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DEVELOPMENT OF ENVIRONMENTAL CONTROL TECHNIQUES WITHIN ENCLOSED TRACTOR CAB

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ABSTRACT

This investigation was mainly carried out to develop and evaluate a stationary environmental cab with effective control techniques. Optical particle counters were used to measure the particulate matter that is 2.5 micrometers ($PM_{2.5}$) aerosol number concentration, $\mu g/m^3$ inside and outside the cab. The ratio of the two measurements (i.e., protection factor = outside concentration / inside concentration) was used to calculate how efficient the tractor cab was at removing aerosols, then Inverted these protection factors termed aerosol penetration. Testing was conducted to evaluate compliance with American Society of Agricultural Engineers Standard S525 [ASAE, 1997], and air quality measurement, (Temperature,°C and humidity,%). In the stationary test, the tractor's cab is isolated by glass wool and placed in a $25m^3$ volume of enclosed testing chamber. Aerosol, generated by burning incense sticks. Experiments were done under four parameters namely three different modes of aeration and filtration systems in insulated cab included, (fresh air mode, re-circulation mode and evaporative cooling mode), four different fan air speed of (1.8, 2.1, 2.5 and 3 m/sec.), two different cab position are used (In-cab and out-cab) and sixty levels of times (1, 2, 3, 4, …and 60 seconds) for each run of optical particle counter) & (Seven levels of 0, 5, 10, 15, 20, 25 and 30 minutes for each reading of air quality measurement. The obtained results showed that the best results of $PM_{2.5}$ concentration for inside cab, was 3.3 $\mu g/m^3$, the maximum values of Protection factors of filter inside cab was record 87, while aerosol penetration through filter inside cab, was record (1 / 87) = 0.0115, and the efficiency of filter with cab was 98.97%, obtained with fresh air mode in-cab at fan air speed of 1.8 m/sec., although getting the best result of the differences in temperatures in-cab, 7 °C, when using the cooling system evaporative, they recorded an increase of undesirable values humidity differences, (ΔRH), 11.7 %, with increasing the speed of the air fan because of the increasing saturation of the air spray of water used in the system.

INTRODUCTION

Environmental Management concept means that the management of the humankind's interaction and impact upon the environment. A complex web of human and ecological relationship make up the biosphere, linked directly with the natural sciences and manufacturing activities essential for human development. Spraying systems mounted on or towed by tractors, during operation of a spraying system, the air surrounding the spray vehicle and the available breathing air for the operator can become contaminated with pesticides, pollen, vapors and fine dusts. Enclosed cabs are an engineering control that can provide a safe, comfortable, and healthy work environment for operators, most of the tractors in Egypt are not equipped with safety cabs and protection facilities to protect the operator during application of spray, in that even under moderate outside conditions the closed cab act like greenhouse and its closed interior could become unpleasant, unbearable and even dangerous, and develops serious health problems. Air quality in-cab are almost depending on air particulate matter, and thermal conditions outside cab. Based upon the evaluation of tractor's cab, the American Society of Agricultural Engineers (ASAE) has developed ASAE S525, which is a consensus standard. This standard specifies requirements for environmental cab that are used for controlling applicator exposure to pesticide spray mist. The standard assumes that all of the pesticide aerosol is larger than 3µm. [ASAE, 1997]. So interested in this research to focuses on control the concentration of fine particulate matter (penetrate into the gas exchange regions of the lungs) less than or equal to 2.5µm in aerodynamic diameter ($PM_{2.5}$) [Reilly 1981]. At the same time to ensure preventing exposure to the larger than 3µm based upon ASAE S525.

Rusinki (1987) indicated that in design of driver cabs beside on ergonomic aspects, safety of the structure against loads from possible overturns of the tractor is one of the main criterions. Also the research including two steps. There by the first step includes the development of the design variants. The best solution is elaborated by repetitive computation of the actual stress and deformation characteristics of the protective structure using a PC and finite element methods. For this solution in the second step a prototype is to be built, for which stress and deformation characteristics are determined by experiments according to best specifications.

(EPA, 2012) proposed to strengthen the nation's air quality standards for fine particle pollution (particulate matter) to improve public health and visibility. Exposure to particle pollution causes premature death and is linked to a variety of significant health problems. Also it harms public welfare, including causing haze in cities and some of our nation's most treasured national parks . EPA has issued a number of rules that will help states meet the proposed revised standards by making significant strides toward reducing fine particle pollution.

Particulate matter is the term used for a mixture of solid particles and liquid droplets found in the air. $PM_{2.5}$ refers to particulate matter that is 2.5 micrometers or smaller in size. 2.5 micrometers is approximately 1/30 the size of a human hair; so small that several thousand of them could fit on the period at the end of this sentence. The sources of $PM_{2.5}$ include fuel combustion from automobiles, power plants, wood burning, industrial processes, and diesel powered vehicles such as buses and trucks. These fine particles are also formed in the atmosphere when gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds are transformed in the air by chemical reactions. Fine particles are of concern because they are risk to both human health and the environment.

Suggs (1991) mentioned that for the farming and forestry operations its recommended to shield the worker from the environment with a cab or similar enclosure. Insulating clothing can be worn to protect against the cold but little can be done, clothing wise, to protect against the heat.

Janssen (1986) stated that heat stress in closed cabs of agricultural machines often could be limited only by pressure cooling. But the relatively high air streams and low temperatures or their part must not cause discomfort. Therefore design and position of air cutters are of great importance for air motion in the cab. An investigation of different air outlets, in which the response of test persons to air motion, thermal sensation, and comfort has been inquired, demonstrates that thermal comfort in cabs under certain conditions can be guaranteed for a great fraction of persons.

