spraying mechanism UTMAS-1, was designed to suit the configuration of the microlight. This mechanism has the special feature of operation just by using the energy from the airflow around the microlight body and thus it does not need any electrical equipment such as battery and pump. The performance of the spraying mechanism was determined through laboratory testings. The choice for suitable microlight for aerial spraying, the design of the spraying mechanism and the results of the laboratory testings on the spraying mechanism performance were presented and discussed in this paper.

1 INTRODUCTION

Malaysia has actively involved in agricultural sector since 1960s through the vision of her 2nd Prime Minister. Since then, a number of Government Agencies has been formed such as FELCRA, FELDA, MARDI, KEJORA, etc. to coordinate the related activities and to ensure the success of the Government Policies. Rubber, oil palm, paddy, cocoa, tea, banana, sugar and coconut plantations are given special attention.

Formerly, activities related to this sector, especially manuring and watering of plants and spraying of insecticedes,weed killers and pollant were mostly done manually since there were abundant of cheap labour. About 10-15 years ago, the increase of productivity was of great national concern and cheap labour becoming scare due to labour migrate to industrial sector, aerial spraying has becoming an important issue in Agricultural sector. Some private companies such as Harrison Crossfields and PKENJ Montel have already move into aerial spraying in their plantations. The main common aircraft in used for aerial spraying are helicopters and light aircraft such Mustang.

The usage of helicopters and light aircrafts incur with high overhead, operational and maintenance costs and the need of very skill operators. These will be a burden to small and medium size plantation owners. It was through the realisation of the above mentioned factors that the research work on using microlight in aerial spraying was undertaken which encompassed of finding suitable microlight and spraying mechanism to come with it.

2 CHOICE OF MICROLIGHT

Currently there are a number of microlight types have been produced by a number of countries around the world. These include the widely used Quick Silver and Hawks. For the purpose of aerial spraying, the choice of suitable microlight must include the following criteria:

a) It must have high landing gears to ensure that there is enough space below the microlight boom for the installation of spraying mechanism. This is very important to ensure that the spraying mechanism does not touch the ground during the takeoff and landing of the microlight. If it

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touches the ground, either the spraying mechanism or the microlight or in severe cases both of them will be damaged.

b) Its configuration should provide enough, strong and suitable points of attachments where the spraying mechanism and its accessories could be installed secured safely.
c) Preferably, the microlight chosen should be of 2 seater type so that:
   i) The weight of the spraying mechanism, accessories and spraying liquid will be limited to one passenger weight
   ii) The second seat could be replaced by spraying liquid (insecticide/manure/water) tank.

In this manner:

i) the microlight performance specified by the manufacturer will not be disturbed in order not to endanger the safety of the microlight as a whole and also to comply with the original flying certification rules issued by the appropriate authority.
ii) the designing process of the spraying mechanism and accessories will not involve in any alteration of the microlight configuration. Thus the designing task will be reduced slightly.

Based on the above mentioned criteria, two types of microlight (Quick Silver and CGS Hawks-1) were selected and thorough study was conducted to determine the most suitable one for the research purpose.

3 DESIGN AND WORKING UTMAS-1 SPRAYING MECHANISM

a) The Design

The design of UTMAS-1 consists of 2 main parts ie the convergent cone and rotating atomiser casing. Figure 1 shows the schematic drawing of the aerial spraying mechanism as a whole while the detail outline of the sprayer is shown in Figure 2.

i) Convergent Cone

The convergent cone is of 60mm diameter with half cone angle of 15 degrees. Welded to the front of the cone is a cylindrical tube of 70mm length. A 15mm diameter tube of 15mm length was welded to the converging end of the cone. The cone was jointed to a rotating atomiser casing via a bearing attached at the end of the cone.

ii) Rotating Atomiser Casing

The casing consist of two circular end plates with 45mm separation. The separation is covered with wire gauge (1mm x 1mm gauge holes) all round. A pair of blades is attached to the front circular end plates. The length of each blade is equal to the diameter of circular end plate.

