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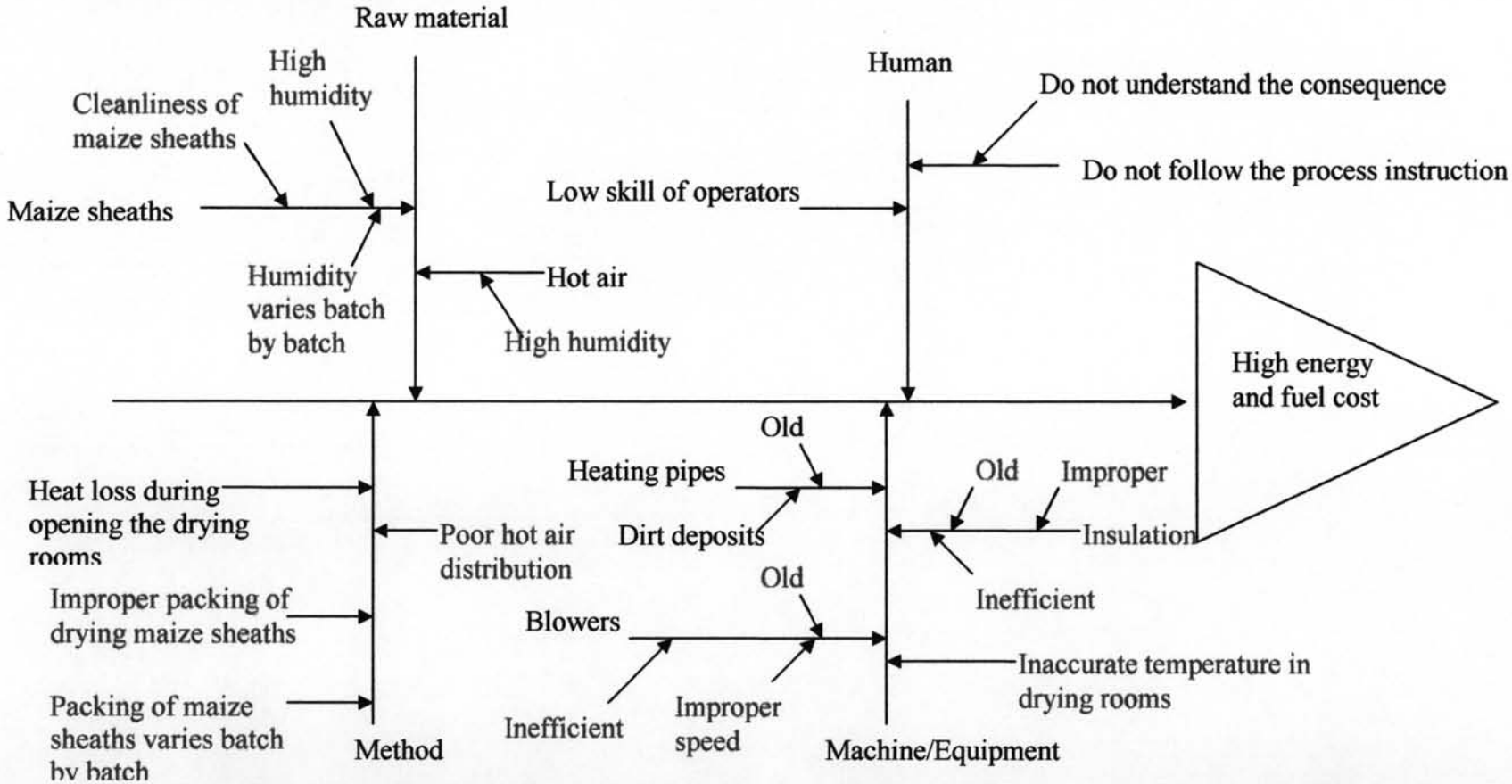
APPENDICES

Appendix I

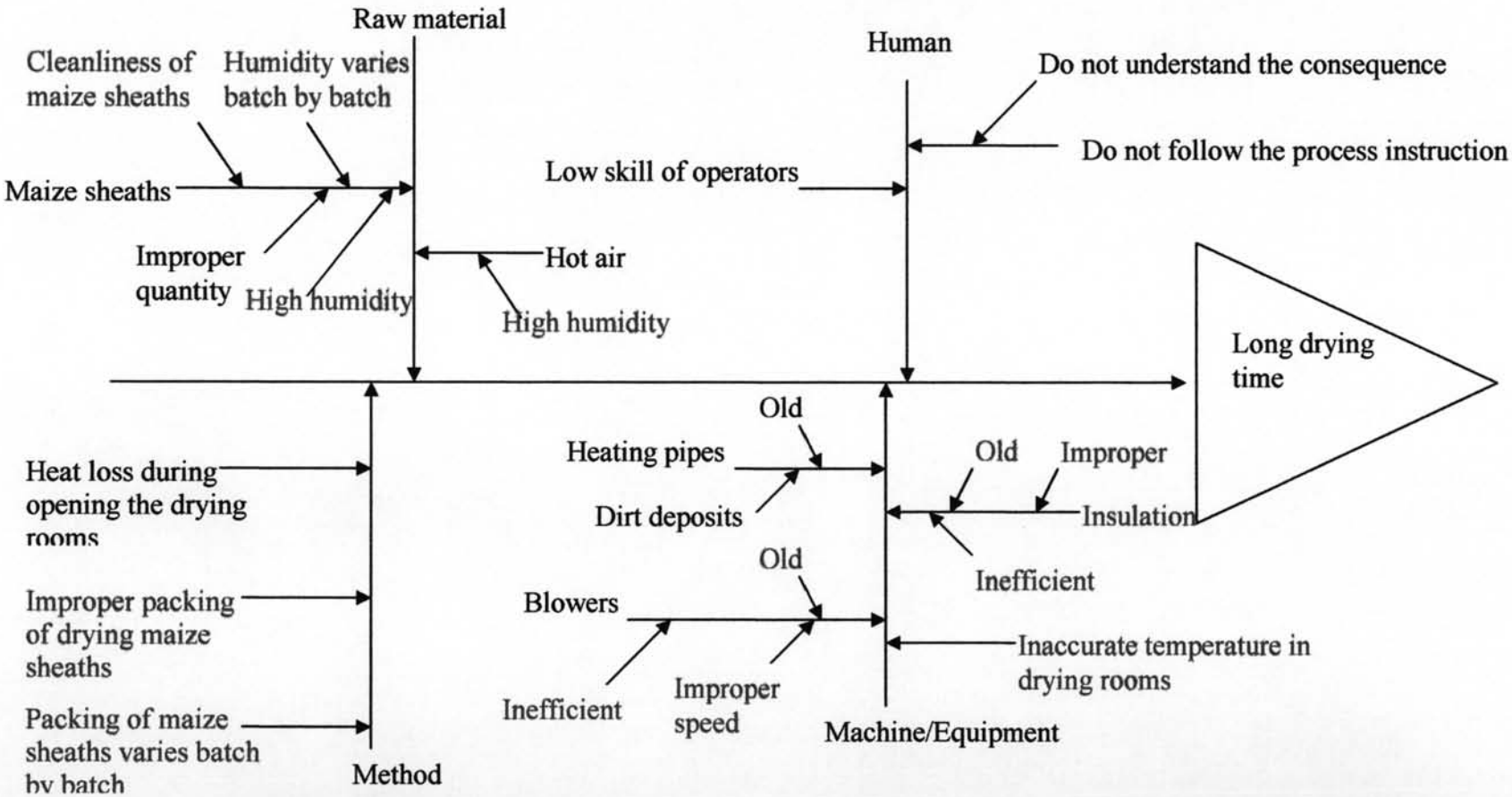
Fish bone diagram for Drying room and furnace workstation units

Drying room workstation unit



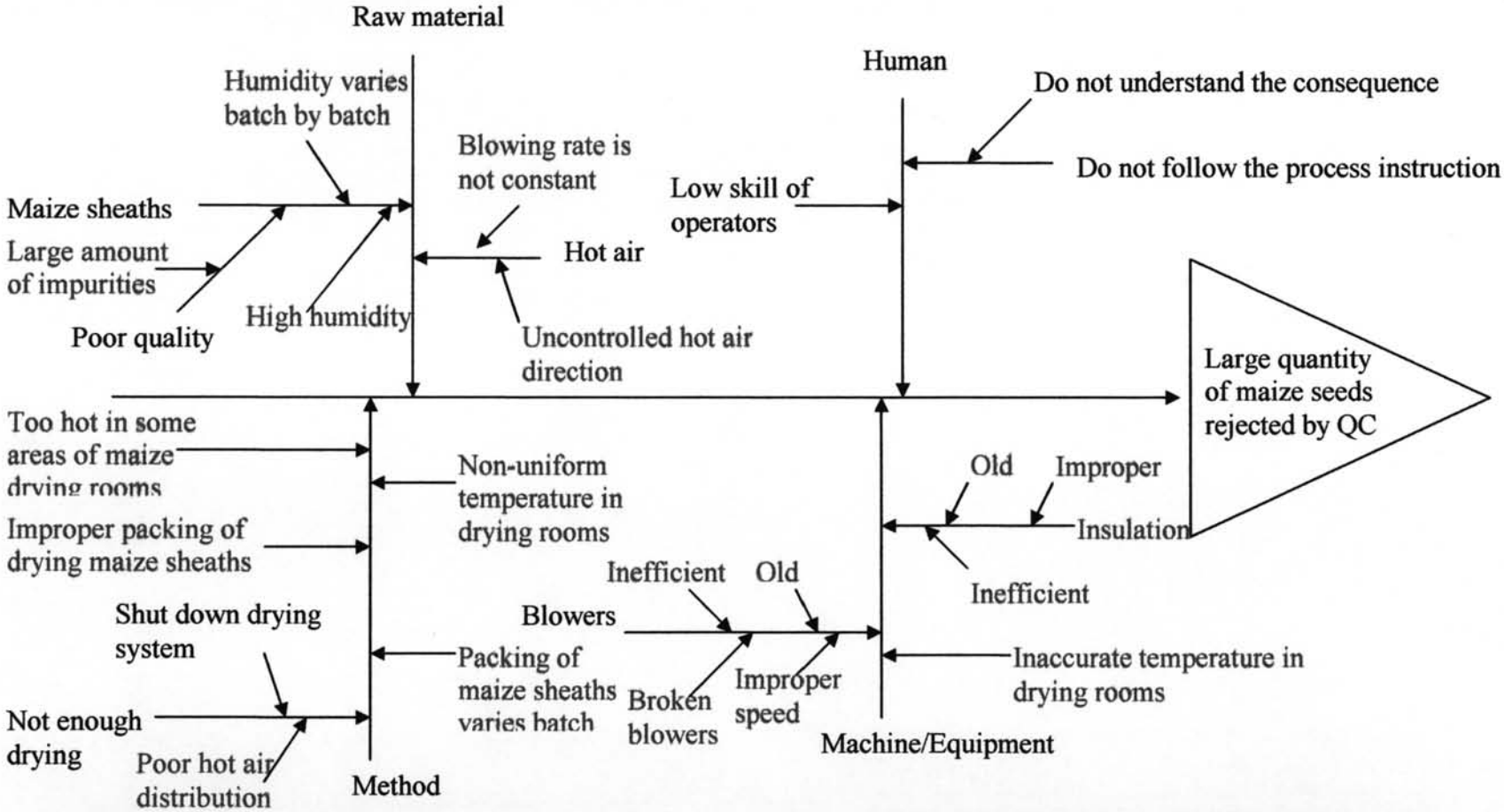
Fish bone diagram for cause and effect analysis at drying room workstation unit: high energy and fuel cost

Drying room workstation unit



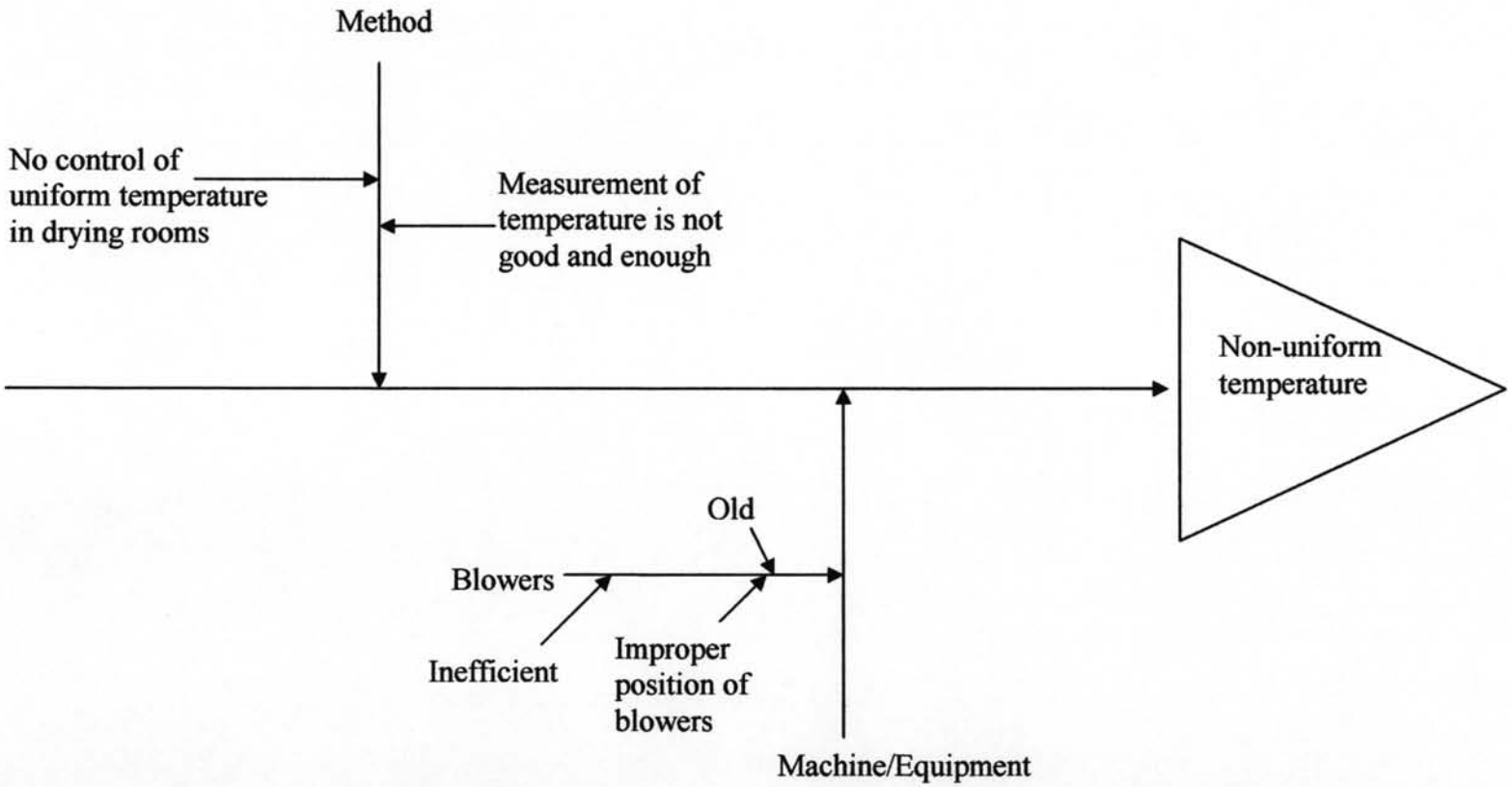
Fish bone diagram for cause and effect analysis at drying room workstation unit: long drying time