The objective of the present study was planned to be realized through the following stages:

1. Study the environmental problems when pesticides sprayed under the Egyptian environmental conditions, to determine the basic data necessary for design and develop the safe cabin .
2. Develop a stationary expedient, simple, quantitative, and reliable cab with effective control techniques from local material. to evaluating the tractor’s cab to be protective of workers.

MATERIALS AND METHODS

The present study was carried out at Mansoura city and Shobrawesh village, Aga, Dakahlia Governorate, Egypt, to determine the basic data necessary for design and develop the safe cab, to evaluate the effectiveness of control techniques to be protective of workers inside cab by measure of outside and in-cab air $PM_{2.5}$ concentration, $\mu g/m^3$; air quality measurement, (Temperature,°C and humidity,%)

The developed stationary cab at enclosure:

Fig.1 shows a schematic diagram of a three systems of air flow through filters which evaluated at the stationary cab at enclosure.

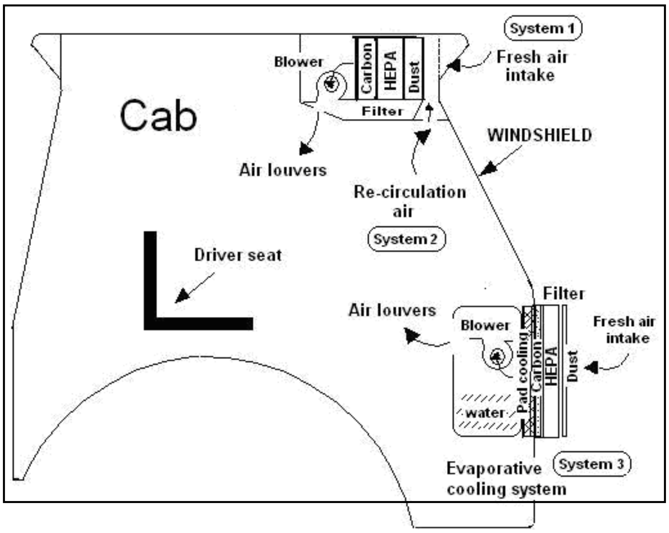

Fig. 1: Schematic diagram of a three systems of air flow through filters at the stationary cab.

Components of the stationary test:

The main parts of stationary test are as follows:

1 – Tractor's cab:

The main frame of Romanian tractor's cab model Universal 650 which has been used as the basis for the development of environmentally a stationary safe cab with $2.5m^3$ Interior volume. As shown in Fig.(2)

Fig. 2: The photograph of the used cab before take off from the tractor.

2 – Test enclosure:

The tractor cab is isolated by glass wool and placed in a $25m^3$ volume of enclosed testing chamber shown in Fig.3, the enclosure is 4m long, 2.5m wide and 2.5m high, the enclosure constructed of wood studs and polyethylene vapor barrier, A fan rapidly ensures concentration homogeneity within the chamber (fan blade diameter 0.3m, fan rotation speed 800 rpm, with minimum air flow rate 720 m^3/hr).

Fig. 3: The photograph of the used cab placed in a testing enclosure.

3 –Filtration system:

The tractor cab is equipped with two sets of filtration system consists of a three stages of filters by a pre-filter followed by a high-efficiency particulate air (HEPA) and followed by bed of Activated carbon as shown in Fig. 4, the first set have overall dimensions (205mm height × 205mm width×390mm thickness) was used with ventilation system, while another one have overall dimensions (310mm height × 310mm width × 486mm thickness) was used with Evaporative cooling system.

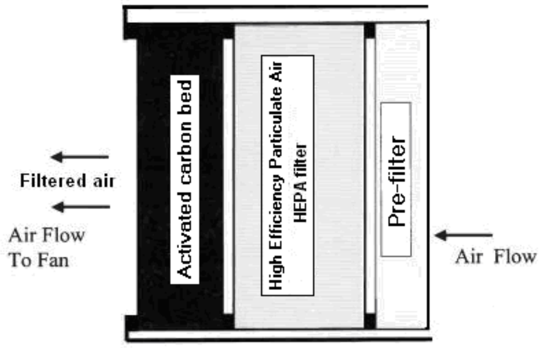

Fig. 4. Schematic cross-sectional view of a three stages of filters.

4 – Ventilation system:

The cab is equipped with ventilation system consists of centrifugal blower fan (12V battery-powered), with air flow rate of 20 m^3/min and outlet air speed range of 4 speeds, (1.8, 2.1, 2.5, 3 m/sec) as shown in Fig. 5, which used to pull fresh air through the first group of filtration system which remove air contaminants and pressurize the cabin. In addition, this cabin is designed to re-circulate air from the cab through the same filtration system and back into the cab again (re-circulate air every 30 minutes).

Fig. 5: Photograph of the ventilation system with a centrifugal blower fan.

5 – Evaporative cooling system:

The cab is equipped with air cooler shown in Fig. 6, through the principle of water evaporation and honeycomb pad, But supply it with the same mentioned centrifugal blower fan used in ventilation system instead of the original, so as to apply the same speeds with the second group of filtration system. It has water pump with 150W and 0.5-0.6 L/hr. of water consumption.

Fig. 6: The photograph of the used Evaporative cooling system.

Treatments:

The studied parameters of the experimental trails are:

1- Aeration and filtration systems; S:

Three different modes of aeration and filtration systems were tested in insulated cabin included, Fresh Air mode (S1), Re-circulation mode (S2) and Evaporative cooling mode (S3).