On top of these two main parts, the spraying mechanism is also provided with a liquid tank (container) which is connected to a hole at the end of the convergent cone via small rubber tubing. Three rotating atomiser casings of diameter 80 mm, 100 mm and 140 mm were fabricated for studying the effectiveness of atomising the liquid supplied and to find the effective and optimum spray area of the sprayer. These three atomiser units were named as G80, G100 and G140 according to their respective diameters.

b) The Working

Primarily the design of UTMAS-1 makes use the principle of venturi. The airflow around the body of the microlight due to the forward motion of the aircraft enters the convergent cone with a velocity Vc m/s, which is equivalent to the speed of the microlight itself and a pressure of Pc Pascals. Due to the reduction in area of the cone, the air reaches the venturi neck (the smallest area of the cone) with a greater velocity Vv m/s and lower pressure of Pv Pascals. This phenomenon is in accordance to Bernoulli's Principal, which could be explained by the equation below:

$$\frac{P_c}{\rho g}+\frac{V_c^2}{2g}=\frac{P_v}{\rho g}+\frac{V_v^2}{2g}=\text{Constant} \qquad \text{..........................(1)}$$

The low pressure created at the neck of the convergent cone will suck the sprayer liquid from its tank to enter the cone. This liquid will then be pushed into the rotating atomiser casing by the air of stronger velocity at the neck of the convergent cone. The rotating atomiser casing will then atomise the liquid into liquid spray of a certain particle size. The atomiser casing is being rotated by the couple of tangential forces created by air flow around the microlight body striking the pair of blades which are attached to the front end plate of the atomiser casing. Other than the density and viscosity of the sprayer liquid, the particle size of spray will also depend on the rotating speed of the atomiser casing and the size of holes of the wire gauze.

4 LABORATORY TESTINGS

Laboratory testings were conducted in the Liquid Mechanic Lab, Faculty of Mechanical Engineering, University Teknologi Malaysia. The objective of these tests was to determine the performance of UTMAS-1. The performance parameters concerned were the spraying area, spraying volume/flowrate and spraying angle of the spraying mechanism using the three different sizes of rotating atomiser casings.

a) Equipments

The equipments in used to conduct these laboratory testings were:

i) A blower wind tunnel
ii) UTMAS-1 Spraying Mechanism which consisted of sprayer liquid tank, convergent cone, connecting rubber tubing and three rotating atomiser casings G80, G100 and G140. The convergent cone and rotating atomiser casings are shown in Figure 3.

b) Testing Procedures

The test set up is shown in Figure 4. The assembly of convergent cone and rotating atomiser casing was placed at the centre of the blower tunnel mouth. The assembly was at a height of 1m above the laboratory floor and 0.3m below the sprayer liquid tank. The assembly height 0.3m below the sprayer liquid tank was chosen in correspondence to the real height permissible for installation of the spraying mechanism on to the CGS Hawk-1 microlight chosen. A four-gallon plastic container was used as sprayer liquid tank. Throughout the tests, coloured water was used as sprayer liquid.

The UTMAS-1 spraying mechanism using one of the three rotating atomiser casings at a time was tested with five different tunnel wind speeds correspondence to 60, 65, 70, 75 and 80 Km/h. The sprayer liquid flowrate and the width and length of floor area covered with the spraying liquid for each rotating atomiser casing and each tunnel wind speed were recorded.

