

**DESIGN OF A SIMPLIFIED INSTRUMENTATION
TO MEASURE AIR POLLUTION PRODUCED
FROM FARM MACHINERY**

**BY
WESSAM SHAWKY ABD EL MOHSEN MOHAMED**

B. Sc. Agricultura (Agricultural Engineering), Faculty of
Agriculture, Cairo University (1999).

A Thesis Submitted in Partial Fulfillment
of
The Requirements for the Master Degree
In
Environmental Science

**Department of Agricultural Science
Institute of Environmental Studies And Research
Ain – Shames University,
Cairo, Egypt.**

2010

APPROVAL SHEET

DESIGN OF A SIMPLIFIED INSTRUMENTATION TO MEASURE AIR POLLUTION PRODUCED FROM FARM MACHINERY

BY

WESSAM SHAWKY ABD EL MOHSEN MOHAMED

B. Sc. Agric. (Agricultural Engineering), Faculty of Agriculture,
Cairo University (1999).

This Thesis Towards a Master Degree in Environmental
Science Has Been Approved by:

Name	Signature
1- Prof. Dr. Ahmed Mohamed Ahmed El-Assal ----- Prof. of Design and Production, Mechanical Engineering, Benha High Institute of Technology, Benha University.	
2- Prof. Dr. Hassan Abd El-Razek Abd El-Mawla ----- Prof. of Agricultural Engineering, Head of Agricultural Engineering Department, Faculty of Agriculture (Assut), Al- Azhar University.	
3- Prof . Dr . Abd-El-Ghany Mohamed El-Gindy ----- - Prof . of Agricultural Engineering. Faculty of Agriculture, Ain Shams University. (Supervisor)	
4- Prof . Dr. Magdy Ahmed Baiomy ----- Chief Researcher, Design and Development Department, Agricultural Engineering Research Institute (AEnRI), Agriculture Research Center, Ministry of Agriculture. (Supervisor)	

DESIGN OF A SIMPLIFIED INSTRUMENTATION TO MEASURE AIR POLLUTION PRODUCED FROM FARM MACHINERY

**BY
WESSAM SHAWKY ABD- EL MOHSEN
MOHAMED**

B. Sc. Agricultural. (Agricultural Engineering), Faculty of
Agriculture, Cairo University (1999).

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Master Degree
In
Environmental Science

Department of Agricultural Science
Institute of Environmental Studies And Research
Ain – Shames University.

Under The Supervision of :

1- Prof . Dr . Abd-El-Ghany Mohamed El-Gindy.

Prof . of Agricultural Engineering, Faculty of Agriculture
Ain Shams University and Previous Dean.

2- Prof . Dr. Magdy Mohamed Abdelhameed

Prof. Design and Production, Faculty of Engineering
Ain Shams University.

3- Prof . Dr. Magdy Ahmed Baiomy

Chief Researcher, Design and Development Department
Agricultural Engineering Research Institute (AEnRI),
Agriculture Research Center, Ministry of Agriculture.

CONTENTS

No	Subject	Page No
1	INTRODUCTION	1
2	REVIEW OF LITERATURE.....	3
2-1	Air Pollution.....	3
2-2	Aerodynamic of Particles.....	7
2-3	Techniques of Air Pollution Measurement ...	10
3	MATERIALS AND METHODS	15
3-1	Materials	15
3-1-1	Physical and mechanical properties of wheat straw	15
	a- Wheat straw size.....	15
	b- Specific density of wheat straw.....	15
	c- Terminal velocity of wheat straw.....	16
3-1-2	Design and construction of proposed portable instrument.....	16
	1- Main device	19
	- Straw collection mechanism.....	19
	i- Main frame.....	19
	ii- Filtration unit.....	19
	iii- Suction air unit.....	22
	- Sensation system.....	22
	i- Weight sensor.. ..	22
	ii- strain gage	23
	iii- Read and analysis results (PCD device)	25
	2- Stand device.....	27
	i- Telescopic stand	27
	ii- Stand base	27
3-1-3	Instruments.....	27
	A- PCD-300A sensor interface	28
	B- Personal dust sampler device.....	28
	C- Hygro Thermo Anemometer.....	30
	D- Combination contact / Photo Tachometer	30
	E- Terminal velocity apparatus.....	30
	F- Balance scale.....	31
	G- Sieves.....	31