2- Air fan speed; V:

Four different air fan speed of 1.8, 2.1, 2.5 and 3 m/sec.

3- Cab position ; C:

Two different measurement of cab position are used In-cab and out-cab

4- Time; t:

Different levels of times (sixty levels of 1, 2, 3, 4, …and 60 seconds for each Run of optical particle counter) & (Seven levels of 0, 5, 10, 15, 20, 25 and 30 minutes for each reading of air quality measurement).

Skeleton of Measurements

1- Particle matter concentration in-cab and outside ($PM_{2.5}$), $\mu g/m^3$.
2- Temperature (T), ^0C & Humidity (RH), %, in-cab and outside.

Instrumentation and technique:

Stop watch with an accuracy of 0.01 second has been used to measure consumed time for each experimental treatment. Two identical digital Handheld $PM_{2.5}$ concentration meter as shown in (Fig. 7) were used to measure of outside and in-cab air $PM_{2.5}$ concentration, ($\mu g/ m^3$). A digital humidity, temperature and airflow meter was used to measure humidity, ambient air Temperature and air velocity at the stationary tests.

Fig. 7: A digital Handheld PM2.5 concentration meter.

Methods:

$PM_{2.5}$ concentration measurement:

While the stationary cab was placed into the enclosure test chamber, to determine the concentrations of particulate matter less than or equal to 2.5

µm in aerodynamic diameter ($PM_{2.5}$, particulate matter into the lungs) by using a method of [Gebhart J (1993)], with raise $PM_{2.5}$ concentration, $\mu g/m^3$ by incense sticks. When burned two incense sticks for 30 minutes before measuring directly into the enclosure test chamber, then the fumes were fanned manually to create a relatively uniform concentration. The incense sticks were then extinguished and the in-cabin and outside $PM_{2.5}$ concentration was monitored, with display the data directly, $\mu g/m^3$, by using two identical digital handheld $PM_{2.5}$ concentration meter which used to measure at the same time of outside and in-cab air $PM_{2.5}$ concentration.

Protection factors (P_F) measurement:

The Protection factors of environmental controlling systems in- cab were expressed according to equation (1) of (EN 799 (2002)):

$$P_F = \{ C_o / C_i \} \quad [1]$$

where:

P_F = The Protection factors for cab with filtration system, Constant.

C_o = Outside cab concentration of Aerosol ($PM_{2.5}$), $\mu g/m^3$

C_i = Inside cab concentration of Aerosol ($PM_{2.5}$), $\mu g/m^3$

Aerosol penetration (P_A) measurement:

The Aerosol penetration of filtration systems in- cab were expressed according to equation (2) of (EN 799 (2002)):

$$P_A = \{ C_i / C_o \} = 1/ P_F \quad [2]$$

where:

P_A = The penetration into filter for cab, Constant.

Efficiency of cab and filter system (η_f)measurement:

The Efficiency of filtration systems in- cab were expressed according to equation (3) of (EN 799 (2002)):

$$\eta_f = 1- \{ C_i / C_o \} \times 100 \text{ , \%.} \quad [3]$$

where:

η_f = The Filtration efficiency, %.

Temperature (T), ^{0}C & Humidity (RH), %, measurement:

The Temperature (T),^{0}C & Relative humidity (RH),%, were determined with display the data directly, by using A digital Humidity, Temperature and Airflow meter which used to measure the difference between in-cab and outside readings at stationary tests.

RESULT AND DISCUSSION

Effect of the time on $PM_{2.5}$ concentration

Figures (8) and (9) shows the effect of the time on the $PM_{2.5}$ concentration in & out – cab at different air fan speeds, with Fresh air mode (S1). In general, a oscillates relationship between the $PM_{2.5}$ concentration, $\mu g/m^3$ and time, sec. was obtained. It was obvious that increasing the air speed increases the $PM_{2.5}$ concentration in-cab. While the $PM_{2.5}$ concentration out-cabin decreased that although he is a characterization of the same measurement conditions inside the cab, but may be due to the presence of the effect of pulling the fan speed of indoor air enclosure test chamber. The amount $PM_{2.5}$ concentration, $\mu g/m^3$ were 5; 7; 6.7 and

5, μg/m^3, obtained at 1.8; 2.1; 2.5 and 3 m/sec air fan speed, respectively and at 30 sec of time for inside cab. The same result were 472.3; 441.3; 461.2 and 419, μg/m^3, for outside cab under the same condition of fan speed 1.8; 2.1; 2.5 and 3 m/sec respectively, time of 30 sec and aeration and filtration systems of Fresh air mode (S1).

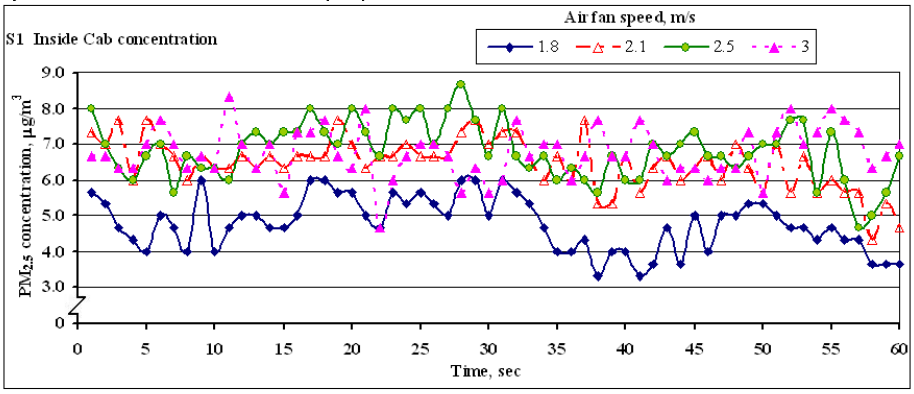

Fig. 8: Effect of time on In - cab $PM_{2.5}$ concentration at different air fan speeds (m/s) with Fresh air mode (S1) under study.

