



Report of Cooperative Education

Troubleshooting of pressure oscillation in pellet transfer system



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Jirayu Lochanachai

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เลขทะเบียน.....078355
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By: Jirayu Lochanachai

Field of Study: Petrochemical Engineering

Advisor: Assoc. Prof. Dr. Duangkamol Na-Ranong

Affiliation: Assist. Prof. Dr. Pornsawan Assawasaengrat

Mentor (Position) : Dr. Phakdee Amornsudthiwad (Improvement Engineer)

Company: Siam Polyethylene Co. Ltd.

Abstract

Dense phase pneumatic conveying system is used in polyethylene production to convey the product pellets. There was a problem of high conveying pressure oscillation causing abrupt pellets transfer system. This project is to study for the effect of variable in pellets transfer system such as pellet size, initial air flow rate, and purging time to determine the new standard condition for a problem free operation. The research founded that the high pressure oscillation was caused by too high initial air flow rate set point leads to delayed plugging. The high pressure oscillation problem was completely solved by reducing the initial air flow rate by 10%.

Keywords: Dense phase. Pneumatic conveying system, Pressure oscillation

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Table of Contents

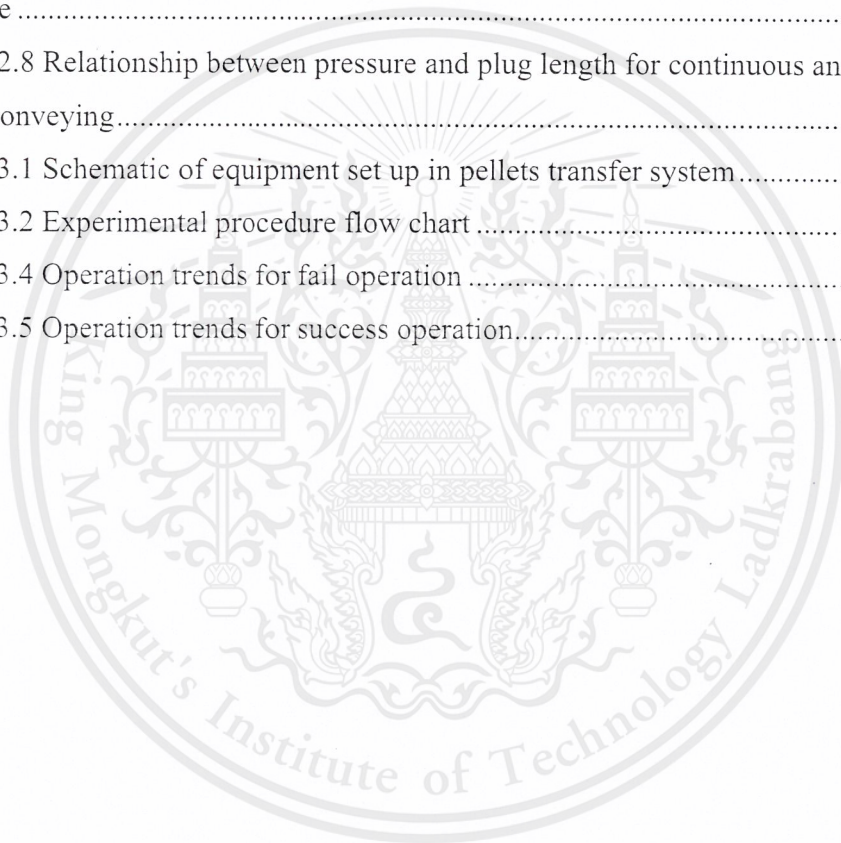
	Page
Abstract	I
Acknowledgements	II
Table of Contents	III
List of Figures	V
List of Tables	VI
Nomenclature	VII
Chapter I Introduction	1
1.1 Background	1
1.2 Objectives.....	1
1.3 Scopes of study.....	2
1.4 Expected outputs	2
Chapter II Literature Review	3
2.1 Polyethylene	3
2.2 Polyethylene production process.....	5
2.3 Pneumatic conveying system.....	7
2.4 Pipeline blockage	17
Chapter III Research Methodology	20
3.1 Analysis of historical data	20
3.2 Experimental setup.....	22
3.3 Experimental procedure	23
Chapter IV Results and Discussion	28
4.1 Analysis of historical data results.....	28
4.2. Experimental result	29
Chapter V Conclusion	35
References	36