Drying room workstation unit



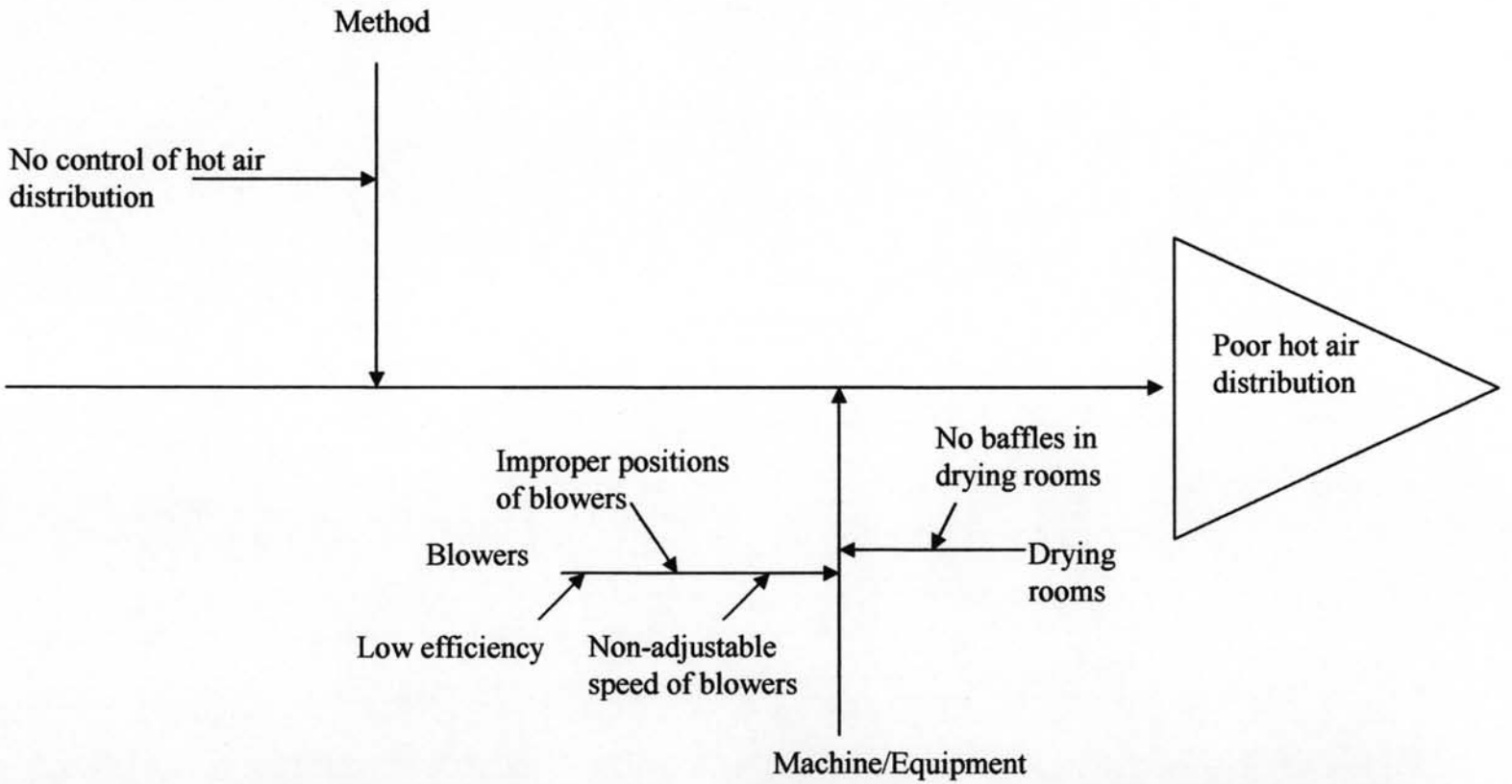
Fish bone diagram for cause and effect analysis at drying room workstation unit: large quantity of maize seeds rejected by QC

Drying room workstation unit



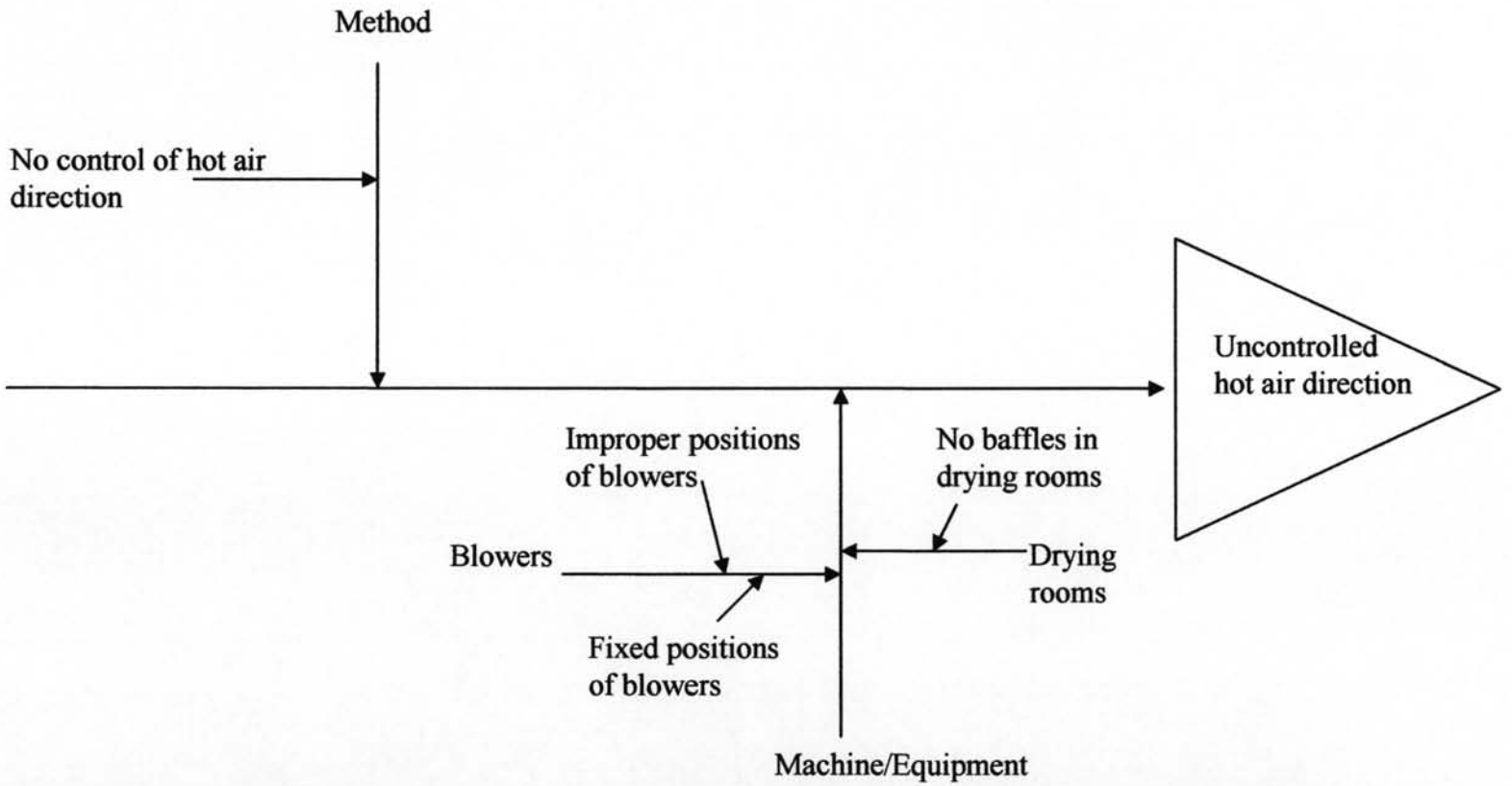
Fish bone diagram for cause and effect analysis at drying room workstation unit: non-uniform temperature

Drying room workstation unit



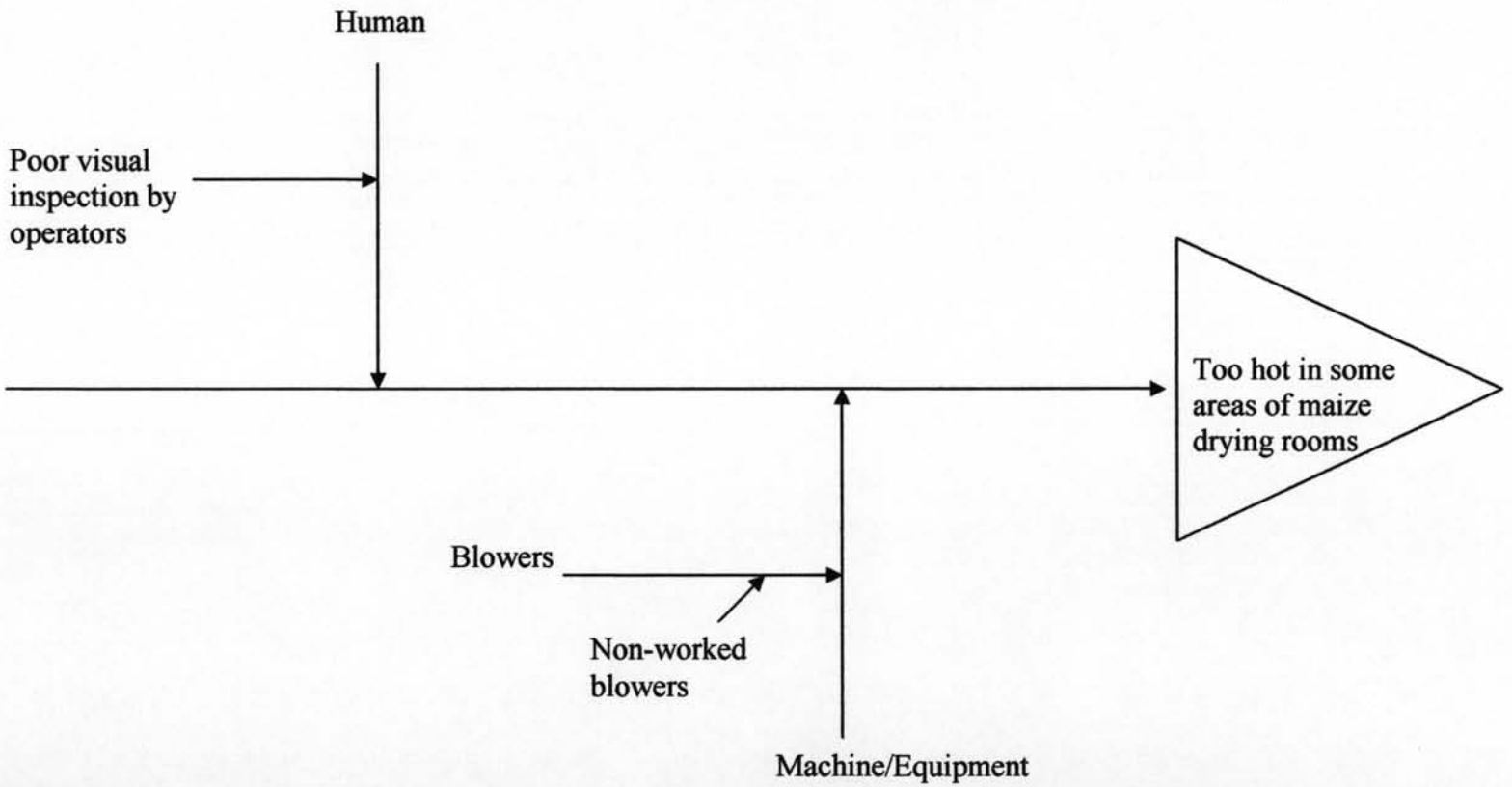
Fish bone diagram for cause and effect analysis at drying room workstation unit: poor hot air distribution

Drying room workstation unit



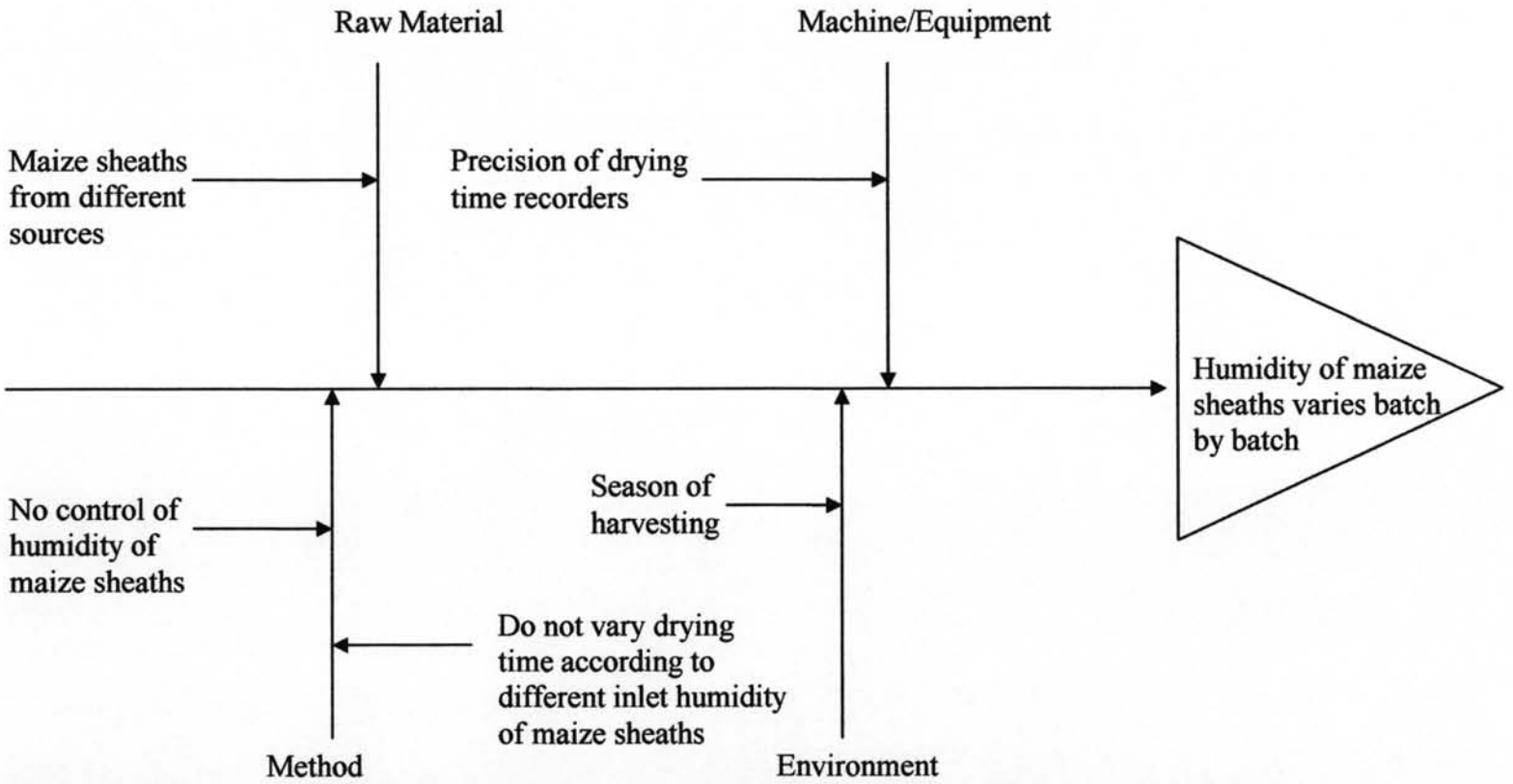
Fish bone diagram for cause and effect analysis at drying room workstation unit: Uncontrolled hot air direction