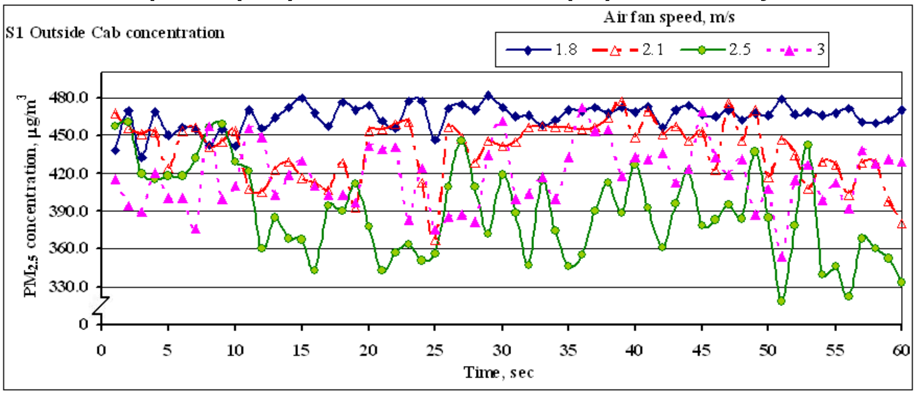

Fig. 9: Effect of time on out - cab $PM_{2.5}$ concentration at different air fan speeds (m/s) with Fresh air mode (S1) under study.

As shown in Figs. (10) and (11), shows the effect of the time on the $PM_{2.5}$ concentration in & out – cab at different air fan speeds, with Re-circulation mode (S2). It was obvious that increasing the air speed increases the $PM_{2.5}$ concentration in-cab. The amount $PM_{2.5}$ concentration, μg/m^3 were 6; 7; 6 and 7.7μg/m^3, obtained at 1.8; 2.1; 2.5 and 3 m/sec fan speed, respectively and at 30 sec of time for inside cabin. The same result were 362; 425; 362.7 and 424 μg/m^3, for outside cabin under the same condition of fan speed 1.8; 2.1; 2.5 and 3 m/sec respectively, time of 30 sec and aeration and filtration systems of Re-circulation mode.

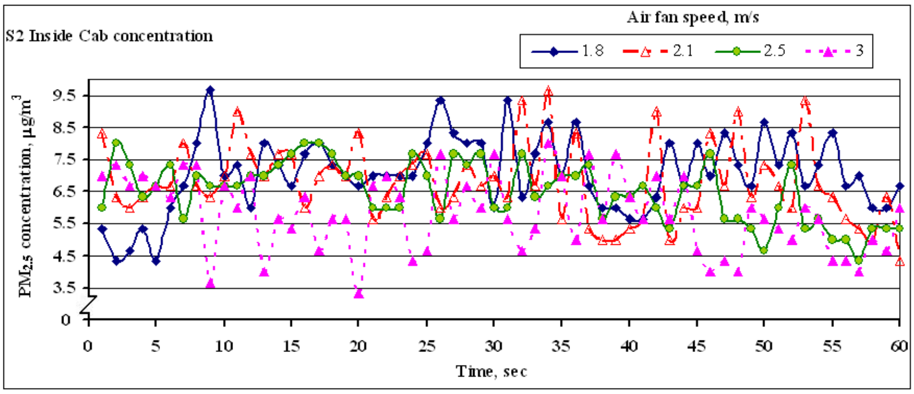

Fig. 10: Effect of time on In - cab $PM_{2.5}$ concentration at different air fan speeds (m/s) with Re-circulation mode (S2) under study.

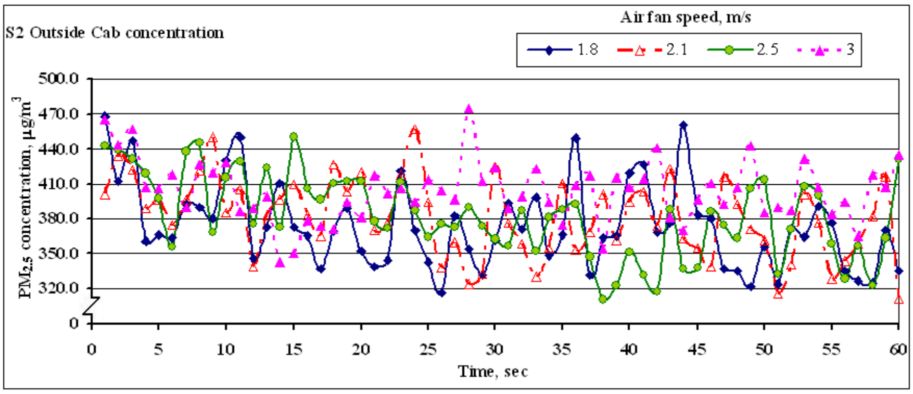

Fig. 11: Effect of time on out - cab $PM_{2.5}$ concentration at different air fan speeds (m/s) with Re-circulation mode (S2) under study.