Appendix A. Operation results38
 A.1 Result table for product P2, P3, P438
Bibliography41



List of Figures

Figure 2.1 Polyethylene production process flow diagram	5
Figure 2.2 Components of pneumatic conveying system	9
Figure 2.3 Schematic of vacuum transfer	10
Figure 2.4 Schematic of pressure transfer.....	10
Figure 2.5 Schematic of dilute phase pneumatic conveying.....	12
Figure 2.6 Schematic of dense phase pneumatic conveying.....	13
Figure 2.7 Relation of conveying phase with conveying velocity and conveying pressure	15
Figure 2.8 Relationship between pressure and plug length for continuous and pulse phase conveying.....	16
Figure 3.1 Schematic of equipment set up in pellets transfer system.....	22
Figure 3.2 Experimental procedure flow chart	23
Figure 3.4 Operation trends for fail operation	26
Figure 3.5 Operation trends for success operation.....	26



List of Tables

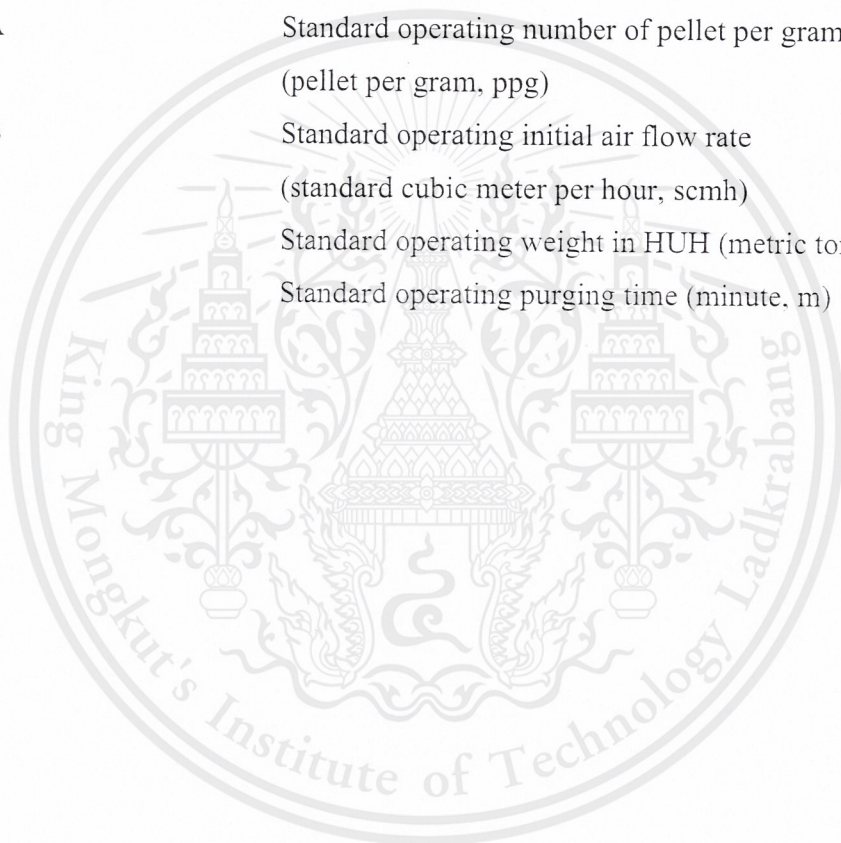
Table 2.1 Differences of operating condition of polyethylene production method	4
Table 3.1 Historical analyzation counting table	21
Table 3.2 Standard operating condition of pellets transfer system	24
Table 3.3 Process operating parameters control range and applied value	24
Table 3.4 Operating condition table.....	25
Table 3.5 Operating result table.....	25
Table 4.1 Summary of historical data analyzation for product specification and percentage of problem occurrence	28
Table 4.2 Operating condition for standard operation	29
Table 4.3 Operating results for standard operation.....	29
Table 4.4 Operating condition for studying of purging time effect.....	30
Table 4.5 Operating results for studying of purging time effect.....	30
Table 4.6 Operating condition for studying of pellet size effect	31
Table 4.7 Operating results for studying of pellet size effect.....	31
Table 4.8 Operating condition for studying of initial air flow rate effect.....	32
Table 4.9 Operating results for studying of pellet size effect.....	32
Table 4.10 Summary of the study of the effect of operating parameters results	33
Table A.1 Operating condition for studying of initial air flow rate effect on P2	38
Table A.2 Operating results for studying of initial air flow rate effect on P2	38
Table A.3 Operating condition for studying of initial air flow rate effect on P2	39
Table A.4 Operating results for studying of initial air flow rate effect on P3	39
Table A.5 Operating condition for studying of initial air flow rate effect on P4	40
Table A.6 Operating results for studying of initial air flow rate effect on P4	40