Drying room workstation unit



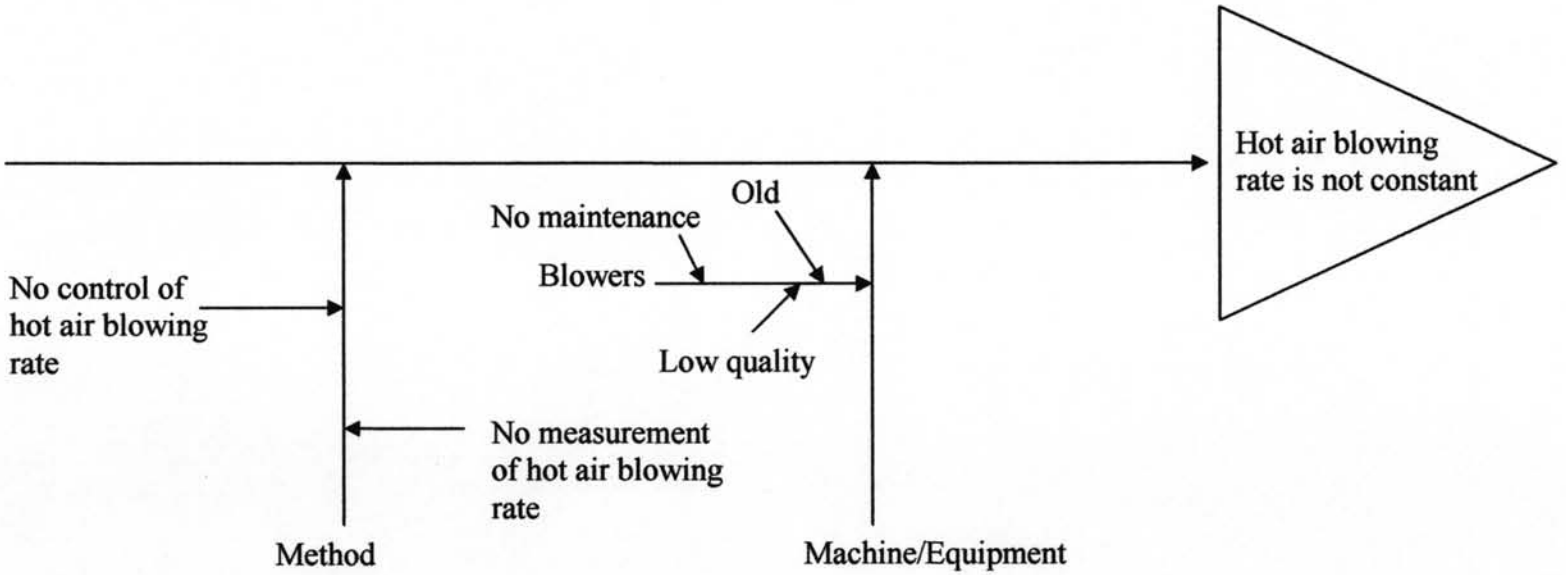
Fish bone diagram for cause and effect analysis at drying room workstation unit: too hot in some areas of maize drying

Drying room workstation unit



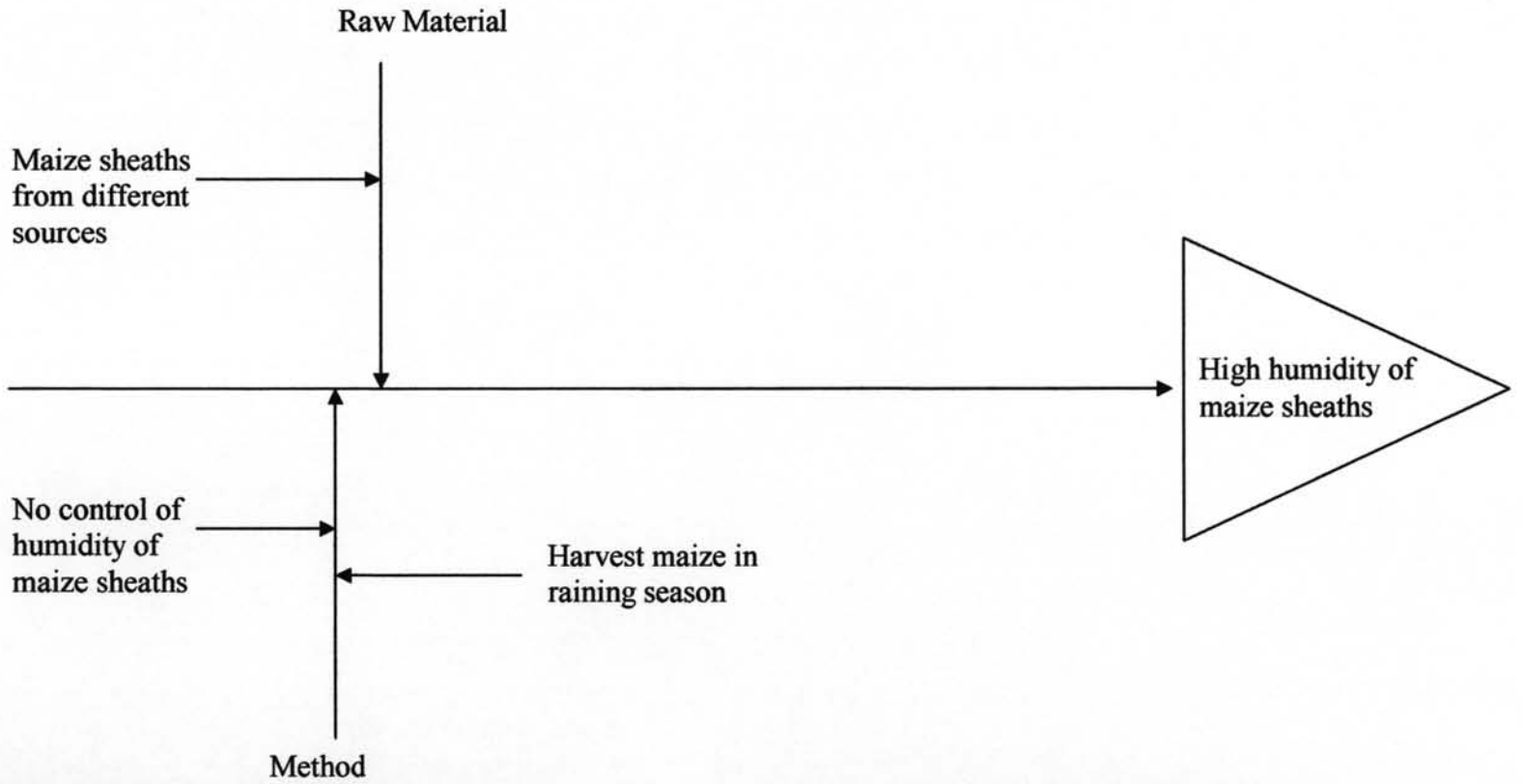
Fish bone diagram for cause and effect analysis at drying room workstation unit: humidity of maize sheaths varies batch by batch

Drying room workstation unit



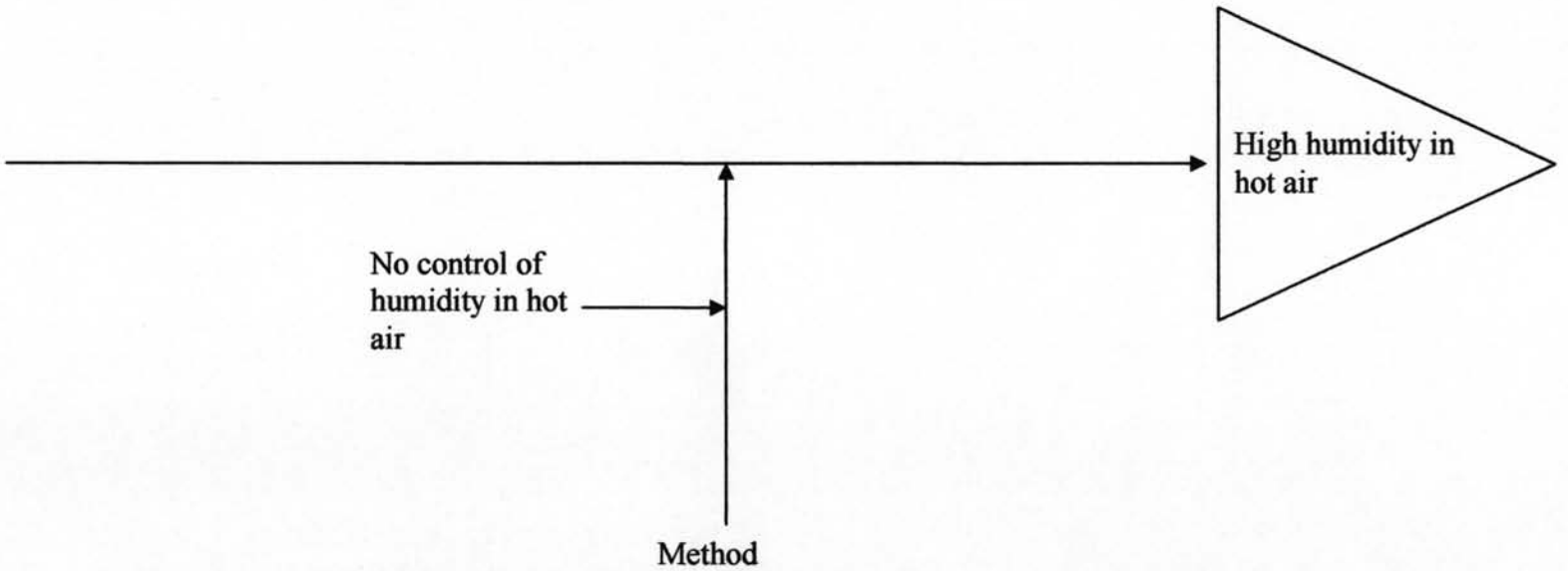
Fish bone diagram for cause and effect analysis at drying room workstation unit: hot air blowing rate is not constant

Drying room workstation unit



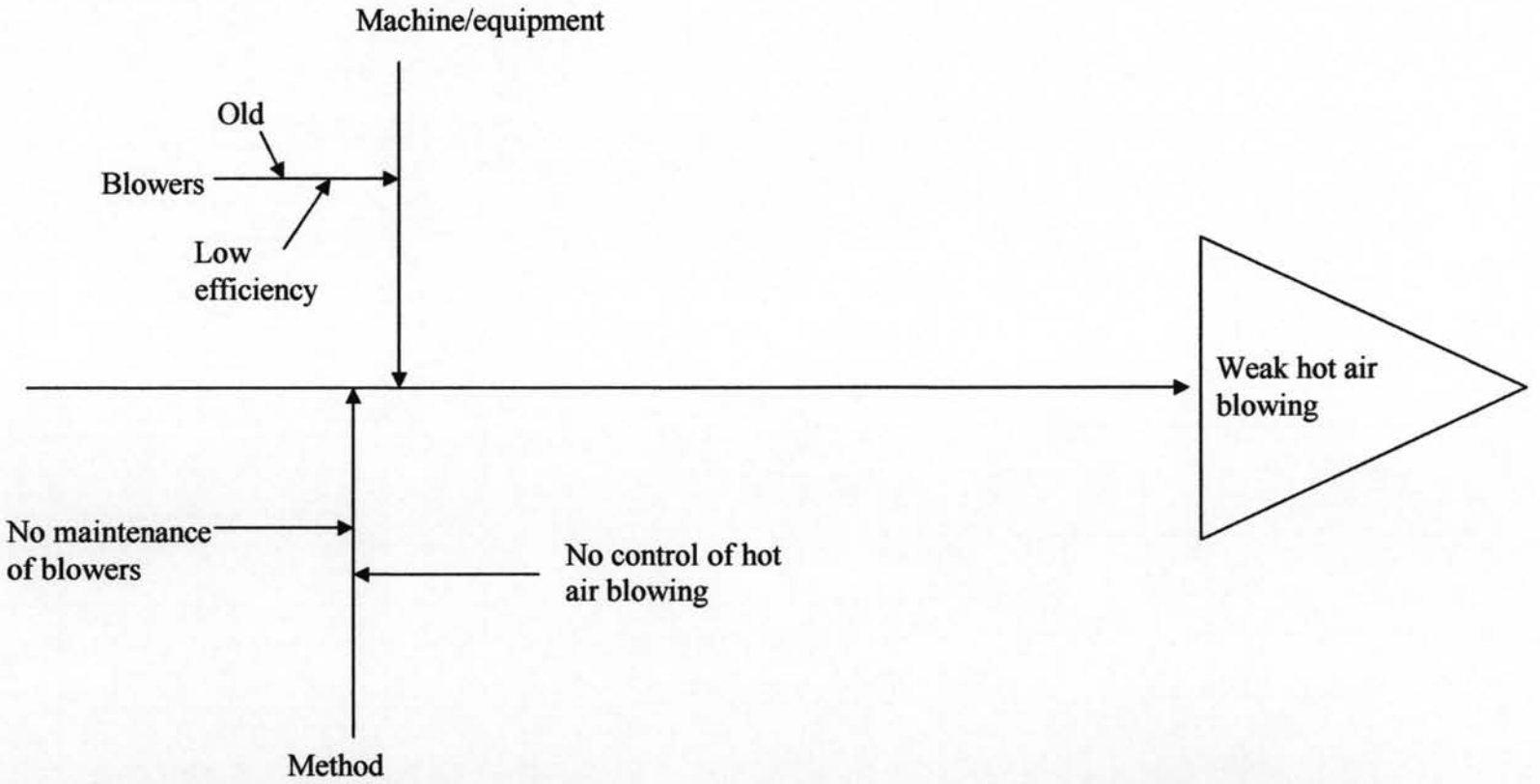
Fish bone diagram for cause and effect analysis at drying room workstation unit: high humidity of maize sheaths

Drying room workstation unit



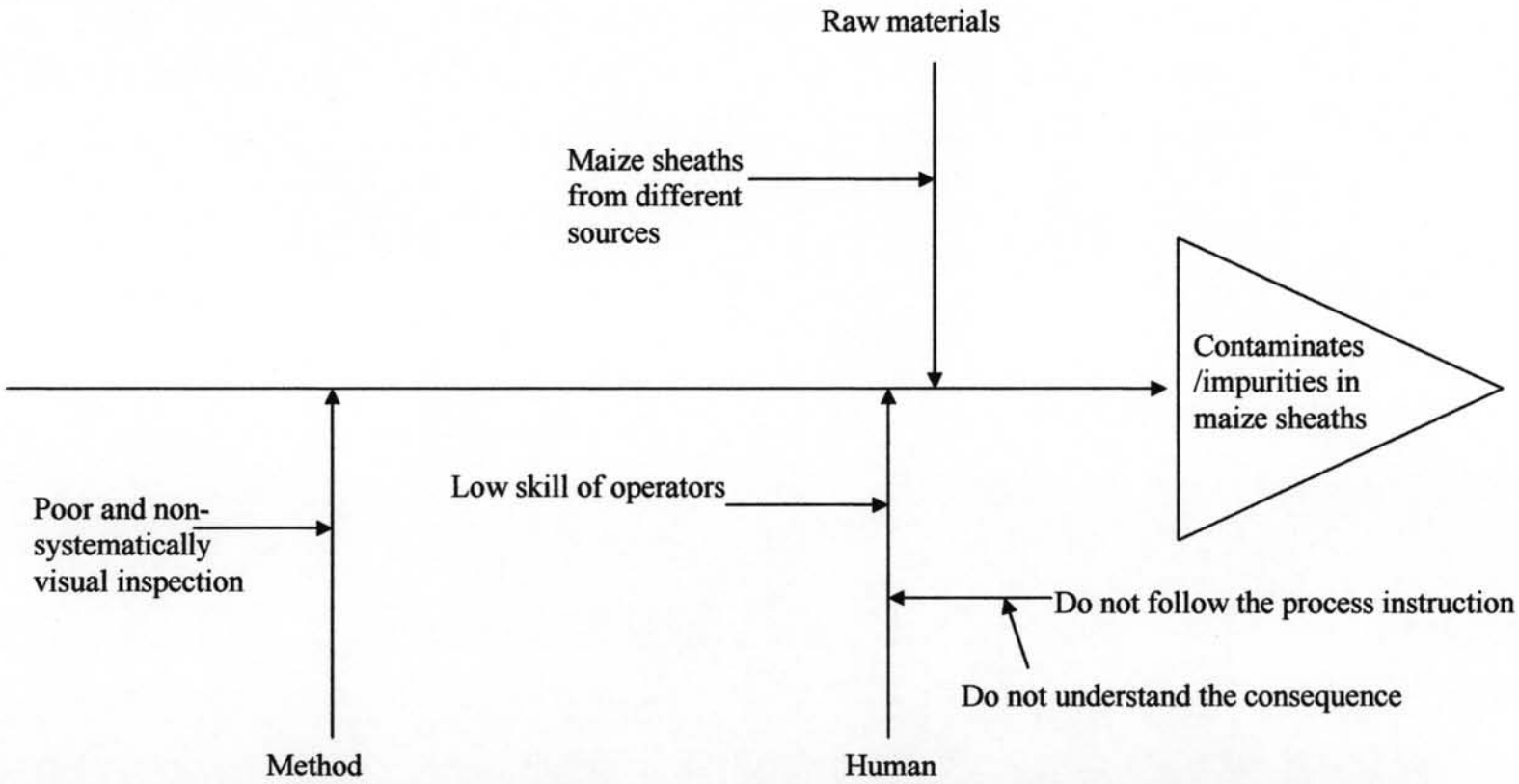
Fish bone diagram for cause and effect analysis at drying room workstation unit: high humidity in hot air