5 RESULTS AND DISCUSSION

The results of the laboratory testings were shown in Figure 5 and Tables 1 and 2. Figure 5 shows a typical liquid spray produced by one of the rotating atomiser casings on test. Table 1 shows the width and length of areas covered by sprayer liquid from each of the three rotating atomiser casings operating at five different wind tunnel speeds while Table 2 shows the corresponding sprayer liquid flowrates. From these results the following observations were made:

i) From Table 1, it was observed that the width and length of areas covered by sprayer liquid using

G80, G100 and G140 rotating atomiser casings for the five wind tunnel speeds were of nearly the same values and in the order of 0.21m and 0.45 m respectively. These may means that the area covered did not depend very much on the size of rotating atomiser casing and the wind tunnel air speed. These values may have changed if convergent cones of different diameters were used which may changed the cone suction rate of sprayer liquid. Thus a reasonable size of spraying mechanism and at a steady microlight cruise speed will do for the purpose of aerial spraying. G80 was taken to be the suitable rotating atomiser casing to be used with the 0.06m diameter convergent cone since it was the smallest and lightest among the three rotating atomiser casings. Its small size will reduce the space required for installation while its lightweight will reduce the total weight of the spraying mechanism in total.

ii) From Table 2, it was observed that the sprayer liquid flow rate was nearly constant at the value of 3.8 liter/min for the three rotating atomiser casings and for the five wind tunnel air speed ranges. This in fact supports the argument in (i).

iii) To get a better picture, graphs of width and length of area covered versus wind tunnel air speeds were plotted and as shown in Figure 4 and Figure 5 respectively. From these two Figures, similar observations as in (i) and (ii) could be made.

iv) From the width of floor area covered by sprayer liquid and the 80% length of the microlight wing span, the number of spraying mechanisms require to be installed was calculated to be four in order to have a well and homogenous sprayer liquid covered width for each microlight flight. The 20% (10% from each of the two wing ends) wing span reduction was made to ensure that the liquid spray does not get into the top vortex region otherwise the spray will be drifted away.

v) From the experiment it was also observed that all the three rotating atomisers produced droplets of sizes in the standard recommended range for aerial spraying of 30 – 150 microns [1]. Among the three rotating atomisers, the G140 produced the smallest spray droplets. Thus the G80 rotating atomiser will be used for future study on the performance of UTMAS-1 in aerial spraying since it has the capability of producing bigger size droplets which will provide better resistance to wind drift.

vi) With four sprayer being used, it was calculated that at a flying speed of 60 to 80 Km/h, the microlight could spray an area of 60 hectares in an hour with the use of 16 gallon of sprayer liquid.

6 CONCLUSION AND RECOMMENDATION FOR FUTURE WORK

From this research work the following conclusion could be made:

i) The CGS Hawk-1 microlight was found to be a suitable microlight for aerial spraying.

ii) An aerial spraying mechanism, the UTMAS-1, has been successfully designed and ground tested. It does not need any electrical system or pump to support its function and could easily be manufactured and installed for aerial spraying operation.

iii) It is envisaged that the installation of UTMAS-1 will not disturb the performance of the microlight. This may need some flight tests in order to prove it.

iv) At a height of 1m above plant canopies, the microlight using UTMAS-1 sprayer mechanism could spray an area of 60 hectares in an hour using 16 gallons of liquid at microlight flight speed between 60 to 80 Km/h.

v) The combination of CGS Hawk-1microlight and UTMAS-1 aerial spraying mechanism could be easily possessed by any medium size plantation owner or by a combination of several small plantation owners since the overhead, operation and maintenance costs are comparatively low and easily affordable. Government Agencies such as FELDA, MARDI, etc, have a better advantage since they have better finance and large hectarage of plantations throughout the country.

vi) By using microlight aerial spraying, the dependent of human labour will be greatly reduced and the time taken to spray insecticides, liquid manure or water will be minimised. Thus productivity will be increased.
vii) The performance of UTMAS-1 aerial spraying mechanism has yet to be tested in flight to study its effectiveness and also the effect of wind speed and direction on the liquid spray it produces.