Nomenclature**Abbreviation**

PE	Polyethylene
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
HDPE	High density polyethylene
HUH	Hold up Hopper

Variable

A	Standard operating number of pellet per gram (pellet per gram, ppg)
B	Standard operating initial air flow rate (standard cubic meter per hour, scmh)
Z	Standard operating weight in HUH (metric ton, mt)
T	Standard operating purging time (minute, m)



Chapter I

Introduction

1.1 Background

Siam Polyethylene Co. Ltd is the manufacturer of linear low density polyethylene (LLDPE), using Dow solution polyethylene technology. The products are in solid pellet forms. The pellets are conveyed from production units to the storage silo using pneumatic conveying system. The pellets transfer is achieved by differential pressure of conveying air. The transfer pressure must be stable for a smooth operation. If the pressure is too high or oscillating, it could damage the transfer system such as rotary feeder or piping system. The equipment damage will cause plant outage for few days which will result in significant of profit loss (approximated a million US dollars). Recently, transfer pressure had been high and oscillating during the standard conveying condition, causing abrupt pellets transfer.

This project is to study the effect of the parameter in conveying system and to solve the problem of high pressure oscillation that potential to risks of production loss, operation failure and equipment failure that will cost much loss to the company.

1.2 Objectives

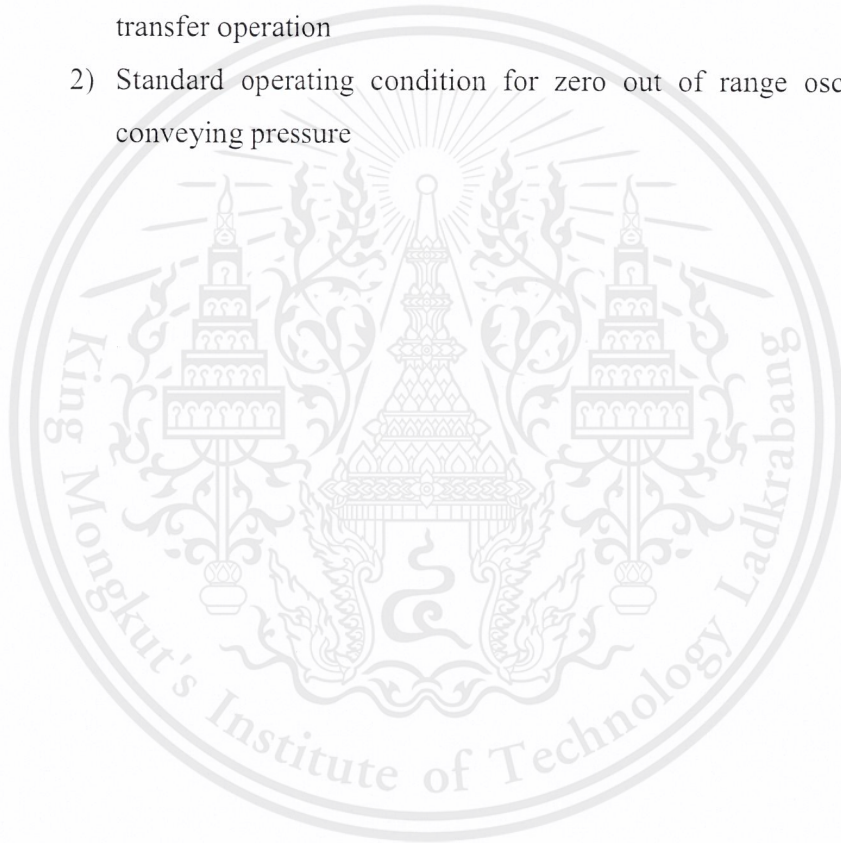
- 1) To understand the working principle of pneumatic conveying system
- 2) To study the effect of parameter to the pressure oscillation
- 3) To solve the high pressure oscillation
- 4) To determine the new standard transfer condition