As shown in Figs. (12) and (13) shows the effect of the time on the $PM_{2.5}$ concentration in & out–cab at different air fan speeds, with Evaporative cooling mode (S3). It was obvious that increasing the air speed increases the $PM_{2.5}$ concentration in-cab. The amount $PM_{2.5}$ concentration, $\mu g/m^3$ were 9.3; 9.3; 10.7 and 11.7 $\mu g/m^3$, obtained at 1.8; 2.1; 2.5 and 3 m/sec fan speed, respectively and at 30 sec of time for inside cab. The same result were 411; 413.3; 403 and 311 $\mu g/m^3$, for outside cab under the same condition of fan speed 1.8; 2.1; 2.5 and 3 m/sec respectively, time of 30 sec and aeration and filtration systems of Evaporative cooling mode.

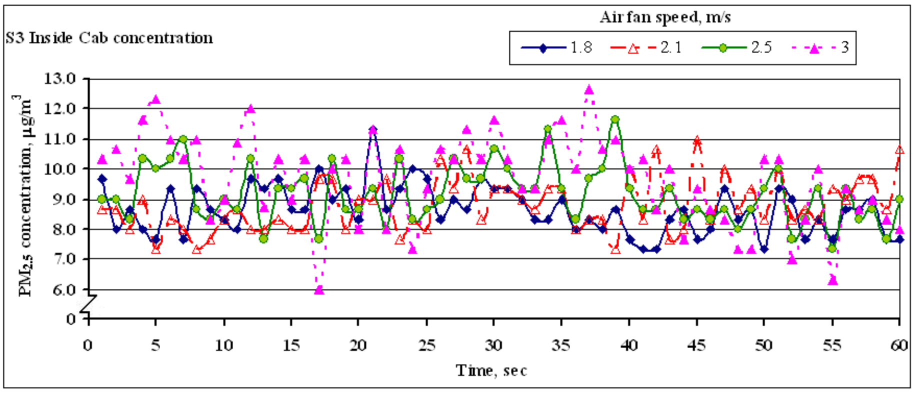

Fig. 12: Effect of time on In - cab $PM_{2.5}$ concentration at different air fan speeds (m/s) with Evaporative cooling mode (S3) under study.

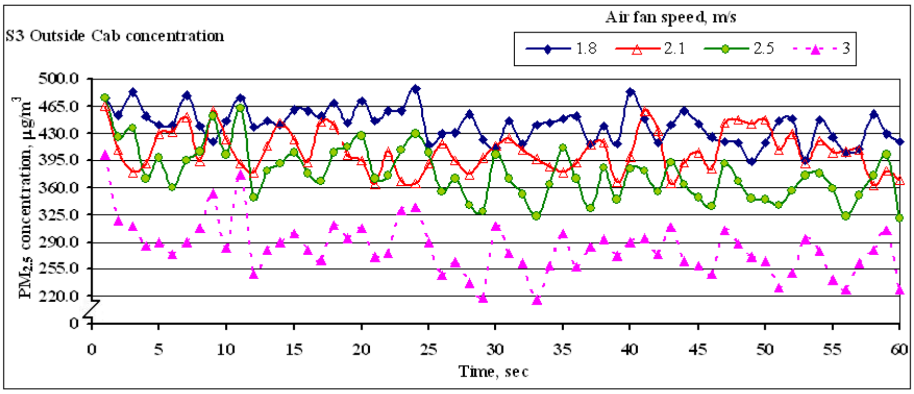

Fig. 13: Effect of time on out - cab $PM_{2.5}$ concentration at different air fan speeds (m/s) with Evaporative cooling mode (S3) under study.

The results indicated that the lowest of mean values of $PM_{2.5}$ concentration for inside cab, was 3.3 $\mu g/m^3$, which obtained at 1.8 m/sec fan speed, 38 sec of time at aeration systems of Fresh air mode. On other hand the highest value of $PM_{2.5}$ concentration for inside cab, was 12.7 $\mu g/m^3$, which obtained at 3 m/sec fan speed, 37 sec of time and aeration systems of Evaporative cooling mode.

Effect of Air fan speed on $PM_{2.5}$ concentration

The effect of Air fan speed on the main average of $PM_{2.5}$ concentration inside cabin under constant other independence factors at different aeration and filtration systems was illustrated in Fig.(14). The data indicated that a positive effect of increasing the Air fan speed on $PM_{2.5}$ concentration at aeration systems of fresh air mode and Evaporative cooling mode while reverse effect at Re-circulation mode. The best result was the minimum value of $PM_{2.5}$ concentration inside cab, it was record 4.783 $\mu g/m^3$ obtained at air fan speed of 1.8 m/sec., at fresh air mode (S1).

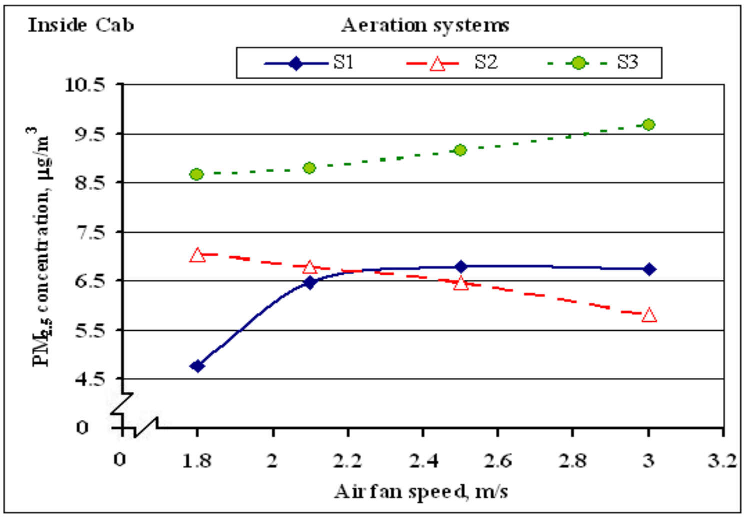

Fig. 14: Effect of Air fan speed on In - cab $PM_{2.5}$ concentration at different aeration systems under study.