Drying room workstation unit



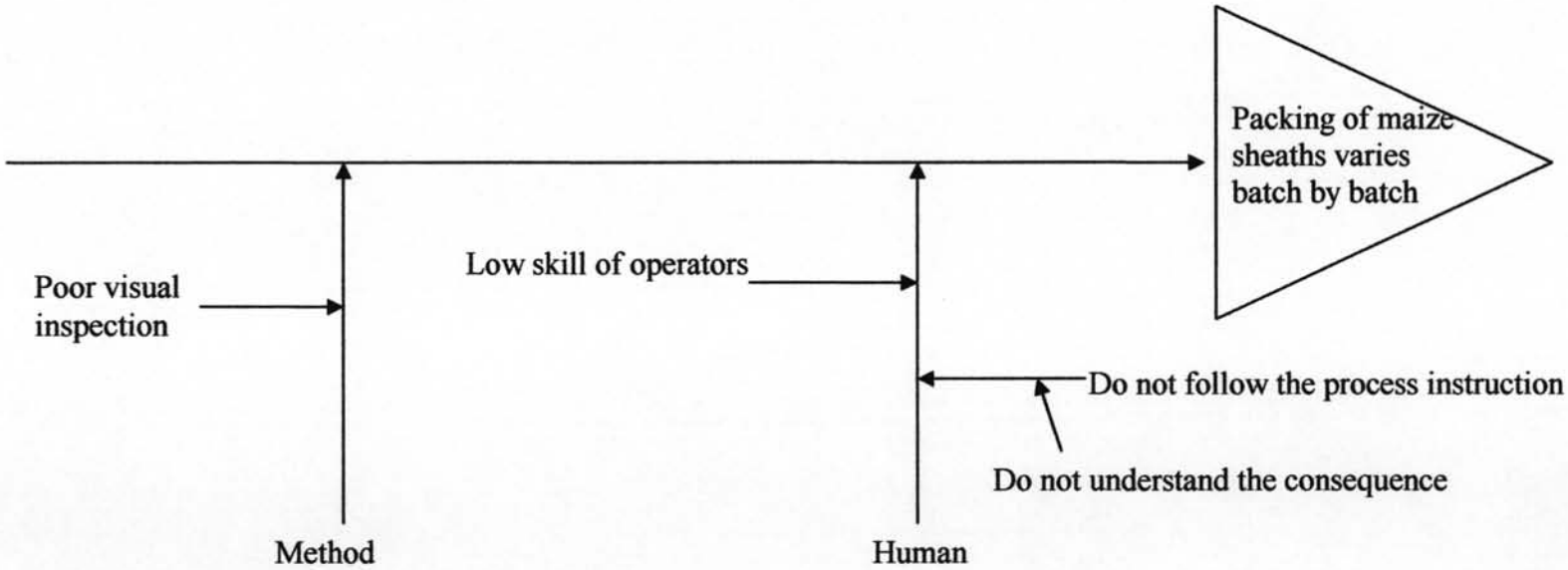
Fish bone diagram for cause and effect analysis at drying room workstation unit: weak hot air blowing

Drying room workstation unit



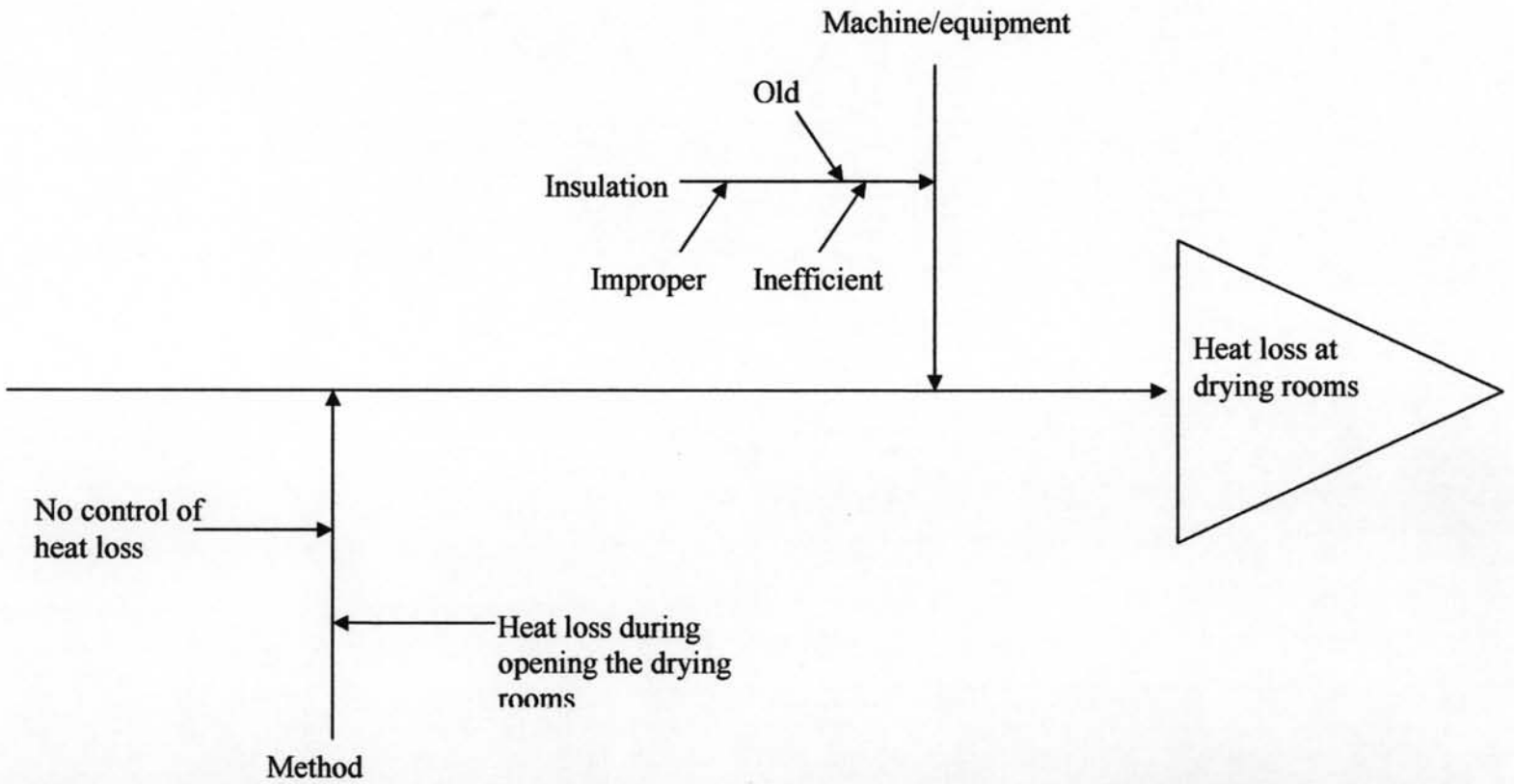
Fish bone diagram for cause and effect analysis at drying room workstation unit: contaminates /impurities in maize sheaths

Drying room workstation unit



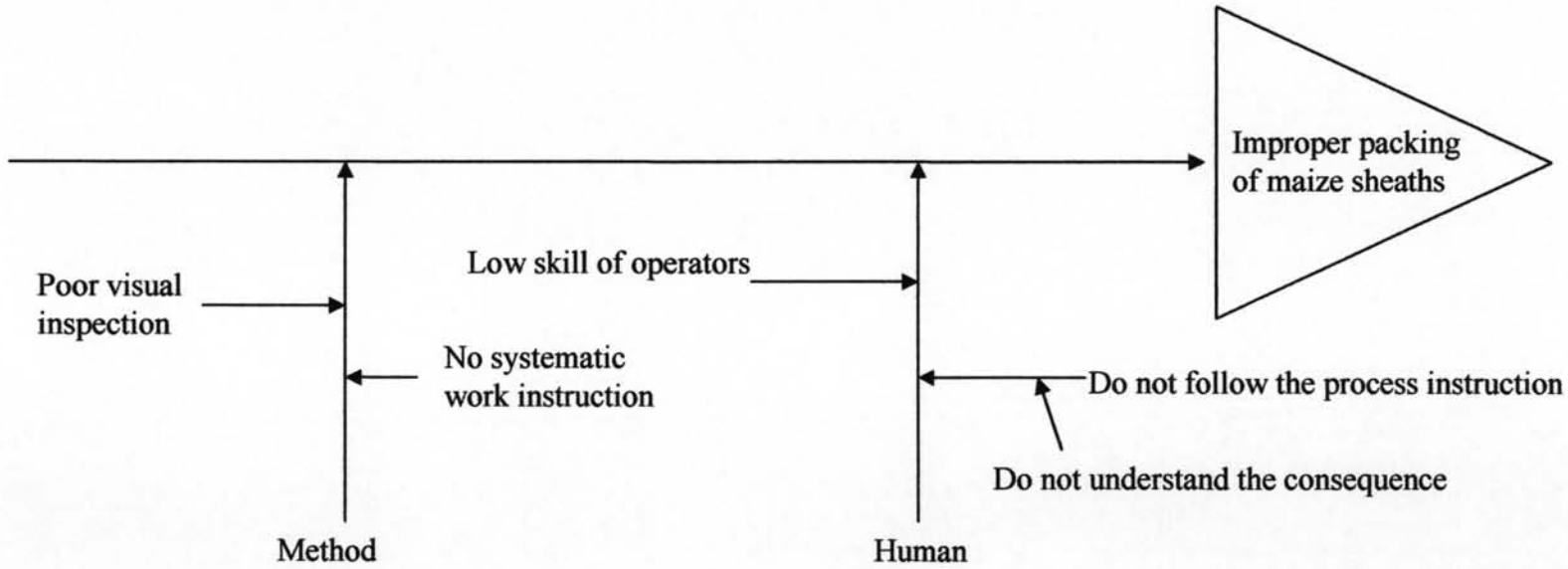
Fish bone diagram for cause and effect analysis at drying room workstation unit: packing of maize sheaths varies batch by batch

Drying room workstation unit



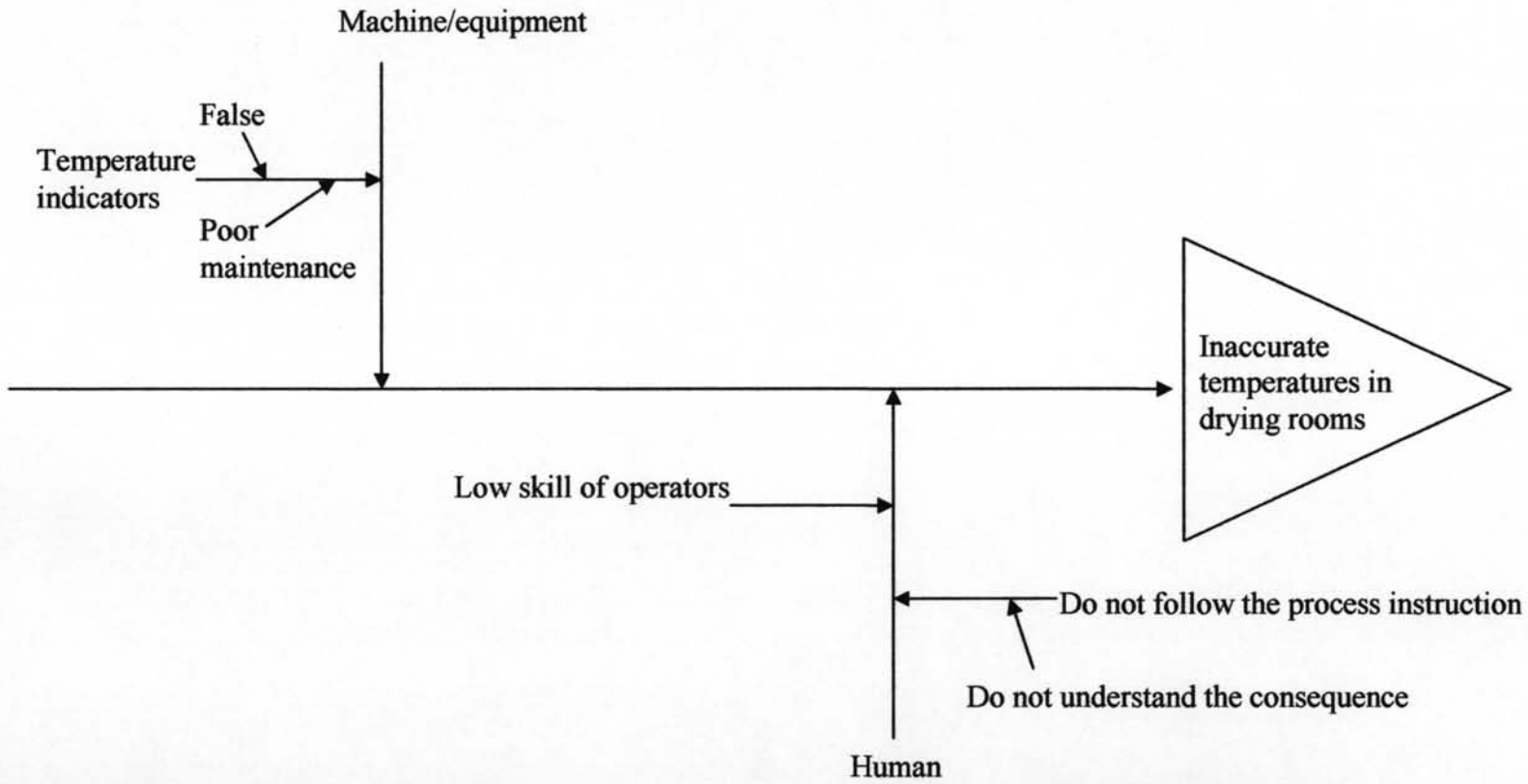
Fish bone diagram for cause and effect analysis at drying room workstation unit: heat loss at drying rooms