1.3 Scopes of study

- 1) Study the process of the polyethylene production and pneumatic conveying system at pellets transfer part
- 2) Study and analyze historical data of operation at pellets transfer system from November, 2015 to September, 2016
- 3) Study the effect of purging time, pellet size and initial air flow rate

1.4 Expected outputs

- 1) Understanding of the effects of operating parameters to the pellets transfer operation
- 2) Standard operating condition for zero out of range oscillation of conveying pressure



Chapter II

Literature Review

2.1 Polyethylene

Polyethylene is a thermoplastic polymer with variable crystalline structure and an extremely large range of applications depending on the particular type. Polyethylene is one of the most widely produced plastics in the world by the variety of uses applications.

PE is classified as a thermoplastic. Thermoplastic materials become liquid at their melting point (110-130 degrees Celsius in the case of LDPE and HDPE respectively). A major useful attribute about thermoplastics is that they can be heated to their melting point, cooled, and reheated again without significant degradation. Instead of burning, thermoplastics like Polyethylene liquefy, which allows them to be easily injection molded and then subsequently recycled. By contrast, thermoset plastics can only be heated once (typically during the injection molding process). The first heating causes thermoset materials to set resulting in a chemical change that cannot be reversed. Heating a thermoset plastic to a high temperature a second time would simply burn it. This characteristic makes thermoset materials poor candidates for recycling.

2.1.1 Polyethylene application

The applications for polyethylene in which certain types depends on their suitability. For examples, High Density Polyethylene (HDPE) is much more crystalline, has a much higher density, and is often used in completely different circumstances than Low Density Polyethylene (LDPE). LDPE is widely used in plastic packaging such as for grocery bags or plastic wrap. HDPE by contrast has common applications in construction

2.1.2 Polyethylene properties

Low Density Polyethylene (LDPE) is a very flexible material with very unique flow properties that makes it particularly suitable to plastic film applications like shopping bags. LDPE has high ductility but low tensile strength which is evident in the real world by its propensity to stretch when strained.

Linear Low Density Polyethylene (LLDPE) is very similar to LDPE with the added advantage that the properties of LLDPE can be altered by adjusting the

formula constituents and that the overall production process for LLDPE is typically less energy intensive than LDPE.

High Density Polyethylene (HDPE) is a strong, high density, moderately stiff plastic with a highly crystalline structure. It is frequently used as a plastic for milk cartons, laundry detergent, garbage bins, and cutting boards.

2.1.3 Polyethylene production

The manufacture of polyethylene follows addition polymerization of in a highly purified form of ethylene under the right conditions of temperature, pressure and catalysis, the double bond of the ethylene monomer opens up and many monomers link up to form long chains. Polyethylene manufacturing processes are usually categorized into "high pressure" and "low pressure" operations

High Pressure Process was developed in the UK using peroxide catalyst at 80-300 °C and produces low density randomly oriented polymer which have a low melting point. The process is run at pressure of 1000 – 3000 barg.