Effect of Air fan speed on Protection factors

Results illustrated in Fig. (15) shows the effect of Air fan speed on the main average of Protection factors inside cab under constant other independence factors at different aeration and filtration systems. The data indicated that a positive effect of increasing the Air fan speed on $PM_{2.5}$ concentration at aeration and Filtration systems of Re-circulation mode while reverse effect at fresh air mode and Evaporative cooling mode. The maximum value of Protection factors of filter inside cab was record 87 obtained in-cab at air fan speed of 1.8 m/sec., at fresh air mode.

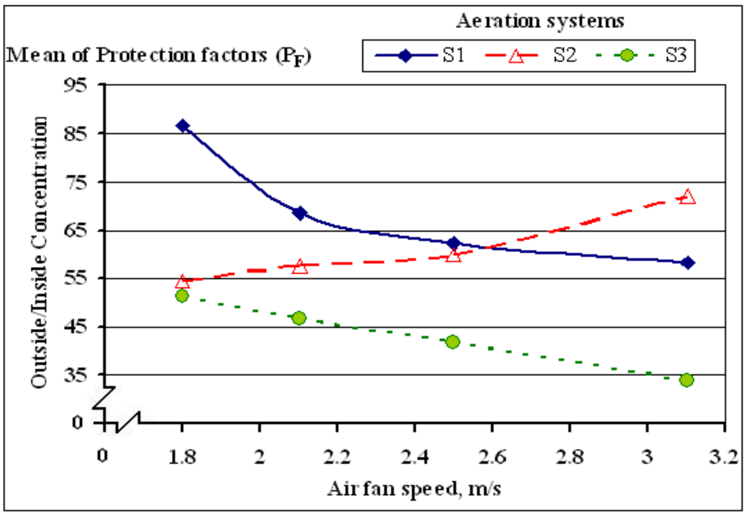

Fig. 15: Effect of Air fan speed on In - cab Protection factors of $PM_{2.5}$ at different aeration systems under study.

Effect of Air fan speed on Aerosol Penetration

Results presented in Fig. (16), show the effect of Air fan speed on the main average of aerosol penetration in-cab under constant other independence factors at different aeration and filtration systems. The data indicated that a positive effect of increasing the air fan speed on $PM_{2.5}$ concentration at fresh air mode and Evaporative cooling mode while reverse effect at Re-circulation mode. The best result was the minimum value of aerosol penetration through filter inside cab, it was record (1 / 87)= 0.0115 obtained in-cab at air fan speed of 1.8 m/sec. and at fresh air mode.

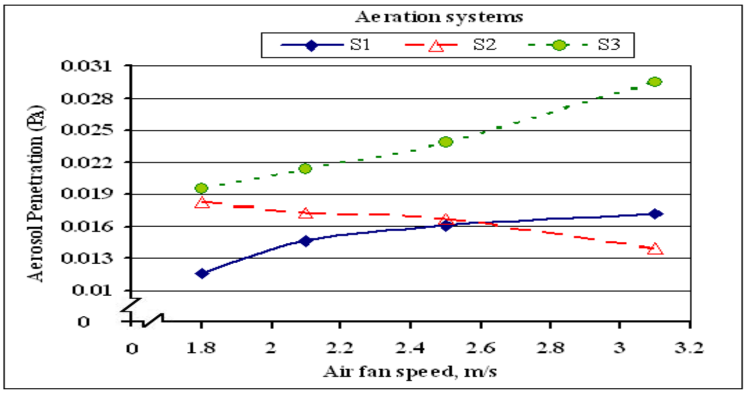

Fig. 16: Effect of Air fan speed on In - cab Aerosol Penetration of $PM_{2.5}$ at different aeration systems under study..

Effect of Air fan speed on filter of cabin efficiency,%

Fig. (17) show the effect of Air fan speed on the main average of filter of cabin efficiency inside cab under constant other independence factors at different aeration and filtration systems. The data indicated that a positive effect of increasing the Air fan speed on $PM_{2.5}$ concentration at aeration systems of Re-circulation mode while reverse effect at fresh air mode and Evaporative cooling mode. The maximum efficiency of filter with cabin was 98.97 %, obtained in-cab at air fan speed of 1.8 m/sec. and at fresh air mode

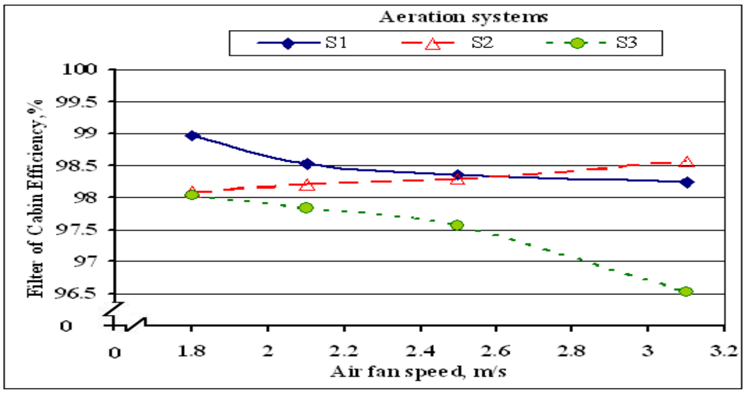

Fig. 17: Effect of Air fan speed on In - cab filter of cab efficiency of $PM_{2.5}$ at different aeration systems under study..