7 ACKNOWLEDGEMENT

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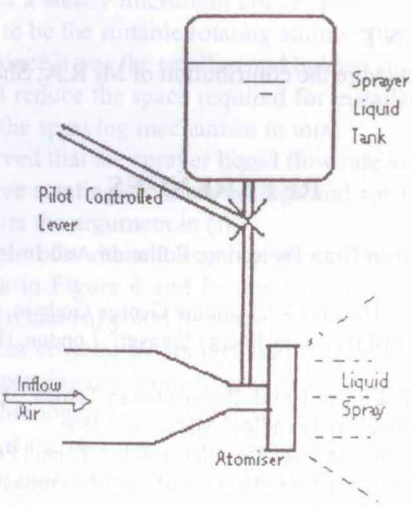

Figure 1 Spraying Mechanism Layout

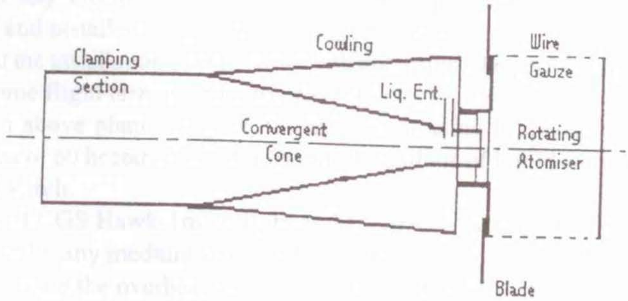

Figure 2 Detail of UTMAS-1 Aerial Sprayer

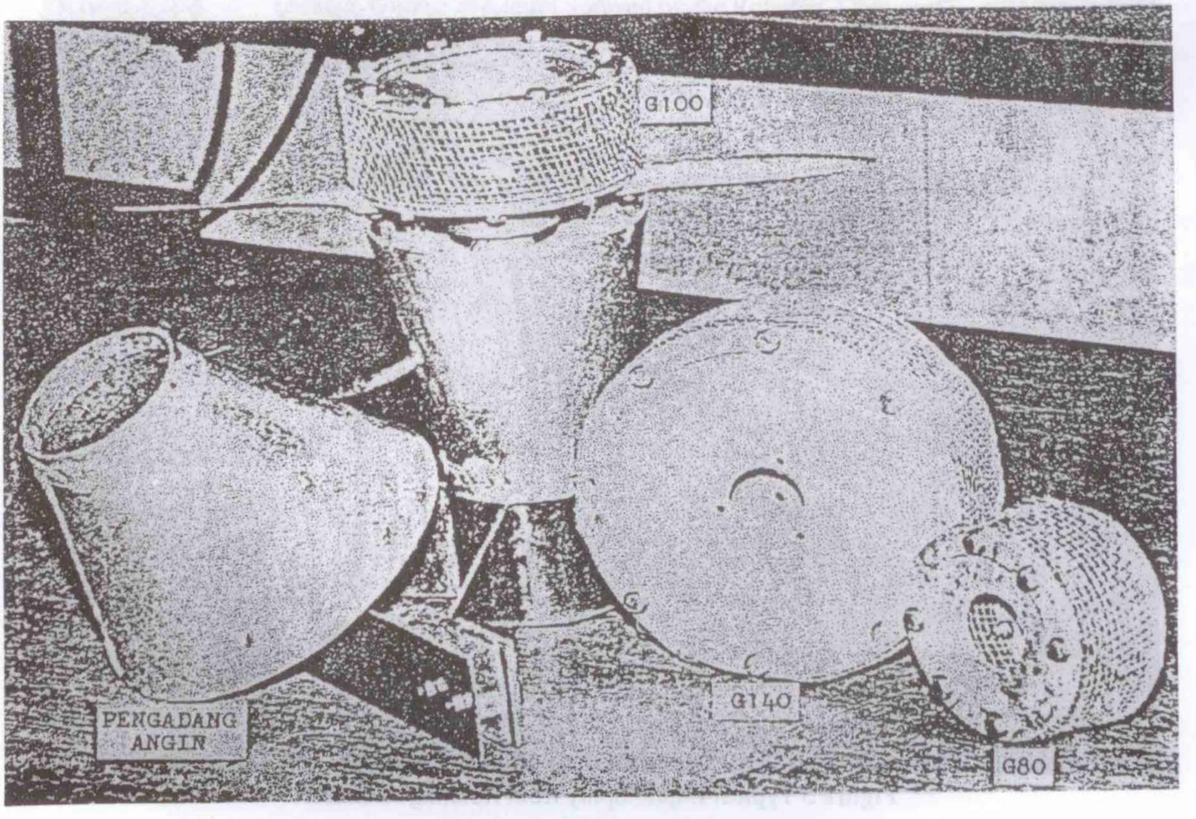

Figure 3 G80, G100 and G140 Rotating Atomiser Casings

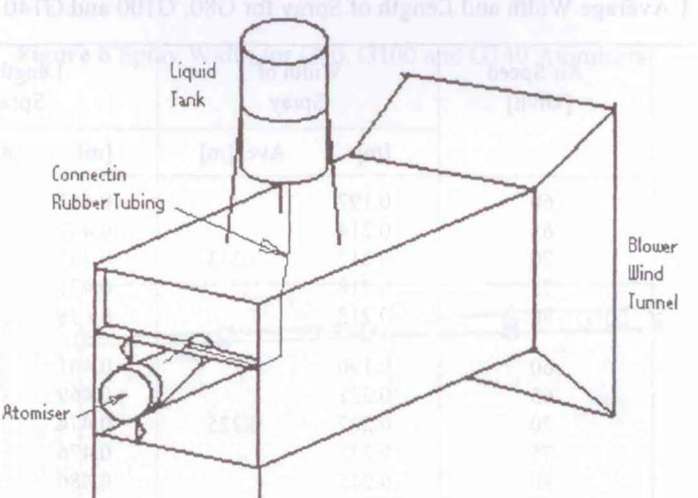

Figure 4 Experimental Set Up

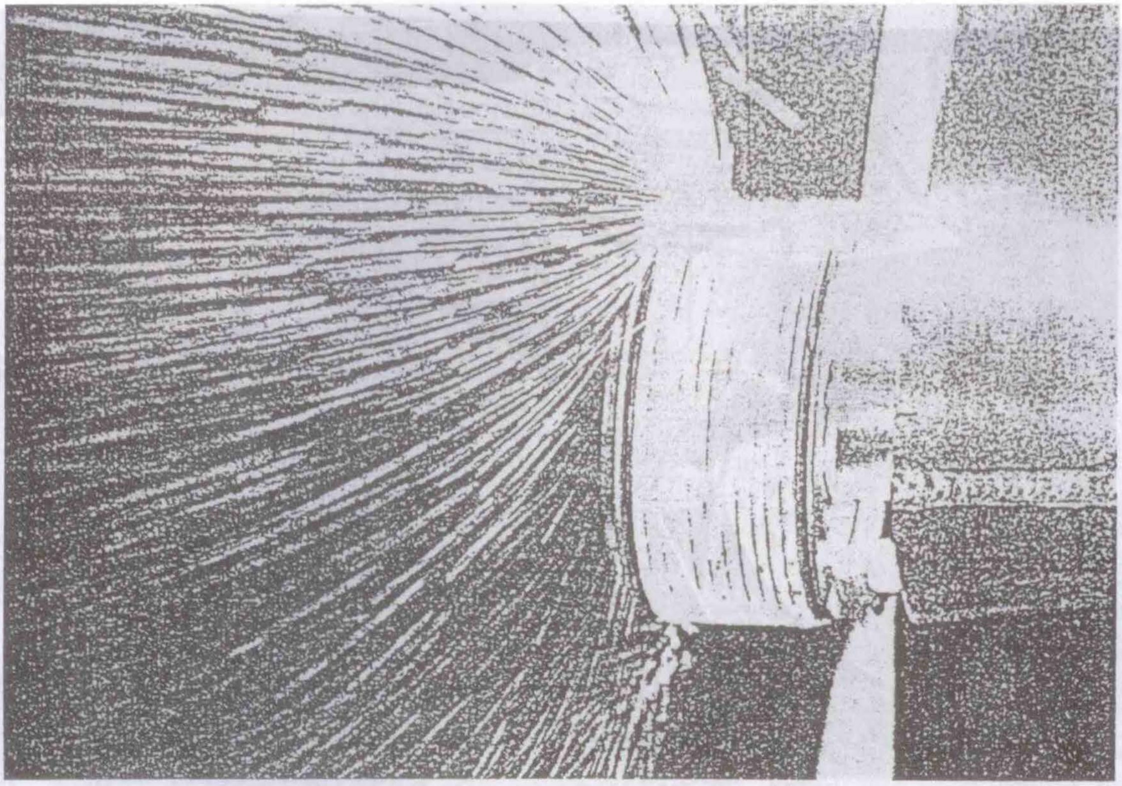