For Low Pressure Process was originally developed in Germany for preparing high density polyethylene (HDPE) and linear low density polyethylene (LLDPE). The catalyst used in this process consists of heavy metal derivatives in 10 – 80 barg.

Table 2.1 Differences of operating condition of polyethylene production method

	Operating pressure	
	High pressure	Low pressure
Product	LDPE	LLDPE, HDPE
Operating pressure	1000 to 3000 barg	10 to 80 barg
Operating temperature	80 to 300°C	70 to 300°C
Type of polymerization	Solution process Slurry process	Gas phase process
Catalyst	Peroxide	Ziegler/Natta Cr/Mo oxide Metallocene

2.2 Polyethylene production process

Polyethylene production basically composed of 7 main steps, Raw material preparation, polymerization, Reactant recovery, polymer purification, pelletizing, material handling, packing.

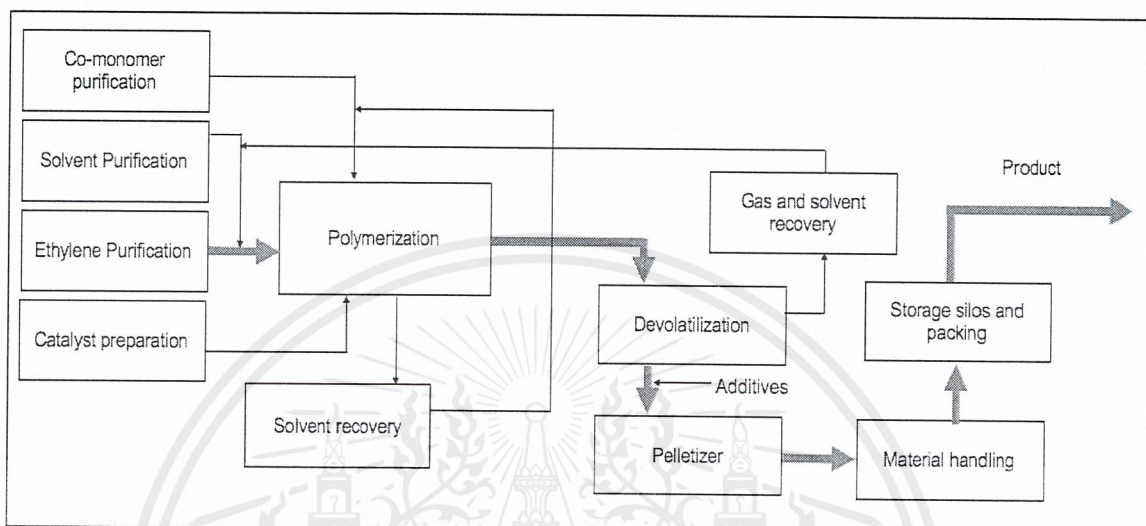


Figure 2.1 Polyethylene production process flow diagram

2.2.1 Raw material preparation

Raw material preparation steps consist of Solvent purification, Co-monomer purification, Ethylene purification and Catalyst preparation. Raw material was purified before fed to the process. At first, high purity ethylene is purified from the process of desulphurization and removal of light end, oxygen, and compounds which can possibly deactivate the catalyst.

2.2.2 Polymerization

Polymerization is a key step of polyethylene production. The polyethylene was produced on this step. The mixed stream of purified ethylene and solvent stream is fed to a reactor where it is mixed with catalyst and co-monomer stream at the in a proper condition at polymerization unit.

2.2.3 Reactant recovery

Reactant recovery is a step to recover the solvent and unreacted ethylene from the polymerization and devolatilization unit.