Effect of aeration time and Air fan speed on difference temperature (ΔT),°C. between in-cab and outside cab

Results presented in Fig. (18), show the Effect of aeration time and Air fan speed on difference temperature (ΔT), °C. between in-cab and outside cab under constant other independence factors at different aeration and filtration systems. The data indicated that a positive effect of increasing the aeration time and air fan speed on difference temperature (ΔT), °C. at aeration systems of fresh air mode and Evaporative cooling mode while reverse effect at Re-circulation mode, this is due to the reason for the increase in the degree of circulating air temperature inside a closed cycle. The best result was the maximum values of difference temperature (ΔT), °C., it was obtained at Evaporative cooling mode, with increasing of air fan speed.

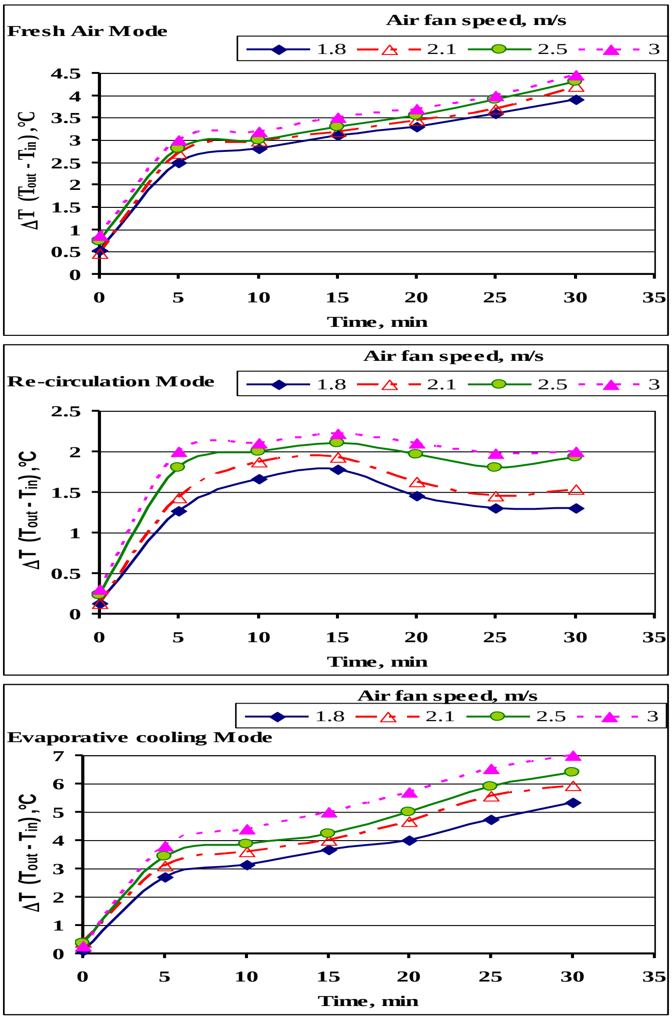

Fig. 18: Effect of aeration time and Air fan speed on difference temperature (ΔT), °C. between in-cab and outside cab

Effect of aeration time and Air fan speed on difference humidity (ΔRH),%, between in-cab and outside cab

Results illustrated in Fig. (19) shows the Effect of aeration time and Air fan speed on difference humidity (ΔRH), %, between outside cab and in-cab under constant other independence factors at different aeration and filtration systems. The data indicated that a positive effect of increasing the aeration time and Air fan speed on difference humidity (ΔRH), %, at fresh air mode and Evaporative cooling mode while reverse effect at Re-circulation mode, this is due to the reason for the increase in the degree of circulating air temperature with decrease in the humidity inside a closed cycle. The best result was obtained at Re-circulation mode with increasing of air fan speed, in-cab, when the undesirable values humidity differences, (ΔRH), 11.7%, with using the cooling system evaporative, at increasing the speed of the air fan.

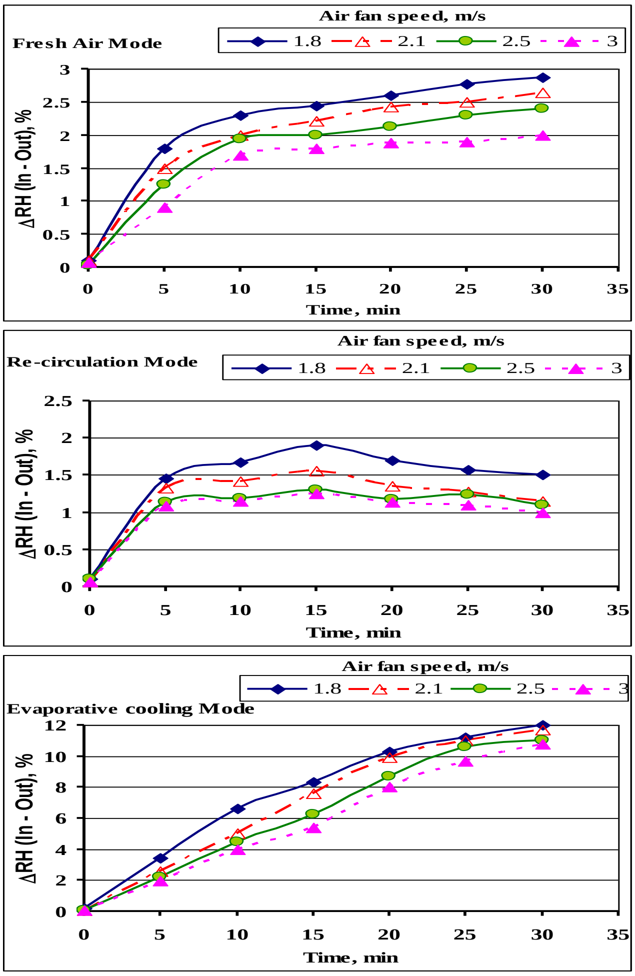

Fig. 19: Effect of aeration time and Air fan speed on difference humidity (ΔRH), %, between in-cab and outside cab