Figure 5 Typical Liquid Spray from Rotating Atomiser

Table 1 Average Width and Length of Spray for G80, G100 and G140 Sprayers

Model	Air Speed [km/h]	Width of Spray		Length of Spray	
		[m]	Ave. [m]	[m]	Ave. [m]
G80	60	0.197		0.442	
	65	0.214		0.447	
	70	0.217	0.213	0.461	0.459
	75	0.218		0.471	
	80	0.218		0.478	
G100	60	0.196		0.461	
	65	0.221		0.469	
	70	0.227	0.225	0.474	0.473
	75	0.237		0.476	
	80	0.245		0.486	
G140	60	0.204		0.463	
	65	0.258		0.475	
	70	0.269	0.257	0.493	0.499
	75	0.275		0.527	
	80	0.281		0.539	

Table 2 Volume of Liquid Sprayed by the Rotating Atomiser

Air Speed [km/h]	Volume of Spray [liter/min]
60	0.255
65	0.256
70	0.257
75	0.259
80	0.259

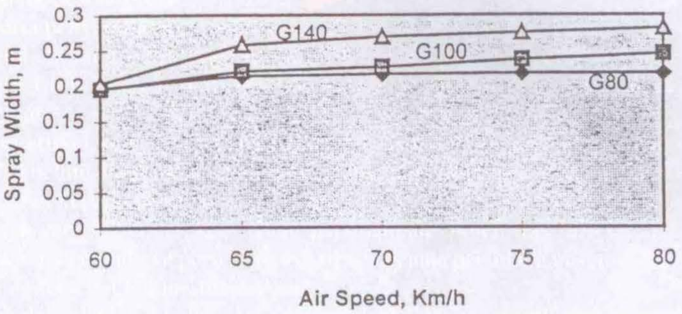

Figure 6 Spray Width for G80, G100 and G140 Atomisers

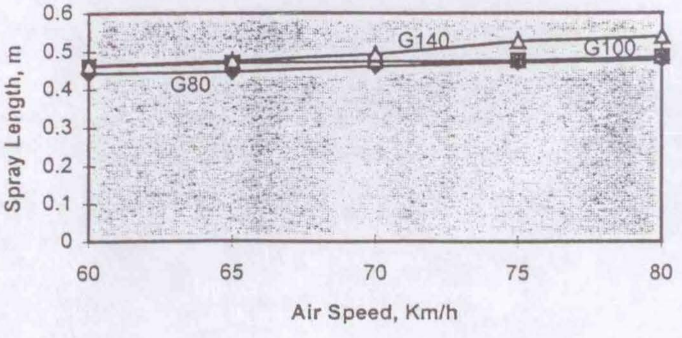

Figure 7 Spray Length for G80, G100 and G140 Atomisers