2.2.4 Polymer purification

Polymer purification is a step to remove the unreacted ethylene, solvent, and low molecular weight polymer from the product polymer. Polymerized polymer from reactor stream is fed to devolatilizer to evaporate the remaining low molecular weight and volatile compound from the polymer before feed to the pelletizer. The specific additives are fed to the polymer at the exit of devolatilization unit to improve the special properties of the polymer.

2.2.5 Pelletizing

Pelletizing is a step to cut the material from the large melt polymer to small pellets. The pelletized polymer is conveyed to a screen shaker to separate the off-sized pellets before sending to material handling and storage part.

2.2.6 Material handling

Material handling is a step to hold the polymer pellets to identify the specification and properties of the product before sending to the storage part. The product is labelled on this step to determine the number of lot. The polymer pellets from pelletizing unit are conveyed to material handling part that holds the material before sending to the storage silos.

2.2.7 Packing

After identifying the specification of the polymer in material handling part, the polymer pellets packing is done in this step to provide into the supply chain and sell as product.

As the product of the polyethylene is a granular particle, the transportation of the polymer pellets throughout the material handling unit is done by pneumatic conveying system.

2.3 Pneumatic conveying system

Pneumatic conveying is the system to transfers small particles through a conveying line in a gas stream. It has been used in chemical and process industries to transport of materials such as flour, granules, chemicals, soda ash, lime, plastic chips and coal. The pellets transfer is achieved by either differential pressure or high velocity of air flow which is supplied by blower or compressor. The pneumatic conveying system can convey the particle in distances. The system is totally enclosed and the system can operate entirely without moving parts coming into contact with the conveyed material to ensure that there is no contamination by the transfer system.

2.3.1 Advantages and disadvantages of a pneumatic conveying system

Advantages:

1. No contamination, the enclosed system prevents product from contamination which is especially important when dealing with sensitive products, as well as keeping hazardous materials in. Pneumatic conveyors eliminate many opportunities for spillage that occur with mechanical conveyance systems. Because mechanical conveyors primarily work in straight lines the routing for the conveying is more difficult to design in a plant and consumes more area for siting the system.

2. Simple and flexibility routing, compared to mechanical conveyors, pneumatic systems help simplify the routing of bulk materials transfer paths throughout a plant.

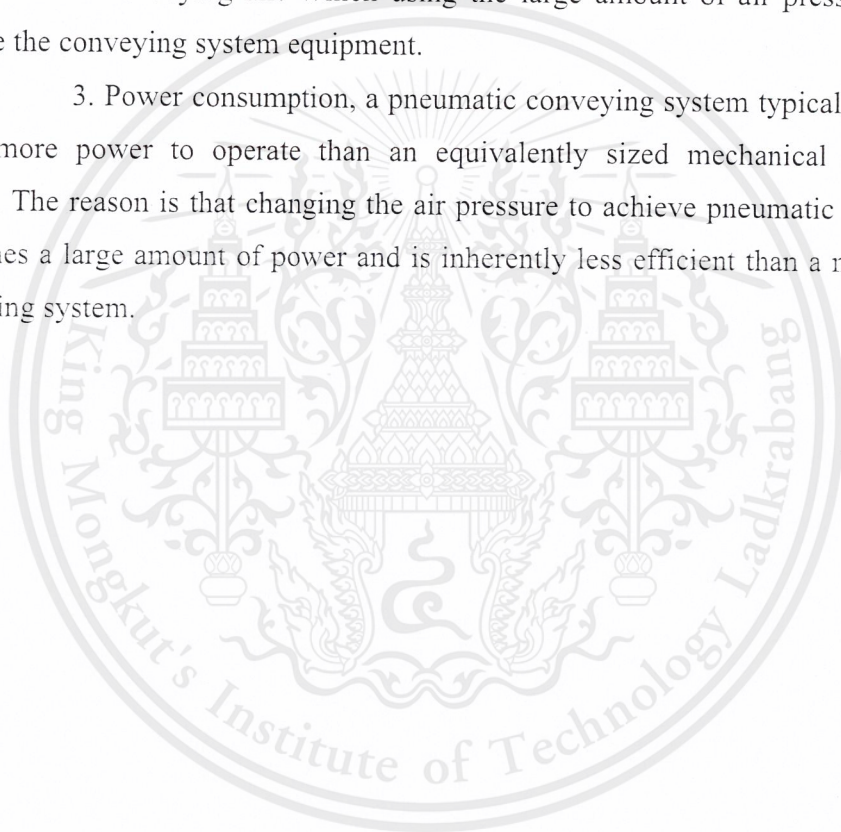
3. Less Maintenance, one thing that all mechanical conveyors have in common is an abundance of moving parts. A multitude of belts, rollers, and bearings are used in their construction, and all of these parts need to be maintained. Compare with the pneumatic conveying system. The system can operate entirely without moving parts just the maintenance of material feeder, air mover (i.e. compressor, blower), and diverter valves is to be required.