Drying room workstation unit



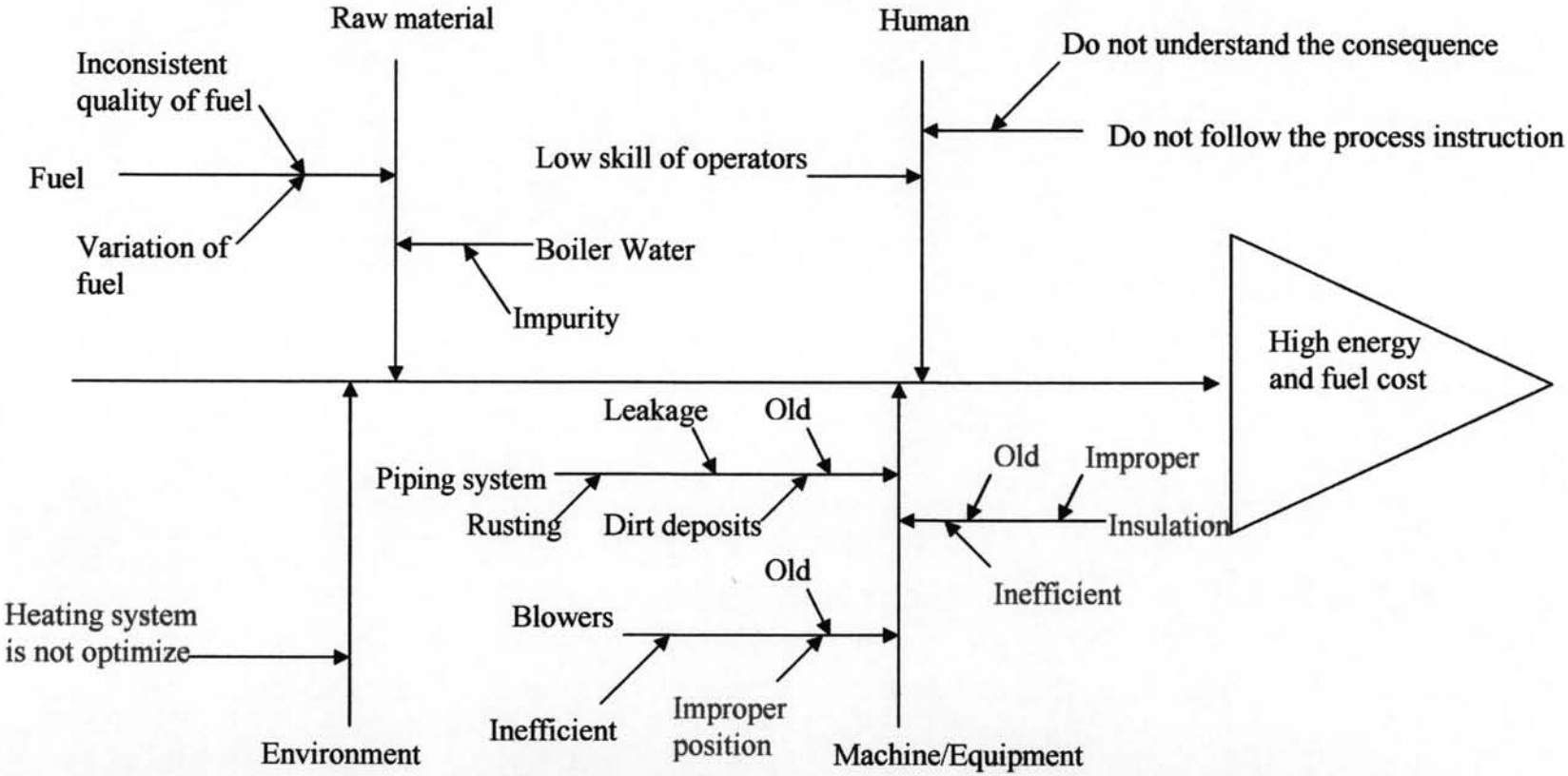
Fish bone diagram for cause and effect analysis at drying room workstation unit: improper packing of maize sheaths

Drying room workstation unit



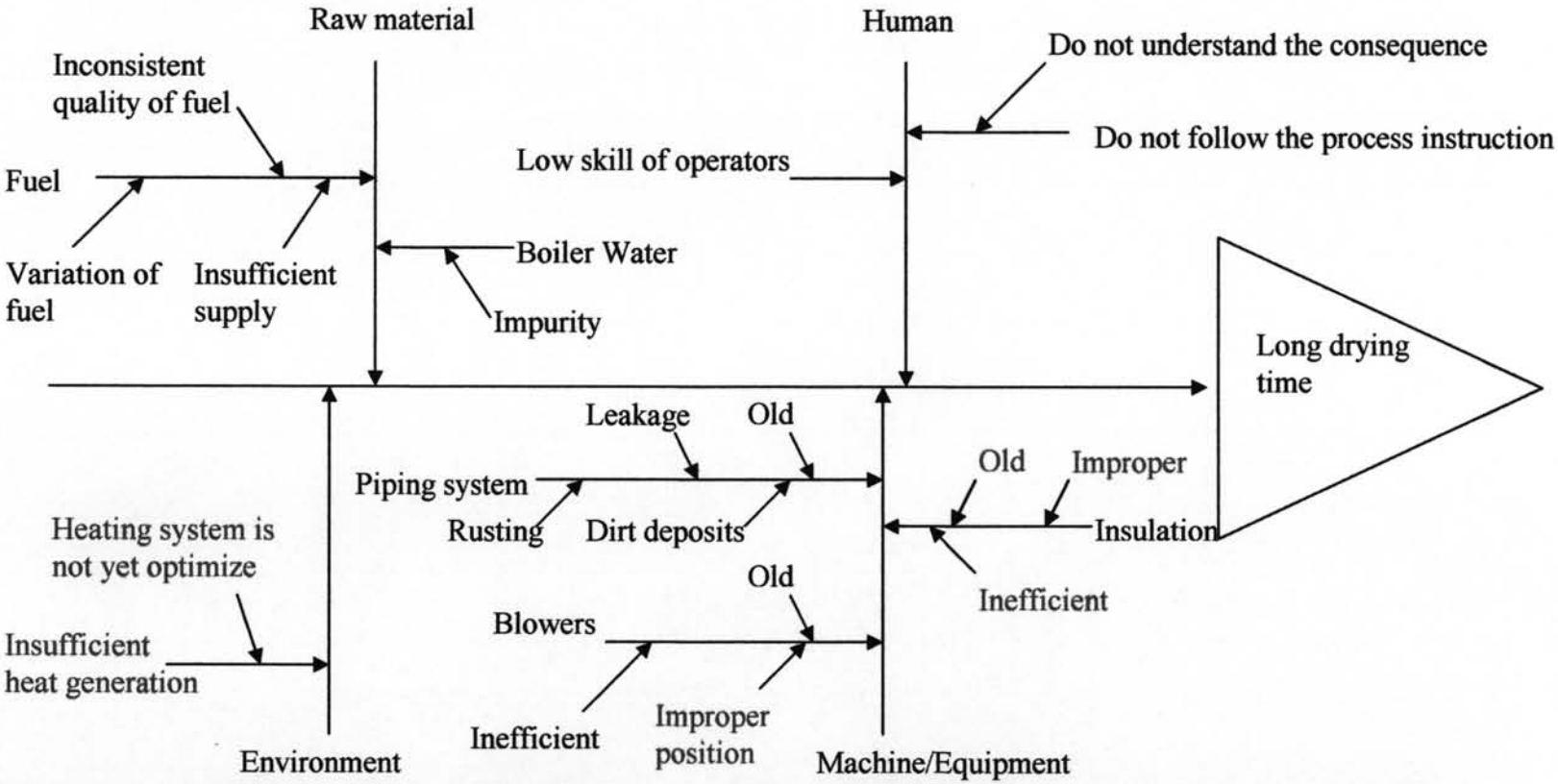
Fish bone diagram for cause and effect analysis at drying room workstation unit: Inaccurate temperature in drying rooms

Furnace workstation unit



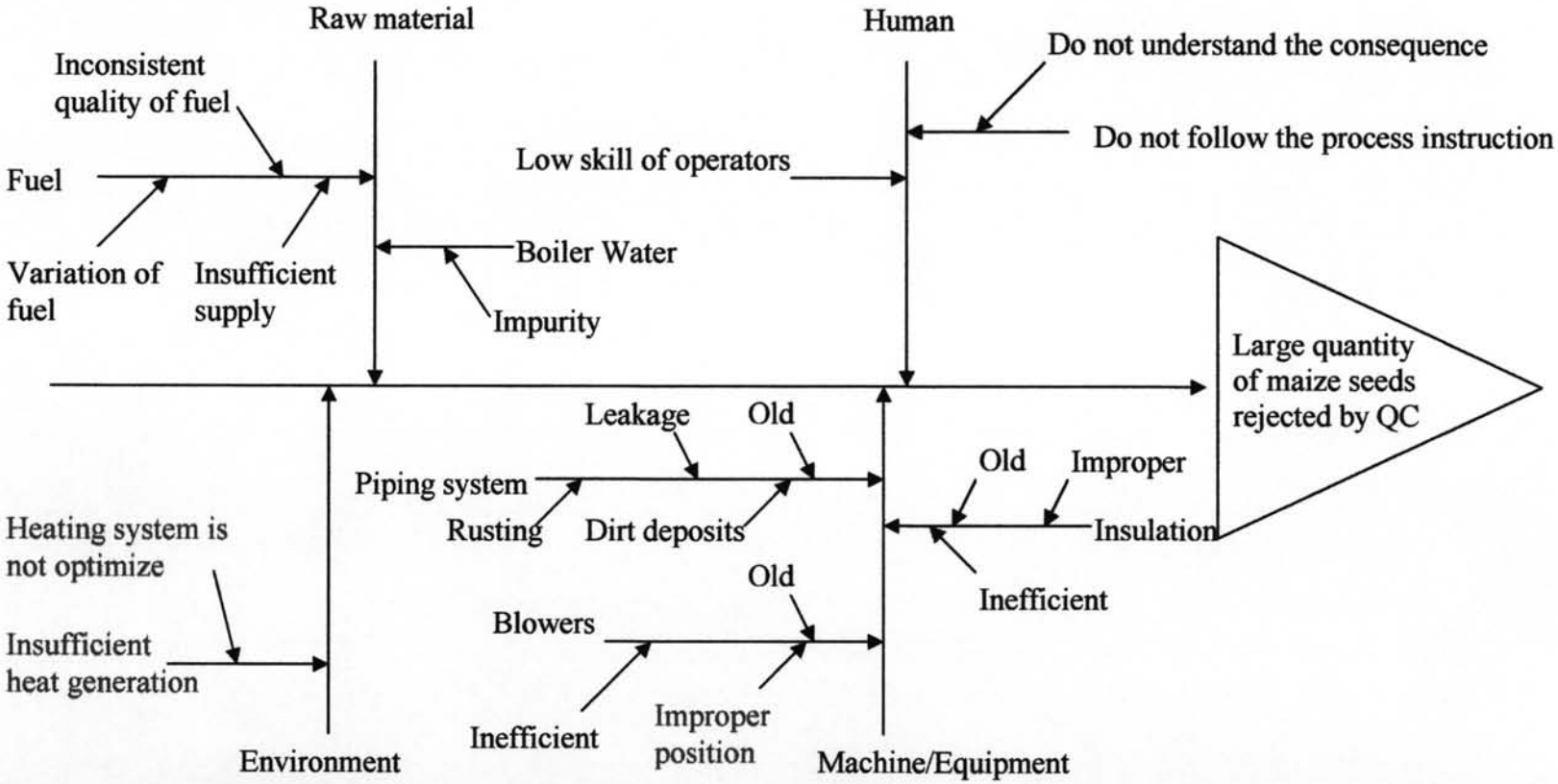
Fish bone diagram for cause and effect analysis at furnace workstation unit: high energy and fuel cost

Furnace workstation unit



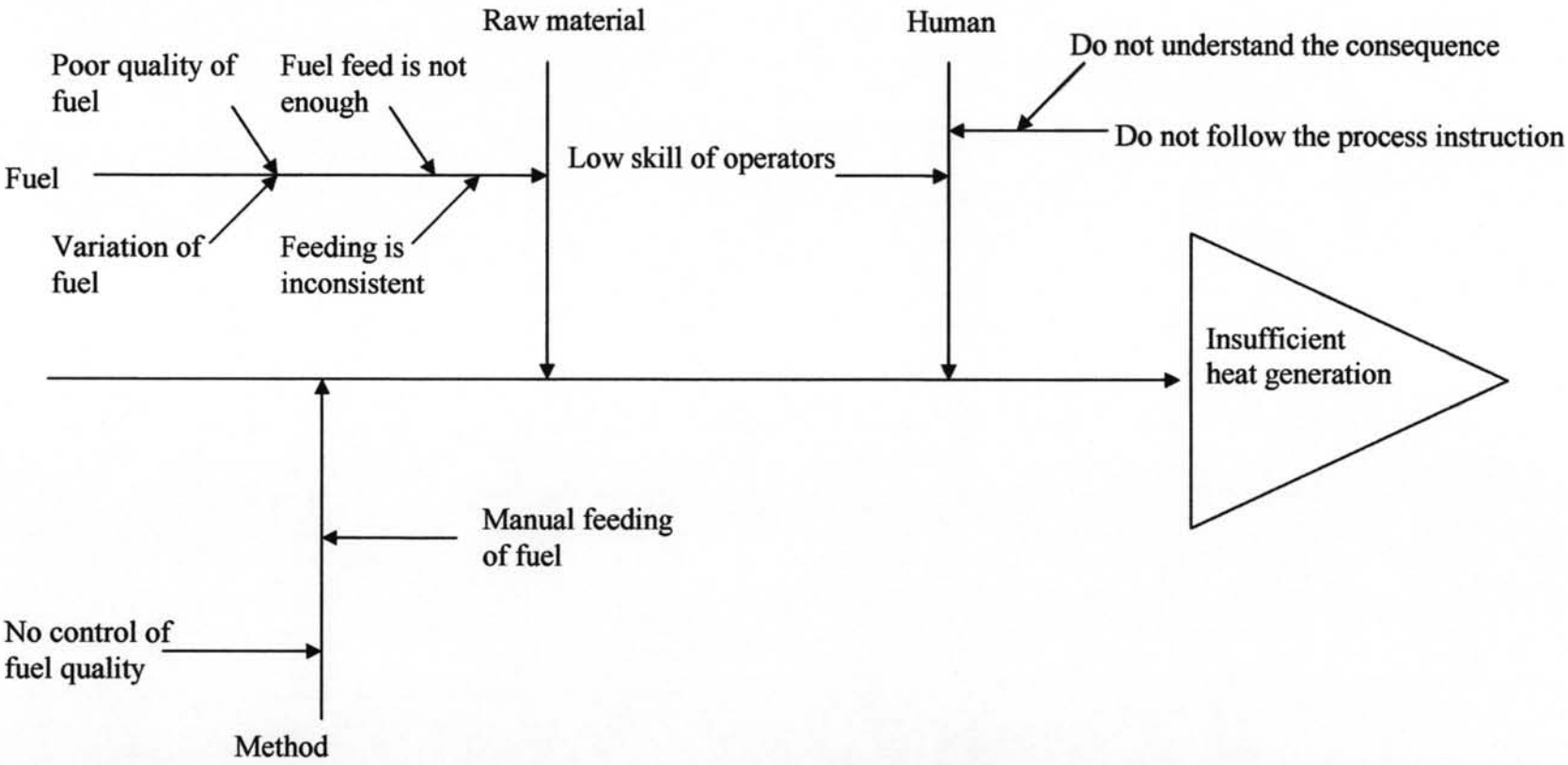
Fish bone diagram for cause and effect analysis at furnace workstation unit: long drying time