CONCLUSION

The obtained results from this study could be summarized as follows:

- The minimum values of $PM_{2.5}$ concentration for inside cab, was 3.3 $\mu g/m^3$, the maximum values of protection factors of filter inside cab was record 87, While aerosol penetration through filter inside cab, was record (1 / 87) = 0.0115, and the maximum efficiency of filter with cab was 98.97%, obtained in-cab at air fan speed of 1.8 m/sec. at fresh air mode
- The best result of difference temperature (ΔT), 7 °C., it was obtained at Evaporative cooling mode, while that the worst result of difference humidity (ΔRH), 11.7 %, with increasing of air fan speed. because of the increasing saturation of the air spray of water used in the system.
- Finally, it is recommended to apply the aeration and filtration system by fresh air mode with air speed of 1.8 m/sec to achieve higher protective factor and efficiency of filter in-cab.

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تطوير تقنيات التحكم البيئي داخل كابينة الجرار المغلقة

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تأخذ المبادئ العامة لإدارة البيئية في اعتبارها التداخل البشري مع البيئة، شبكة معقدة من العلاقات بين الإنسان والبيئية تشكل المحيط الحيوي وترتبط مباشرة مع العلوم الطبيعية وأنشطة الصناعة التحويلية الأساسية للتنمية البشرية. فأثناء تشغيل أنظمة رش المبيدات مع الجرارات، فإن الهواء المحيط بالجرار والهواء المتاح لتنفس المشغل يصبح ملوث بالمبيدات الحشرية، وخلالها تتشكل منظومة بيئية (السائق مع الجرار). وتعد الكبائن المغلقة أهم عناصر التحكم الهندسية التي يمكن أن توفر بيئة عمل آمنة ومريحة وصحية للمشغلين، وحيث أن معظم الجرارات الزراعية في مصر ليست مجهزة بكبائن مغلقة أو وسائل أمان وحماية لصحة المشغل أثناء تطبيق الرش، حتى مع كابينة الجرار التقليدية، قد يتعرض المشغل لمستويات عالية من الملوثات داخل الكابينة، وجودة الهواء داخل الكابينة قد يكون لها آثار كبيرة على صحة المشغل وسلامته، ونجد أنه حتى في ظل الظروف الجوية المعتدلة خارج الكابينة المغلقة قد تتكون ظاهرة الاحتباس الحراري داخلها، وبالتالي لا يطاق الجو داخلها بل وتصبح خطيرة. تعتمد جودة الهواء داخل كابينة الجرار أساسيا على تركيز الملوثات بالهواء والظروف الحرارية خارجها. لذلك اهتم هذا البحث بتطوير نموذج كابينة آمنة من التلوث البيئي في محاولة لإيجاد حل لهذه المشكلة. وقد أجريت هذه الدراسة لتطوير وتقييم تقنيات التحكم البيئي داخل كابينة الجرار المغلقة. حيث تم استخدام العدادات الضوئية للجسيمات العالقة بقطر 2,5 ميكرومتر لقياس تركيزها داخل وخارج الكابينة في دراسة معملية ثابتة، تم عزل كابينة الجرار بواسطة الصوف الزجاجي ووضعها داخل غرفة اختبار مغلقة حجمها 25 م3. ويتم توليد الجسيمات العالقة داخل غرفة الاختبار عن طريق حرق أعواد البخور. وقد أجريت التجارب تحت أربعة معايير وهي دراسة ثلاثة أنماط مختلفة من أنظمة التهوية والترشيح في كابينة معزولة شملت، (وضع الهواء النقي، وضع إعادة التداول ووضع التبريد التبخيري)، أربعة أنواع مختلفة من سرعة هواء المروحة من (1,8، 2,1، 2,5 و 3 م/ثانية)، وتستخدم اثنين من موقع القياس (داخل الكابينة وخارجها) ومستويات مختلفة من الوقت بعدد ستون مستوى (1 و 2 و 3 و 4 و ... و 60 ثانية) زمن كل جولة من عداد الجسيمات البصرية وسبعة مستويات 0، 5، 10، 15، 20، 25 و 30 دقيقة لكل قراءة لقياس جودة الهواء). وأظهرت النتائج المتحصل عليها أن أفضل النتائج من تركيز الجسيمات العالقة بقطر 2,5 ميكرومتر داخل الكابينة، كانت 3,3 ميكروجرام/م3 ، وكانت القيمة القصوى لعامل الحماية لنظام الترشيح داخل الكابينة هي 87 ، بينما كانت قيمة الاختراق من خلال نظام الترشيح داخل الكابينة، هي (1 / 87) = 0,0115. وكانت كفاءة منظومة الترشيح والكابينة هي 98,97٪، تم الحصول عليها عند سرعة هواء المروحة 1,8 متر / ثانية. في وضع الهواء النقي. على الرغم من الحصول على أفضل نتيجة لفروق درجات الحرارة، 7 °م داخل الكابينة، عند تشغيل منظومة التبريد التبخيري، إلا أنها سجلت زيادة غير مرغوبة لقيم فروق الرطوبة، 11,7٪، مع زيادة سرعة مروحة الهواء وذلك بسبب زيادة تشبع الهواء برذاذ الماء المستخدم في هذه المنظومة .