Disadvantages:

1. Narrow range of product application, some materials have characteristics that is difficult to convey in a pneumatic system. For example, a material with a large particle size and high bulk density or an extremely sticky material which tends to build a coating on any material-contact surface such buildup often leads to total pipeline blockage. These material should be easier to convey with mechanical conveyors.

2. Limited distance and capacity, thus the pneumatic conveying system is less amount of moving part. The motive force for transportation was limitedly provided from conveying air. Which using the large amount of air pressure would damage the conveying system equipment.

3. Power consumption, a pneumatic conveying system typically requires much more power to operate than an equivalently sized mechanical conveying system. The reason is that changing the air pressure to achieve pneumatic conveying consumes a large amount of power and is inherently less efficient than a mechanical conveying system.



2.3.2 System component

The pneumatic conveying system main components can be divided in 4 main sections: 1. The air supplier 2. Feeding, mixing and acceleration zone 3. The conveying zone 4. Gas-solids separation zone as shown in the Figure 2.2

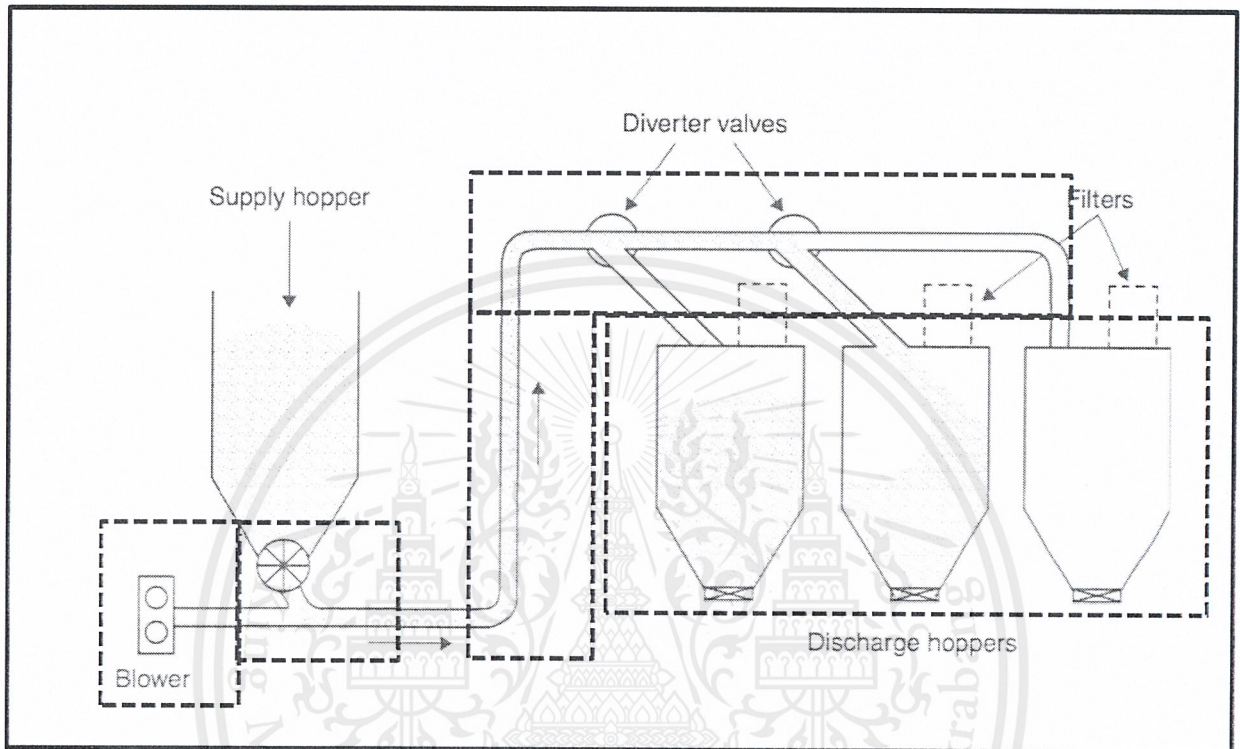


Figure 2.2 Components of pneumatic conveying system

The air supplier