3-2	Methods And Measurements	31
3-2-1	Sizes of wheat straw.....	31
3-2-2	Terminal velocity.....	33
3-2-3	Experiments.....	33
3-2-3-1	laboratory experiments.....	33
3-2-3-2	Field experiments.....	34
	1- Calibrating of the instrument	34
	2- Testing the instrument.....	39
3-2-4	Fine dust inhaled by the thresher operator	39
4	RESULTS AND DISCUTION.....	42
4-1	Physical and Mechanical Properties of Pollution Straw Particles Which Measured by Design Instrument.....	42
	Wheat straw sizes.....	42
4-2	Laboratory Experiments.....	45
4-3	The Field Experiments.....	46
4-3-1	Calibrating the instrument.....	46
4-3-2	Analysis of The Relationship Between Weight of Chaff on Filter And Weight of Chaff on Sensor.....	58
4-3-3	Instrument Sensitivity for Measuring Pollution Due to Threshing Operation at Variable Distances from The Machine.....	67
4-3-4	Testing the instrument	68
4-4	Relationship Between Feeding Weight (tan) of Wheat Crop and Quantity of Straw (Chaff) Which Suspended.....	69
4-5	Effect of Air Pollution on Thresher Operator.....	69
5	SUMMARY AND CONCLUSION	71
6	REFERENCES.....	75
7	ARABIC SUMMARY.....	

LIST OF TABLES

No	Table	Page No.
1	Table (2-1): Ambient air quality limit values as given by law no.4 of Egypt.....	5
2	Table (3-1): The axel flow fan specification.....	22
3	Table (3-2): The specification of the PCD-300A device.....	28
4	Table (3-3): Set. of experiments and their objectives.....	34
5	Table (3-4): Conditions of the measurements during the field experiments to design instrument recorded at the same time of each experiment.....	35
6	Table (4-1): The total area, yield, production of wheat crop and wheat straw.....	43
7	Table (4-2): The sizes of wheat straw at 60 m and 100 m distances from thresher machine...	43
8	Table(4-3):Physical and mechanical properties for Wheat straw.....	44
9	Table (4-4): calibration the design instrument in laboratory.....	45
10	Table (4-5): The relationship between the weight of pollution particles absorbed by the filter and weight of pollution particles fall on sensor at distance 60m (B) from the machine at different heights.	46
11	Table (4-6): The relationship between the weight of pollution particles absorbed by the filter and weight of pollution particles fall on sensor at distance 60m (C) from the machine at different heights.....	47
12	Table (4-7): The relationship between the weight of pollution particles absorbed by the filter and weight of pollution particles fall on	

	sensor at distance 60m (A) from the machine at different heights.	48
13	Table (4-8): The relationship between the weight of pollution particles absorbed by the filter and weight of pollution particles fall on sensor at distance 100m (E) from the machine at different heights.	49
14	Table (4-9): The relationship between the weight of pollution particles absorbed by the filter and weight of pollution particles fall on sensor at distance 100m (F) from the machine at different heights.	50
15	Table (4-10): The relationship between the weight of pollution particles absorbed by the filter and weight of pollution particles fall on sensor at distance 100m (D) from the machine at different heights.	51
16	Table (4-11): The relationship between weight of chaff at filter and weight of chaff at sensor at distance 140m from farm machine (at G point) for different heights	52
17	Table (4-12): The relationship between weight of chaff at filter and weight of chaff at sensor at distance 140m from farm machine (at H point)for different heights	53
18	Table (4-13): The relationship between weight of chaff at filter and weight of chaff at sensor at distance 140m from farm machine (at I point)for different heights with wheat crop.....	54
19	Table (4-14): The relationship between total chaff at distances 60m from farm machine at points A, B and C with different heights of the instrument	62
20	Table (4-15):The relationship between total chaff at distances 100m from farm machine at points D, E and F for different heights of instrument	63
21	Table (4-16): The relationship between total chaff at distances 140m from farm machine at points G, H and I for different heights of instrument.....	63

22	Table (4-17): Distribution of pollution at height 0.75m	65
23	Table (4-18): Distribution of pollution at height 2m	65
24	Table (4-19): Distribution of pollution at height 2.5m.....	66
25	Table (4-20): Distribution of pollution at height 3m	66
26	Table (4-21): The relationship between the weight of pollution particles absorbed by the filter and weight of pollution particles fall on sensor during the instrument test.....	68
27	Table (4-22): Relationship between feeding weight (tan) of wheat crop and quantity of straw (chaff) which suspended, with different heights of instrument and different distances from farm machine.....	70

.