Furnace workstation unit



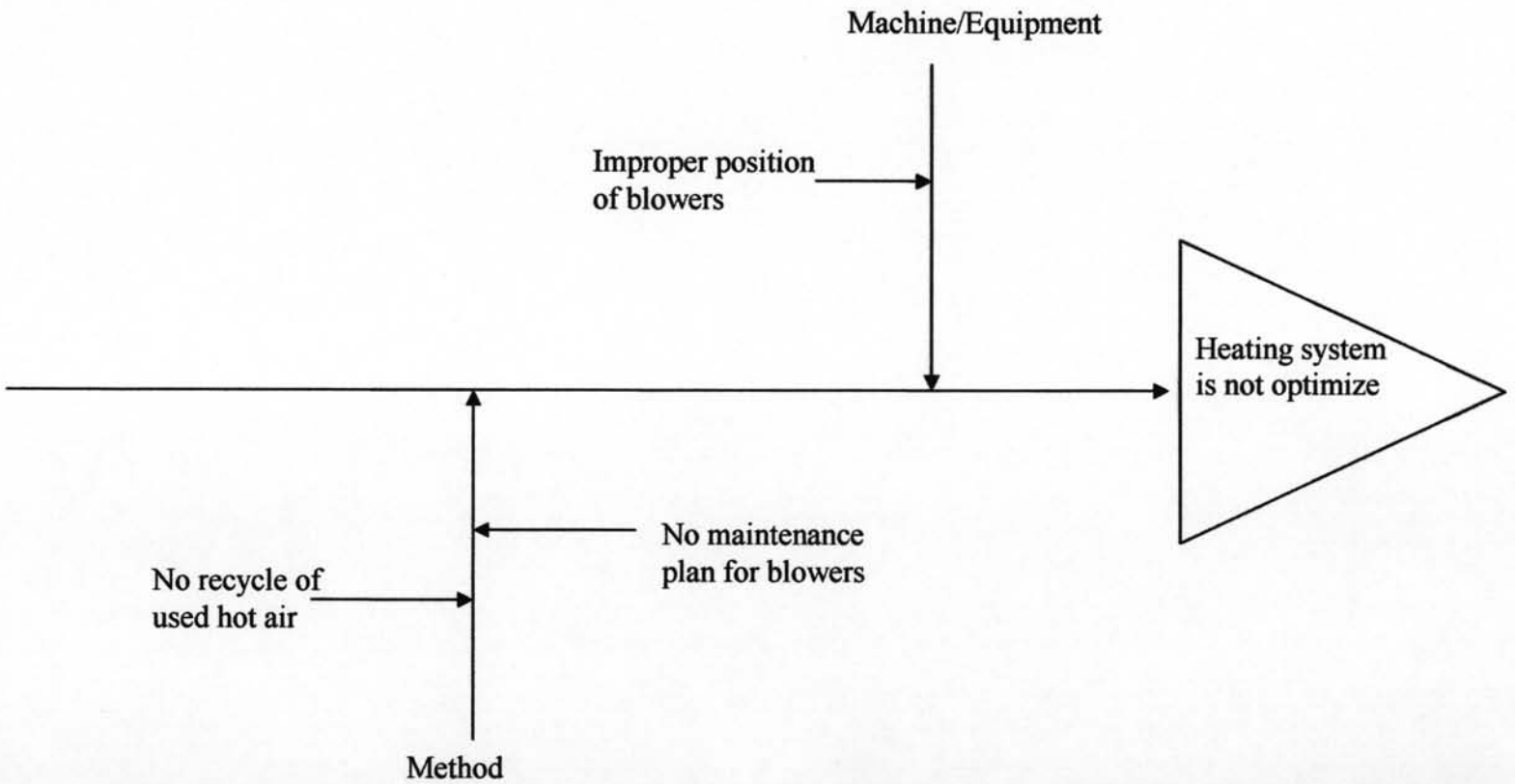
Fish bone diagram for cause and effect analysis at furnace workstation unit: large quantity of maize seeds rejected by QC

Furnace workstation unit



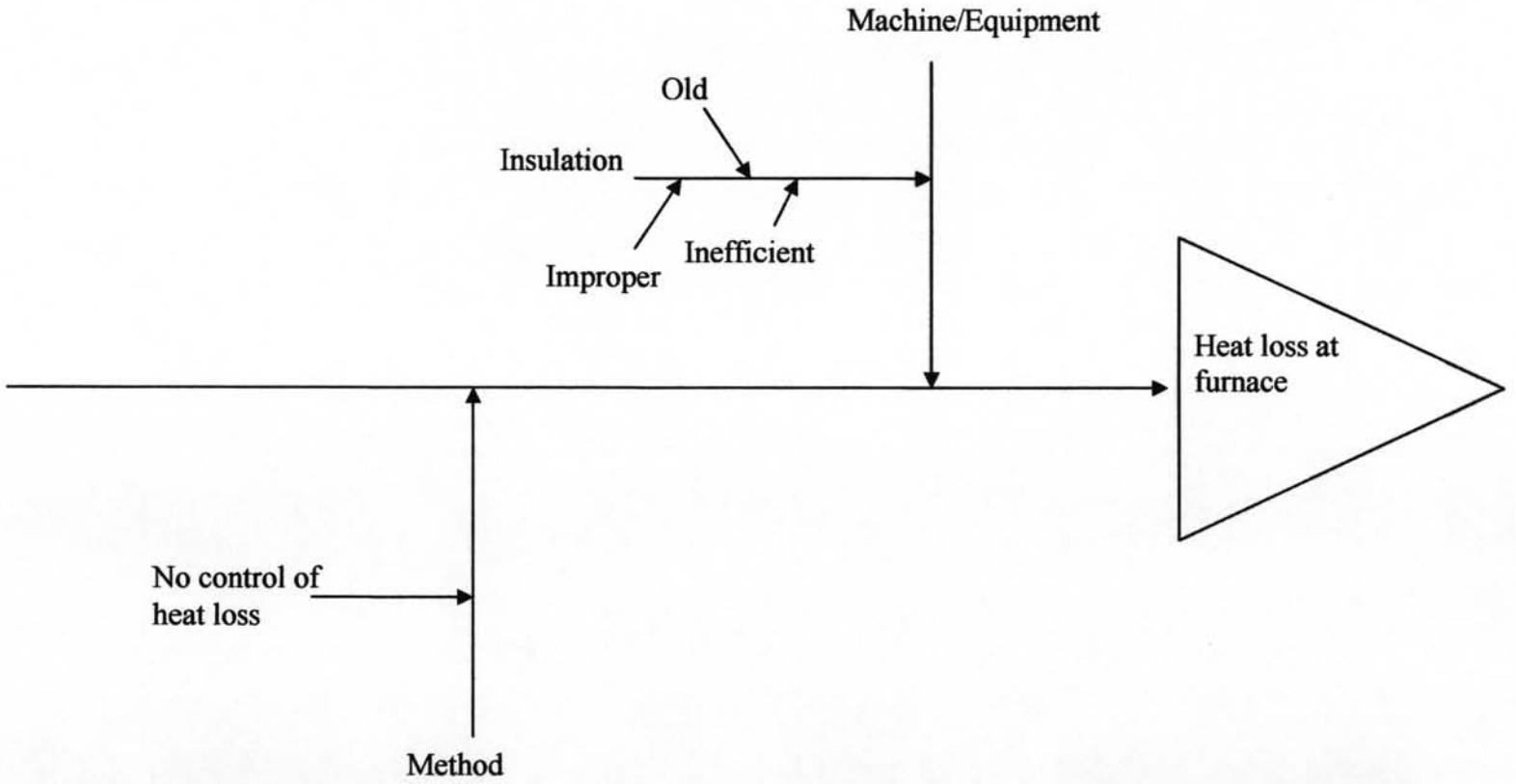
Fish bone diagram for cause and effect analysis at furnace workstation unit: Insufficient heat generation

Furnace workstation unit



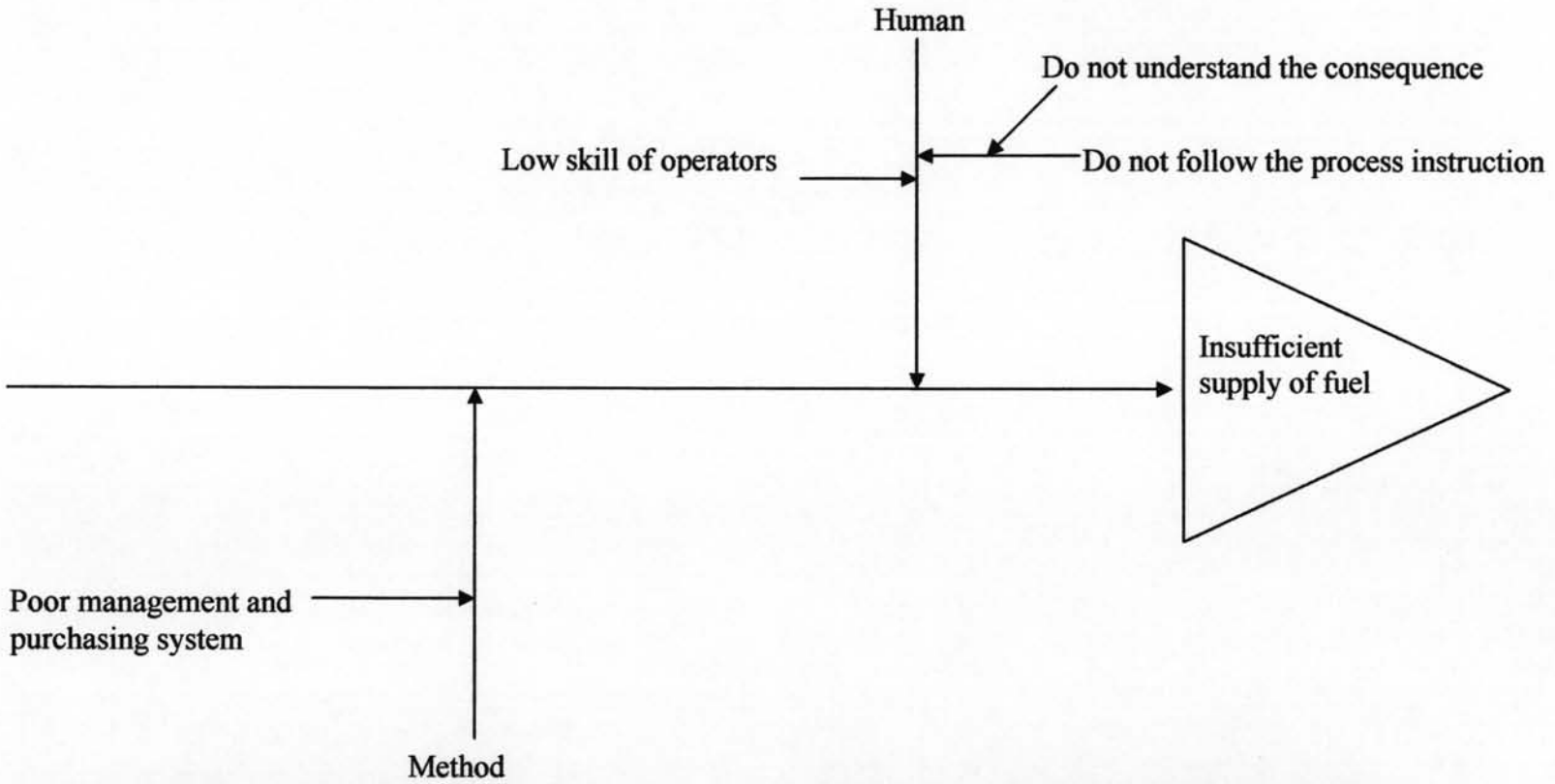
Fish bone diagram for cause and effect analysis at furnace workstation unit: heating system is not optimize

Furnace workstation unit



Fish bone diagram for cause and effect analysis at furnace workstation unit: heat loss at furnace

Furnace workstation unit



Fish bone diagram for cause and effect analysis at furnace workstation unit: Insufficient supply of fuel

Appendix II

Failure Mode and Effects Analysis (FMEA) form for Maize Drying Process

Failure Mode and Effect Analysis (FMEA)

Workstation unit: Drying rooms
Process name: Drying process at drying rooms
Documented by: Pachara L.
FMEA Date (Org.): 8/1/07
Approved by: Factory Manager
Approved date: 9/3/07
FMEA Date (Rev.):
Team members: Pachara L., Somsak T., Yupin K., Chainipat L., Manoch S., Noppadol K.

Process Function & Requirement	Potential Failure Mode	Potential Effect(s) of Failure	S	Potential Cause(s)/ Mechanism(s) of Failure	O	Current Process Controls	D	RPN	Recommended Actions(s)	Resonsibility & Target Completion Date	Action result			
											S	O	D	RPN
Maize drying rooms	Inaccurate temp. in drying rooms	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Temp. indicator false, poor maintenance	5	Random check of temp. indicator	7	175	set up work instruction for calibration	Maintenance (10/5/07)	5	2	4	40
	Non-uniform temp. in drying rooms	Some dried maize sheaths are off-spec	5	Position of blowers, efficiency of blowers	8	No control	8	320	Modify blowers set up preventive maintenance, install more temp. indicators	Process Eng. (13/5/07) Maintenance (10/5/07)	5	4	4	80
	Humidity of maize sheaths varies batch by batch	High energy and fuel cost, long drying time Some dried maize sheaths are off-spec	5	Different sources of maize sheaths, season of harvesting, drying time unchnages with humidity of maize sheaths	8	No control for humidty of maize sheaths	6	240	set up work instruction to vary drying time according to inlet humidity, calibration drying time recorder	Process Eng. (13/5/07)	5	3	4	60
	High humidity of maize sheaths	High energy and fuel cost, long drying time Some dried maize sheaths are off-spec	5	Harvest maize in raining season, maize sheaths from different sources	8	No control for humidty of maize sheaths	6	240	set up work instruction i.e. sun drying	Production (15/5/07)	5	2	4	40
	Hot air blowing rate is not constant	Some dried maize sheaths are off-spec	5	Old and low quality blowers, no maintenance plan for blowers	7	No inspection but it is guaranteed by the supplier	8	280	set up preventive maintenance	Maintenance (10/5/07)	5	4	4	80

Failure Mode and Effect Analysis (FMEA)

Workstation unit: Drying rooms
Process name: Drying process at drying rooms
Documented by: Pachara L.
Approved by: Factory Manager
Approved date: 9/3/07
Team members: Pachara L., Somsak T., Yupin K., Chainipat L., Manoch S., Noppadol K.

FMEA Date (Org.): 8/1/07
FMEA Date (Rev.):

Process Function & Requirement	Potential Failure Mode	Potential Effect(s) of Failure	S	Potential Cause(s)/ Mechanism(s) of Failure	O	Current Process Controls	D	RPN	Recommended Actions(s)	Resonsibility & Target Completion Date	Action result			
											S	O	D	RPN
Maize drying rooms	Weak hot air blowing	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Old, low efficient blowers No maintenance plan for blowers	5	No control	8	200	set up preventive maintenance	Maintenance (10/5/07)	5	4	4	80
	Poor hot air distribution	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Non-adjustable speed and low efficiency of blowers, improper positions of blowers, no baffles in drying rooms	8	No control	8	320	Reposition blowers modify blowers and drying rooms i.e. add baffles	Process Eng. (13/5/07)	5	4	4	80
	Uncontrolled hot air direction	Some dried maize sheaths are off-spec	5	Improper positions of blowers, no baffles in drying rooms	8	No control	8	320	Modify blowers & drying room i.e. add baffles	Process Eng. (13/5/07)	5	4	4	80
	Improper packing of maize sheath	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Production operators do not follow manuals, poor visual inspection	5	Visual inspection by shift engineers	5	125	Training operators, set up work instruction	Production (15/5/07)	5	2	4	40
	Packing of maize sheath varies batch by batch	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Production operators do not follow manuals, poor visual inspection	7	Visual inspection by shift engineers	5	175	Training operators, set up work instruction	Production (15/5/07)	5	2	4	40

Failure Mode and Effect Analysis (FMEA)

Workstation unit: Drying rooms
Process name: Drying process at drying rooms
Approved by: Factory Manager
Team members: Pachara L., Somsak T., Yupin K., Chainipat L., Manoch S., Noppadol K.