LIST OF FIGURES

No.	Figure	Page No
1	Fig.(3-1): The design of the proposed instrument.....	17
2	Fig. (3-2): The instrument device to measure air pollution produced from farm machinery.....	18
3	Fig.(3-3): Design and construction of the instrument.....	20
4	Fig. (3-4): The main assembly of new design instrument	21
5	Fig.(3-5): Sensation system	24
6	Fig.(3-6): The diagrams of bonding and full-bridge strain gage circuit the flat spring steel sensor.....	25
7	Fig. (3-7): Measurement system.....	26
8	Fig.(3-8): The diagram of measurement system.....	26
9	Fig. (3-9): PCD-300A sensor interface.....	29
10	Fig.(3-10): The laboratory instrument.....	32
11	Fig. (3-11) Pollution effective zone of wheat straw.....	36
12	Fig. (3-12)The design of the field experiment (distribution of instrument) for thresher.....	37
13	Fig. (3-13): calibration of new design instrument to measure pollution which resulted from wheat threshing machine during field experiment.	38
14	Fig. (3-14): The air pollution from wheat straw and dust during threshing operation.....	40
15	Fig. (3-15): The instrument during the wheat straw threshing, (height 0.75m).....	41
16	Fig. (4-1) The relationship between weight of chaff at filter and weight of chaff at sensor at distance 60m from the machine (at B point) for different heights	46
17	Fig. (4-2) The relationship between weight of chaff at filter and weight of chaff at sensor at distance 60m from the machine (at C point) for	

	different heights	47
18	Fig. (4-3) The relationship between weight of chaff at filter and weight of chaff at sensor at distance 60m from farm machine (at A point) for different heights	48
19	Fig. (4-4): The relationship between weight of chaff at filter and weight of chaff at sensor at distance 100m from farm machine (at E point) for different heights	49
20	Fig. (4-5): The relationship between weight of chaff at filter and weight of chaff at sensor at distance 100m from farm machine (at F point) for different heights	50
21	Fig. (4-6): The relationship between weight of chaff at filter and weight of chaff at sensor at distance 100m from farm machine (at D point) for different heights	51
22	Fig. (4-7): The relationship between weight of chaff at filter and weight of chaff at sensor at distance 140m from farm machine (at G point) for different heights	52
23	Fig. (4-8): The relationship between weight of chaff at filter and weight of chaff at sensor at distance 140m from farm machine (at H point) for different heights	53
24	Fig. (4-9): The relationship between weight of chaff at filter and Weight of chaff at sensor at distance 140m from farm machine (at I point) for different heights	54
25	Fig.(4-10): predicted model of the instrument.....	56
26	Fig.(4-11): The relationship between actual and predicted weight of pollution particles on filter....	57
27	Fig.(4-12): Effect of the distances from farm machine on the total chaff with different heights of the instrument.....	64
28	Fig. (4-14): Relationship between feeding weight (tan) of wheat crop and quantity of straw (chaff) which suspended, with different heights of instrument and different distances from farm machine.....	70

Abstract

Wessam Shawky Abd El-Mohsen. Design of a simplified instrumentation to measure air pollution produced from farm machinery. Unpublished the Master of Environmental Science, Department of Agricultural Science, Ain Shams University, Institute of Environmental Studies and Research (2010).

Air pollution is one of the most important problems around the world. Agricultural activities which related to mechanical operations of crops are a major source of high levels of pollution in rural atmosphere. Fine particles are harmful to human health. Fine particles emission from threshing machine needs to be quantified for many purposes.