Documented by: Pachara L.
Approved date: 9/3/07

FMEA Date (Org.): 8/1/07
FMEA Date (Rev.):

Process Function & Requirement	Potential Failure Mode	Potential Effect(s) of Failure	S	Potential Cause(s)/ Mechanism(s) of Failure	O	Current Process Controls	D	RPN	Recommended Actions(s)	Resonsibility & Target Completion Date	Action result			
											S	O	D	RPN
Maize drying rooms	Too hot in some areas of maize drying room	Some dried maize sheaths are off-spec	6	Non-worked blowers, poor visual inspection	8	Visual inspection by operators	6	288	Preventive maintenance, training	Maintenance (10/5/07)	6	4	4	96
	Contaminates/ impurities in maize sheaths	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	maize sheaths from different sources, poor visual inspection	9	Visual check by operators	7	315	Internal training, set up work instruction	QC (18/5/07)	3	4	4	48
	Heat loss at drying rooms	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Old, inefficient, improper insulation,	8	No control	8	320	Set up work instruction	Production (15/5/07)	5	4	4	80

Failure Mode and Effect Analysis (FMEA)

Workstation unit: Furnace
Process name: Drying process at drying rooms
Documented by: Pachara L.
Approved by: Factory Manager
Approved date: 9/3/07
Team members: Pachara L., Somsak T., Yupin K., Chainipat L., Manoch S., Noppadol K.

FMEA Date (Org.): 8/1/07
FMEA Date (Rev.):
Page: 4 of 5

Process Function & Requirement	Potential Failure Mode	Potential Effect(s) of Failure	S	Potential Cause(s)/ Mechanism(s) of Failure	O	Current Process Controls	D	RPN	Recommended Actions(s)	Resonsibility & Target Completion Date	Action result			
											S	O	D	RPN
Furnace	Inaccurate temp. at furnace	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Temp. indicator false Poor maintenance	4	Temp. check every shift	7	140	set up work instruction for calibration	Maintenance (10/5/07)	5	2	4	40
	Insufficient supply of fuel	Some dried maize sheaths are off-spec, long drying time	5	Poor management and purchasing systems, operators do not follow work instruction	5	Plan of fuel in advance	7	175	Set up work instruction	Inventory (11/5/07)	5	2	4	40
	Insufficient heat generation	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Not good quality of fuel, variation of fuel	5	No control	8	200	develop methods to evaluate fuel quality	Process Eng. (13/5/07)	5	2	4	40
	Fouling inside hot water tubes	Some dried maize sheaths are off-spec	5	Dirty water is used	3	water quality check monthly	3	45	Set PM plan in water pipe	Maintenance (10/5/07)				
	Insufficient heat generation	Some dried maize sheaths are off-spec, long drying time	5	Fuel feed is not enough, feeding is inconsistent	4	manual feed of fuel	7	140	Set up work instruction, training	Production (15/5/07)	5	2	4	40

Failure Mode and Effect Analysis (FMEA)

Workstation unit: Furnace
Process name: Drying process at drying rooms
Documented by: Pachara L.
Approved by: Factory Manager
Approved date: 9/3/07
Team members: Pachara L., Somsak T., Yupin K., Chainipat L., Manoch S., Noppadol K.

FMEA Date (Org.): 8/1/07
FMEA Date (Rev.):

Process Function & Requirement	Potential Failure Mode	Potential Effect(s) of Failure	S	Potential Cause(s)/ Mechanism(s) of Failure	O	Current Process Controls	D	RPN	Recommended Actions(s)	Resonsibility & Target Completion Date	Action result			
											S	O	D	RPN
Furnace	Heat loss at furnace	Some dried maize sheaths are off-spec, long drying time, high energy cost	5	Old, inefficient insulation	8	No control	8	320	set up work instruction	Production (15/5/07)	5	4	4	80
	Heating system is not optimize	High energy cost, long drying time, Some dried maize sheaths are off-spec	5	No recycle of used hot air, no maintenace plan for bloweres, improper positions of blowers	10	No control	8	400	Modifying heating system	Process Eng. (13/5/07)	5	7	3	105

Appendix III

Work Instruction for Maize Drying Process

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คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

Document 1

Work Instruction

Maize drying in drying rooms

WI-PC-03- 21

Authorization to use this document

Producer(s) and reviser(s)	Authorisation person(s)

Doc no. : WI-PC-03-21	Rev : 01
Work Instruction	Page : 2
คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

History of revision

No.	**Revised Page**	**Description of revision (Briefly)**	**Date of revision**
1.	1.	First use as formal work instruction document	13 May 2007

Doc no. : WI-PC-03-21	Rev : 01
Work Instruction	Page : 3
คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

Objectives

1. To control maize drying process in drying rooms as standard
2. To reduce the humidity of maize sheaths according to the required specification of dried products before proceeding to other processes (i.e. milling etc.)
3. To control the temperature of drying uniformly and suitably

Scope

1. Drying to reduce humidity of maize sheaths

Definition

Maize sheaths inspector: staff who works in the process of maize sheaths inspection

Standard for maize sheath drying

1.1 After maize sheath inspect process, maize sheath inspector place the maize sheaths into the drying containers in an appropriate position (usually in cross direction, see work instruction no.7). The maize sheaths inspectors then fill the work details into the form (WI-PC-03-17) which include dates, types of maize sheaths, batch number, drying container number, weight and initial humidity before sending to drying operators.

1.2 Drying operators read and check the data recorded in the form before adjusting the position of maize sheaths in drying containers. If there is something wrong, the operators need to inform the maize sheaths inspectors for revision and correction. The drying operators have to fill the data into the drying record form.

1.3 Drying operators control the drying process and set up the temperature of drying according to the **Direction of maize drying**

1.4 Drying operators regularly check the temperature in drying rooms every hour and make a record into the form. All temperature indicators in the drying rooms are recorded every hour. They also need to be calibrated at least once a week using their operation manuals. If any temperature indicator is false or broken, drying operators need to inform shift engineers in order to replace it quickly as possible.

1.5 Drying operators take samples at 8.00 and 16.00 daily and send to laboratory for analysis. Drying operators need to get back the laboratory result in the form of "Corn and seed moisture report" (FM-QA-01-05) which indicates the humidity at 9.00 and 17.00 daily.

1.6 Drying operators adjust the drying temperature according to the lab results.

1.7 Drying operators operate the drying process until the maize sheaths have humidity that passes the specification indicated in the **Direction of maize drying**

1.8 Drying operators write a report and check before submit to the head.

Sampling Technique

Samples need to be taken from both upper and lower parts of the drying containers. In the upper parts, five positions which are about a hand depth from the surface are selected

Direction of maize drying

1. **Quantity of maize sheaths to be placed in drying containers for sweet corn**

Humidity	Suggested quantity (bags)
>40%	Not more than 120 bags
<40%	Not more than 150 bags

2. **Quantity of maize sheaths to be placed in drying containers for field corn**

Humidity	Suggested quantity (bags)
>25%	Not more than 300 bags
20-25%	Not more than 350 bags
15-20%	Not more than 380 bags
<15%	Do not need to dry

3. Temperature of drying

Humidity	Temperature for drying sweet corn	Temperature for drying field corn
	Switch on fans for 24 hours	
>25%	35-37 °C	35-37 °C
20-25%	37-38 °C	37-38 °C
<20%	38-40 °C	38-40 °C
	(Not more than 42 °C)	(Not more than 42 °C)

4. Humidity required for stop drying

Type of maize	Sweet corn	Field corn
Maize sheaths	11.00-15.00% (upper-lower)	13.00-15.00% (Average)
Maize seeds	6.50-7.50%	9.50-10.5%

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Document 2

Work Instruction

Suitable drying time in drying rooms

WI-PC-03- 11

Authorization to use this document

Producer(s) and reviser(s)	Authorisation person(s)

Doc no. : WI-PC-03-11	Rev : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

History of revision

No.	Revised Page	Description of revision (Briefly)	Date of revision
1.	1.	First use as formal work instruction document	13 May 2007

Doc no. : WI-PC-03-11	Rev : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

Objectives

1. To suggest suitable drying time according to the inlet humidity of the maize sheaths

Scope

1. To determine suitable drying time to reduce humidity of maize sheaths

Definition

Maize sheaths inspector: staff who works in the process of maize sheaths inspection

Procedure

1.1 Drying operators carefully read and check the record form from maize sheaths inspector.

1.2 Drying operators take samples of maize sheaths to send for initial humidity analysis.

1.3 After receiving the result and record it into the drying form, drying operators set up the drying time according to the Table III below. First temperature of drying needs to be controlled in the range specified in the drying temperature Table (Table II) according to the type of maize sheaths (sweet corn or field corn).

1.4 Apart from that drying operators take samples at 8.00 and 16.00 in order to send to laboratory for analysis; they have to take samples at the suggested drying time to send for analysis. This will ensure that the drying time is not too much and the energy can be saved if the tested humidity from QC analysis passes the specification reported in Table I.

1.5 Drying operators write a report and check before submit to the head.

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Sampling Technique

Samples need to be taken from both upper and lower parts of the drying containers. In the upper parts, five positions which are about a hand depth from the surface are selected

Specification of dried maize sheath

Table 1: Specification of dried maize sheaths

Type of maize	Sweet corn	Field corn
Maize sheaths	11.00-15.00% (upper-lower part of drying containers)	13.00-15.00% (Average)
Maize seeds	6.50-7.50%	9.50-10.5%

Drying temperature

Table 2: Drying temperature according to the initial humidity and the type of maize sheaths

Humidity	Temperature for drying sweet corn	Temperature for drying field corn
	Switch on fans for 24 hours	
>25%	35-37 °C	35-37 °C
20-25%	37-38 °C	37-38 °C
<20%	38-40 °C	38-40 °C
	(Not more than 42 °C)	(Not more than 42 °C)

Drying time

Table 3: Suggested drying times according to the inlet humidity of maize sheaths (based on previous data)

Inlet humidity	Drying time for sweet corn (minutes)	Drying time for field corn (minutes)
11-15%	0	0
16-20%	2500 ± 300	2000 ± 300
21-25%	3600 ± 300	3050± 300
26-30%	4750 ± 300	4200 ± 300
31-35%	5300± 300	4800 ± 300
36-40%	6050 ± 300	5500 ± 300
41-45%	6600 ± 300	6000 ± 300
46-50%	7100 ± 300	6600 ± 300
51-55%	7600 ± 300	7100 ± 300
56-60%	8000 ± 300	7600 ± 300

The suggested drying time needs to be revised every year in order to update the data and provide more accurate drying time.

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คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

Document 3

Work Instruction

Calibration procedure for drying time recorders

WI-PC-03- 13

Authorization to use this document

Producer(s) and reviser(s)	Authorization person(s)

Doc no. : WI-PC-03-13	Rev : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

History of revision

No.	Revised Page	Description of revision (Briefly)	Date of revision
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Doc no. : WI-PC-03-13	Rev : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

Objectives

1. To suggest procedure to calibrate drying time recorders
2. To specify schedule for checking and calibrating drying time recorders

Scope

1. To describe procedure and schedule of checking and calibrating drying time recorders in drying rooms

Procedure

1. Drying operators check drying time recorders of each drying room every hour whether they are still working

2. Drying operators clean drying time recorders every time they check them

3. For calibrating the drying time recorders, standard stopwatches are required. First operators turn on the drying time recorders and at the same time start timing using stopwatches. The operators then record the result in every 10 minutes until 1 hour in order to compare drying time indicated by the drying time recorders with that from standard stopwatches. If they differ by more than 20%, the drying time recorder should be judged faulty and be repaired.

Quality Records

See the calibration record form below:

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Calibration record form for drying time recorders

Drying time recorder number	Time of record	Drying time recorder (minutes)	Stopwatch time (minutes)	%Error
1		0	0	-

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Document 4

Work Instruction

Preparation of maize sheaths before drying

WI-PC-03- 01

Authorization to use this document

Producer(s) and reviser(s)	Authorization person(s)

Doc. No. : WI - PC - 03-01	Rev. : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :15 May 2007

History of revision

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1.	1.	First use as formal work instruction document	15 May 2007

Doc. No. : WI - PC - 03-01	Rev. : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :15 May 2007

Objective

1. To control the quality of raw material (maize sheaths) before sending to drying process

Scope

This document is used for controlling the quality of maize sheaths after downloading them from trucks by describing methods to remove impurities or contaminates from maize sheaths.

Definitions

- PPS = Plant Processing Supervisor
- PPF = Plant Processing Foreman
- PDS = Production Support

Involved documents

- Record form of receiving maize sheaths (FM-PC-03-01)
- Form for labeling maize sheaths (FM-PC-03-16)
- Form for sending samples to QA (FM-QA-01-01)

Procedure

- PPF or authorized persons receive delivery form (DA) from trucks carrying maize sheaths
- PPF or authorized persons check delivery form (DA) with the name of farmers, the farmers' code, type of maize sheaths, batch, grade and quantity of maize sheaths
- In the case of wrong DA or the trucks do not have DA, PPF or authorized persons contact with PDS for corrective action before receiving the maize sheaths every time

- Place and classified the received maize sheaths into piles and clearly label each pile (FM-PC-03-16). It is necessary to ensure that the floor is clean and dry before loading the maize sheaths.
- Sampling each pile of maize sheaths for QA department check according to the procedure WI-QA-02-01 using the form FM-QA-01-01
- Remove contaminates from each pile by sieving and manual separation. Contaminates here include stones, woods, metals, etc.
- In the case of maize sheaths that have bad quality (R-Grade), separate it as a different pile with label (FM-PC-03-16) for selling as waste later on
- In the case of maize sheaths that have very high humidity or visually wet which cannot be preceded to drying process directly, PPF has to inform maintenance department in order to perform air blowing or sun drying before processing.
- PPF or authorized persons need to conclude the maize sheath receiving daily according to FM-PC-03-01 for recording and informing PPS
- Maize sheaths already checked for contaminates will be labeled with FM-PC-03-16 and be ready to proceed to drying process.

Safety caution

Use appropriate safety and health device such as safety shoes and caps. No smoking is allowed. If operators want to smoke, they have to stop working and smoke in the provided smoking area.

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Document 5

Work Instruction

Sun drying of maize sheaths

WI-PC-03- 02

Authorization to use this document

Producer(s) and reviser(s)	Authorization person(s)

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Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :15 May 2007

History of revision

No.	Revised Page	Description of revision (Briefly)	Date of revision
1.	1.	First use as formal work instruction document	15 May 2007

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Objective

1. To naturally dry wet maize sheaths before sending to drying process

Scope

This document is used for reducing the humidity of wet maize sheaths using sunshine before actual drying process in drying rooms takes place. This helps saving energy.

Definitions

- PPF = Plant Processing Foreman
- PPS = Plant Processing Supervisor
- MF = Maintenance Foreman
- PDS = Production Support

Involved documents

- Form for labeling maize sheaths (FM-PC-03-16)

Procedure

- After receiving maize sheaths from farmers, PPF or authorized persons will separate them into piles according to the type of maize sheaths and the quality of them. Each pile will be labeled with the form FMPC-03-16.
- For the pile of maize sheaths that have very high humidity or visually wet, PPF or authorized persons will inform maintenance department for performing sun drying.
- MF or PDS will take the pile of high humidity maize sheaths to outdoor area for sun drying. The outdoor area is floored with canvas and the canvas needs to be cleaned and dried before placing the maize sheaths.
- MF or PDS will distribute the maize sheaths to fully cover the total area of the canvas. The maize sheaths will typically be dried for an hour in the

strong sunshine or longer when the sunshine is not strong. This relies on the consideration of PPS. The maize sheaths need to be turned over every half an hour using spades.

- Maize sheaths already sun-dried will be placed back, labeled with FM-PC-03-16 and be ready to proceed to drying process.

Safety caution

Use appropriate safety and health device such as safety shoes and caps. No smoking is allowed. If operators want to smoke, they have to stop working and smoke in the provided smoking area.

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Document 6

Work Instruction

Suitable fuel composition used at furnace

WI-PC-03- 35

Authorization to use this document

Producer(s) and reviser(s)	Authorisation person(s)

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คู่มือการปฏิบัติงาน	Rev. Date :13 May 2007

History of revision

No.	Revised Page	Description of revision (Briefly)	Date of revision
1.	1.	First use as formal work instruction document	13 May 2007

Doc no. : WI-PC-03-35	Rev : 01
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Objective

1. To suggest the types of fuels to be used at the furnace in order to give enough heat for drying process.

Scope

This document is written in order to provide guideline on what type of fuels that should be used for burning at the furnace to give enough heat. The scope also includes the method of how to blend different types of fuels in order to make the fuel that gives the required heat. At the moment, corncobs, firewood, fuel oil, lignite, and diesel are used as fuel in the factory. Corncobs are the most often used fuel since they can be obtained directly from the milling process of dried maize sheaths to maize seeds. They are by-product which does not need to be bought.

Recommendation of fuel composition used at the furnace

Table 1: Recommended fuel to be used at furnace (ranking based on both the heating value of each type of fuel generates and the cost of fuel)

Rank	Type of fuel	Quantity (kg)	Ratio of corncob : fuel
1	Corncobs	19.1	-
2	Corncobs + firewood	21	0.9 : 20.1 kg
3	Corncobs + lignite	17	16.0 : 1.0 kg
4	Corncobs + fuel oil	17	16.3 : 0.7 kg
5	Corncobs + diesel	17	16.3 : 0.7 kg
6	Firewood	21.1	-
7	Lignite	6.0	-
8	Fuel oil	4.8	-
9	Diesel	4.5	-

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Note:

- Required heat for the furnace is 150,000-250,000 kJ (from manual of the furnace). Therefore the average heat required for the furnace is 200,000 kJ. The furnace has maximum loading capacity of fuel of 30 kg.
- Calculation is based on the average value of high heating values and low heating values, i.e. Corncob has an average heating value of 10456.5 kj/kg
- The cost of fuel in the descending order is: diesel > fuel oil > lignite > firewood > corncob
- Formulation needs to be revised in every six months

Procedure for feeding fuel to furnaces

1. Check fuel feeding system, fuel quantity and composition, fuel conveyor to the furnace, water valves, and furnace control system (Figure 1).
2. Make sure that all important equipments are workable. These equipments include furnace fans, screw conveyor, screw ask and water pump.
3. To start the furnace, first check the fuel feed, water level in the boiler, and water feed tank.
4. Manually turn on the switches of fuel conveyor and the screw conveyor in order to feed the fuel into the furnace. The quantity and composition of fuel required for the furnace are mentioned in Table 1.
5. Ignite the fuel in the furnace.
6. When the fuel is burnt, start the fans of the furnace and turn it to automatic position.
7. Turn other switches to automatic positions. Now the furnace is automatically processing.
8. Start running the blowers in each drying rooms one by one.

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Figure 1: Furnace controlling system

Table 2: Heating values of various types of fuel

	Rice husk	Rice straw	Bagasse	Cane trash	Parawood	Palm fibre	Palm shell	Palm oil empty bunch	Palm tree	Frond	Corncob	Corn stalk	Tapioca rhizome	Eucalyptus bark
	แกลบ	ฟางข้าว	ชานอ้อย	ใบอ้อย	ไม้ยางพารา	ใยปาล์ม	กะลาปาล์ม	ทะลายปาล์ม	ต้นปาล์ม	ทางปาล์ม	ซังข้าวโพด	ลำต้นข้าวโพด	เหง้ามันฯ	เปลือกไม้ยูคาฯ
Proximate analysis														
Moisture, %	12.00	10.00	50.73	9.20	45.00	38.50	12.00	58.60	48.40	78.40	40.00	41.70	59.40	60.00
Ash, %	12.65	10.39	1.43	6.10	1.59	4.42	3.50	2.03	1.20	0.70	0.90	3.70	1.50	2.44
Volatile Matter, %	56.46	60.70	41.98	67.80	45.70	42.68	68.20	30.46	38.70	16.30	45.42	46.46	31.00	28.00
Fixed Carbon, %	18.88	18.90	5.86	16.90	7.71	14.39	16.30	8.90	11.70	4.60	13.68	8.14	8.10	9.56
Ultimate Analysis														
Carbon, %	37.48	38.17	21.33	41.60	25.58	30.82	44.44	21.15	23.90	10.13	28.19	27.83	18.76	18.60
Hydrogen, %	4.41	5.02	3.06	5.08	3.19	3.74	5.01	2.56	3.04	1.25	3.36	4.06	2.48	2.12
Oxygen, %	33.27	35.28	23.29	37.42	24.48	21.61	34.70	15.34	22.91	9.44	27.42	22.47	17.50	16.68
Nitrogen, %	0.17	0.56	0.12	0.40	0.14	0.84	0.28	0.27	0.56	0.07	0.12	0.13	0.32	0.15
Sulfur, %	0.04	0.09	0.03	0.17	0.02	0.08	0.02	0.04	0.06	0.02	0.03	na	0.04	0.02
Chlorine, %	0.09	na	na	0.01	0.01	0.11	0.02	0.16	na	0.12	0.05	na	0.05	0.10
Ash, %	12.65	10.39	1.43	6.10	1.60	4.42	3.52	2.03	1.20	0.70	0.90	3.70	1.50	2.44
Moisture, %	12.00	10.00	50.73	9.20	45.00	38.50	12.00	58.60	48.40	78.40	40.00	41.70	59.40	60.00
Other Characteristics														
Bulk Density, kg/m3	150	125	120	100	450	250	400	380	na	na	na	na	250	na
Higher heating value, kJ/kg	14,755	13,650	9,243	16,794	10,365	13,127	18,267	9,196	9,370	3,908	11,298	11,704	7,451	6,811
Lower heating value, kJ/kg	13,517	12,330	7,368	15,479	8,600	11,400	16,900	7,240	7,556	1,760	9,615	9,830	5,494	4,917
Source of data	EFE	Kinoshita	ERI	EFE	Gulf	Songkhla	Gulf	Songkhla	EFE	EFE	EFE	EFE	EFE	EFE
Revision : March 2007														
หมายเหตุ ผลวิเคราะห์ข้างต้นอ้างอิงจากตัวอย่างชีวมวลที่นำมาทดสอบเท่านั้น ซึ่งอาจจะมีค่าแตกต่างกันไปตามสายพันธุ์พืชและพื้นที่ปลูก														
Remark: The above analysis data is based on only taken biomass sample, which may be varied to species and plantation area.														

	Lignite	Diesel	Fuel oil
High heating value (kJ/kg)	34100	45900	42400
Low heating value (kJ/kg)	33000	43000	40600

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Table 3: Cost per unit of fuel

Cost per unit of fuel	Corncob	Firewood	Lignite	Fuel oil	Diesel
(Baht/kg)	-				

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Document 7

Work Instruction

Packing of maize sheaths for drying

WI-PC-03- 26

Authorization to use this document

Producer(s) and reviser(s)	Authorisation person(s)

Doc no. : WI-PC-03-26	Rev : 01
Work Instruction	Page :
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History of revision

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Doc no. : WI-PC-03-26	Rev : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :15 May 2007

Objectives

1. To control the method of packing of maize sheaths for drying in the drying rooms

Scope

This document is created in order to inform drying operators on how to pack maize sheaths for drying in the drying room.

Procedure for packing of maize sheath for drying

1. After maize sheath inspect process, maize sheath inspector place the maize sheaths into the drying containers in an appropriate position as illustrated in Figure 1. Maize sheaths needs to be filled layer by layer from bottom to the top part of drying containers. The upper layer will be cross with the lower layer as illustrated in the figure. The maize sheaths inspectors then fill the work details into the form (WI-PC-03-17) which include dates, types of maize sheaths, batch number, drying container number, weight and initial humidity before sending to drying operators.

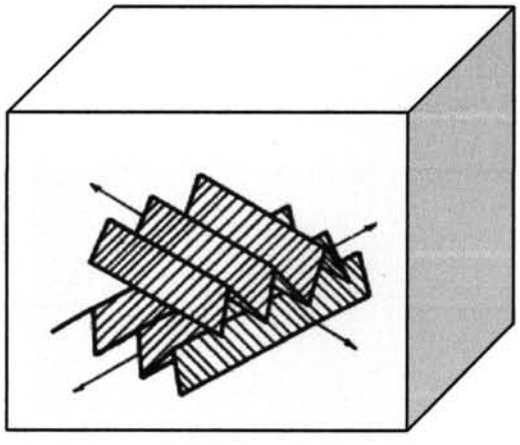

Figure 1: Packing of maize sheaths in drying containers (in cross direction)

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2. Drying operators read and check the data recorded in the form and adjust the packing if required. The drying operators then put the drying containers in appropriate positions in drying rooms and fill the data into the drying record form.

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Document 8

Work Instruction

Checking insulation at drying rooms, furnaces and connections between them

WI-PC-03- 34

Authorization to use this document

Producer(s) and reviser(s)	Authorisation person(s)

Doc no. : WI-PC-03-34	Rev : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :15 May 2007

History of revision

No.	Revised Page	Description of revision (Briefly)	Date of revision
1.	1.	First use as formal work instruction document	15 May 2007

Doc no. : WI-PC-03-34	Rev : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :15 May 2007

Objectives

1. To control the quality of insulation at drying rooms, furnaces, and connections between drying rooms and furnaces

Scope

This document is created in order to describe the procedure of schedule checking the efficiency of insulation, methods to evaluate the efficiency of insulation, and the time period to replace old insulation.

Definitions

- PPF = Plant Processing Foreman
- PPS = Plant Processing Supervisor

Procedure

1. Daily checking the status of insulation around drying rooms, furnaces, and connections between furnaces and drying rooms are carried out by PPF. They need to visually check the surface of insulation whether there is any defect or dirt or strains. In case of dirt and strains, PPF has to remove them and clean insulation. For defect, they have to inform PPS immediately for replacement.

For actual checking the efficiency of insulation, the service staff from the companies that sold the insulation will be called to visit and check the efficiency in every three months. The time period to replace old insulation depends on the recommendation of the sale services.

2. The suggested types of insulation to be used at the process depend on the R-value of materials used as insulation. R-value is a term predominantly used to quantify the insulative properties of insulation materials. The higher the R-value, the greater insulation. According to the insulation sale services and the process engineer, recommend materials to be used for insulation are those who have minimum R-value of 1 m^2 K/W.

Doc. No. : WI - PC - 03-42	Rev. : 01
Work Instruction	Page :
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Document 9

Work Instruction

Fuel stock control

WI-PC-03- 42

Authorization to use this document

Producer(s) and reviser(s)	Authorization person(s)

Doc. No. : WI - PC - 03-42	Rev. : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :11 May 2007

History of revision

No.	Revised Page	Description of revision (Briefly)	Date of revision
1.	1.	First use as formal work instruction document	11 May 2007

Doc. No. : WI - PC - 03-42	Rev. : 01
Work Instruction	Page :
คู่มือการปฏิบัติงาน	Rev. Date :11 May 2007

Objective

1. To establish a consistent and documented method for the requisition and management of fuel supply for furnaces

Scope

This document is applied to administrative requests for fuel supply at the factory from the furnace workstation unit.

Definitions

- FNF = Furnace Foreman

Involved documents

- Fuel supply sheet (FM-PC-03-32)

Procedure

- FNF has a responsibility to look after the quantity of fuel used at the furnace. Fuel that needs to be remained at the furnace all time is corncobs, firewood, diesel, lignite, and fuel oil. Each one need to be in stock at least 10 kg. If a particular fuel is not in stock, or low, FNF are to identify which fuel needs to be replenished on the supply sheet (FM-PC-03-32) that is posted inside the furnace workshop.
- The requester then will submit the completed form to the Stock and Purchasing Department.
- The Stock and Purchasing department after obtaining a determination of the request from FNF will evaluate and revise their stock control

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- Upon approval of the request, the request will be processed for acquisition and the Stock and Purchasing Department will also inform the furnace workstation unit.

Appendix IV

Preventive maintenance plan for blowers

Preventive maintenance plan for blowers

Blower No.	Drying Room No.	Detail	Responsible Person	Due Date
1	1	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.1	Maintenance	Monthly
2	1	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.1	Maintenance	Monthly
3	1	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.1	Maintenance	Monthly
4	2	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.2	Maintenance	Monthly
5	2	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.2	Maintenance	Monthly
6	2	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.2	Maintenance	Monthly
7	3	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.3	Maintenance	Monthly
8	3	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.3	Maintenance	Monthly

9	3	Inspection the blower, cleaning the blower, checking the air flow rate, checking the air flow rate, cleaning the ventilation system in drying room No.3	Maintenance	Monthly
10	4	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.4	Maintenance	Monthly
11	4	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.4	Maintenance	Monthly
12	4	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.4	Maintenance	Monthly
13	5	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.5	Maintenance	Monthly
14	5	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.5	Maintenance	Monthly
15	5	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.5	Maintenance	Monthly
16	6	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.6	Maintenance	Monthly
17	6	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.6	Maintenance	Monthly

18	6	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.6	Maintenance	Monthly
19	7	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.7	Maintenance	Monthly
20	7	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.7	Maintenance	Monthly
21	7	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.7	Maintenance	Monthly
22	8	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.8	Maintenance	Monthly
23	8	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.8	Maintenance	Monthly
24	8	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.8	Maintenance	Monthly
25	9	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.9	Maintenance	Monthly
26	9	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.9	Maintenance	Monthly
27	9	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.9	Maintenance	Monthly

28	10	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.10	Maintenance	Monthly
29	10	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.10	Maintenance	Monthly
30	10	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.10	Maintenance	Monthly
31	11	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.11	Maintenance	Monthly
32	11	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.11	Maintenance	Monthly
33	11	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.11	Maintenance	Monthly
34	12	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.12	Maintenance	Monthly
35	12	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.12	Maintenance	Monthly
36	12	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.12	Maintenance	Monthly
37	13	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.13	Maintenance	Monthly

38	13	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.13	Maintenance	Monthly
39	13	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.13	Maintenance	Monthly
40	14	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.14	Maintenance	Monthly
41	14	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.14	Maintenance	Monthly
42	14	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.14	Maintenance	Monthly
43	15	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.15	Maintenance	Monthly
44	15	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.15	Maintenance	Monthly
45	15	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.15	Maintenance	Monthly
46	16	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.16	Maintenance	Monthly
47	16	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.16	Maintenance	Monthly

48	16	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.16	Maintenance	Monthly
49	17	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.17	Maintenance	Monthly
50	17	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.17	Maintenance	Monthly
51	17	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.17	Maintenance	Monthly
52	18	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.18	Maintenance	Monthly
53	18	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.18	Maintenance	Monthly
54	18	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.18	Maintenance	Monthly
55	19	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.19	Maintenance	Monthly
56	19	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.19	Maintenance	Monthly
57	19	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.19	Maintenance	Monthly

58	20	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.20	Maintenance	Monthly
59	20	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.20	Maintenance	Monthly
60	20	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.20	Maintenance	Monthly
61	21	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.21	Maintenance	Monthly
62	21	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.21	Maintenance	Monthly
63	21	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.21	Maintenance	Monthly
64	22	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.22	Maintenance	Monthly
65	22	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.22	Maintenance	Monthly
66	22	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.22	Maintenance	Monthly
67	23	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.23	Maintenance	Monthly

68	23	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.23	Maintenance	Monthly
69	23	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.23	Maintenance	Monthly
70	24	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.24	Maintenance	Monthly
71	24	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.24	Maintenance	Monthly
72	24	Inspection the blower, cleaning the blower, checking the air flow rate, cleaning the ventilation system in drying room No.24	Maintenance	Monthly

BIOGRAPHY

Pachara Laoaraya was born in Phrae, Thailand, 1980. He graduated from Sirindhorn International Institute of Technology, Thammasat University, Thailand in 2002 with a Bachelor's degree in Industrial Engineering. He continues his study in Engineering Business Management for Master's Degree at Regional Centre for Manufacturing Systems Engineering, Chulalongkorn University (TH) and University of Warwick (UK).