The aim of this study is to design a simplified instrumentation to measure air pollution produced from farm machinery. The instrument prototype was designed as a simplified instrument and it was fabricated at the workshop of Agriculture Engineering Research institute (AEnRI).

The instrument consists of two main parts, first: main device which consists of straw collection mechanism (main frame-filtration unite- suction fan unit) and sensation system (spring steel- sensor- PCD device). Second: stand device (telescopic stand- stand base).

Many experiments were run in the laboratory and field to calibrate the new design instrument. The results from laboratory calibration found the relationship between the weight on spring steel sensor (gm) and Read of spring steel sensor by using PCD

device (micro-strain), $gm = \frac{1}{60}$ Micro-strain.

The experiments in field were run during wheat harvesting season of 2008 in Monofia Governorate, to calibrate and test the instrument. The instrument was fixed at variable heights from the ground surface 0.75, 2, 2.5 and 3m, at different distances far from the machine 60, 100, 140 m to cover an area of 80 m width X140m length. Computer Program was used to analyze data to found the relation between the pollution particles absorbed by the filter (W_f), the weight of pollution particles fall on sensor (W_s), the distance between farm machine and the instrument (d) and the height of the instrument (h) then found total pollution (W_t).

The obtained general regression equation (the instrument software) was $W_f = 1.9 - 0.05 h + 0.002 d + 3.462 W_s$, $R^2 = 0.96$

This regression equation is limited to the condition of the experiments.

ACKNOWLEDGMENT

*First and forever I would thank **ALLAH** for his gracious kindness.*

I wish to express my deepest appreciation and sincere gratitude to **Prof. Dr. Abd-El-Ghany Mohamed El-Gindy**, Prof. of Agricultural Engineering, Faculty of Agriculture, Ain Shams University, for his continuous encouragement, valuable consultation, and sincere advice.

Good wishes and gratitude are due to **Prof. Dr. Magdy Mohamed Abdelhameed**, Prof. Design and Production, Faculty of Engineering, Ain Shams University, for his supervision, helpful and guidance.

Deep thanks, great indebtedness and deep gratitude to **Prof. Dr. Magdy Ahmed Baiomy**, Chief Researcher of Agricultural Engineering Research Institute (AEnRI), Agriculture Research Center, Ministry of Agriculture, for suggesting the topic, supervising, and kindly providing all necessary facilities. His planning, continuous quittance, objective criticism, encouragement, valuable directions and careful revision of the thesis are deeply appreciated.

Deep thanks to **Dr. Nahed Khairy Ismail** Senior researcher, of Agr. Eng. Res. Inst. (AEnRI), for her great helpful and support.

And many thanks to **Hala Salah El-Dine** agriculture engineer (AEnRI) for helpful.

Deep thanks and appreciation are expressed to staff members of AEnRI.

Finally, expressing my deep appreciation to my family for continuous encouragement, which enabled me to complete this study.

1- INTRODUCTION

Air pollution is considered the most dangerous pollution to the environment. There are many sources of air pollution such as smoke from industry; vehicles and direct combustion of organic waste materials. Dust and suspended particles are other sources of air pollution. Agriculture operations produce several types of air dust and suspended particles that pollute the environment of the rural areas. Fine dust stays suspended in the air for long time which affects human health, animals, and plants. For humans, it can cause many diseases such as asthma, heart attacks and lung cancer. It can trigger symptoms that include nose, eyes, and throat irritation. Agricultural operations are one of source of air pollution in the rural area, such as harvesting and threshing.

Currently, there are about three millions feds cultivated by wheat which used more than 50,886 of the thresher machines (**Ministry of agriculture, 2008**). The quantities of dust to surround environment during wheat crops threshing may reach 2905 gm.m²/h when using threshers, and 98 gm.m²/h when using harvesters (**Sahar, 2002**). The quantities of fine dust inhaled by labor during wheat threshing by different machines and combine respectively, the quantities were recorded from 15 : 62 gm/m³ (**El Gindy et al., 2001**). The world limit for allowed pollution is about 9.2 gm/m³ (**NMAOH, 1999**).

A simple instrument easy to move (portable) device that can be used at variable elevations from the ground surface can be devoted.