Air air supplier is an important part for pneumatic conveying system. Air supply was provided for the pneumatic conveying system by using air compressors, blower, fan or vacuum pump to provide the appropriate gas flow rate and pressure of conveying gas. The conveying air condition are available in both pressure transfer and vacuum transfer.

1. Vacuum transfer: A vacuum system's basic components are a vacuum generator (the air mover), pickup nozzle, conveying line, and receiver. The vacuum generator creates the required negative pressure to pull the material through the conveying line and into the receiver and can be a regenerative blower or a positive-displacement vacuum pump.

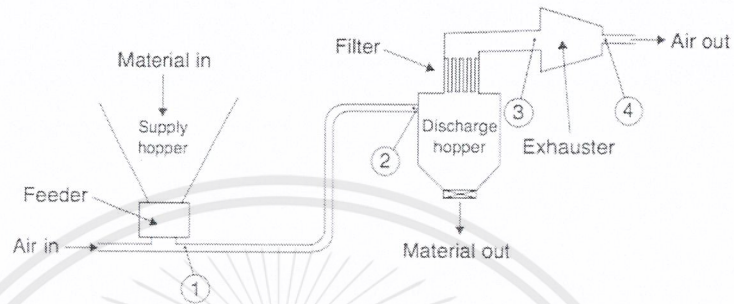


Figure 2.3 Schematic of vacuum transfer

2. Pressure transfer: A pressure system's basic components are blower, fan or air compressor to serve as the air mover, rotary airlock feeder, pressure vessel, conveying line, and receiver. By creating pressure to push the material through the conveying line. The pressure conveying system is generally preferred for transporting a heavier material over a longer distance.

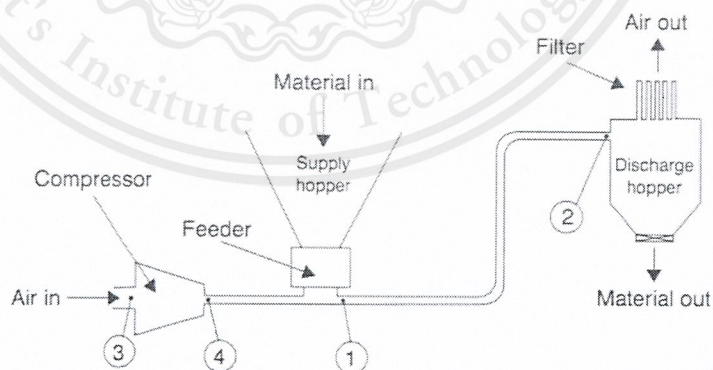


Figure 2.4 Schematic of pressure transfer

Feeding, mixing and acceleration zone: The mixing area is the most important area in pneumatic conveying system. This area is the determination of the transfer phase for the conveying. The materials are fed into flowing gas stream. The materials are mixed with the flowing gas and provide acceleration zone establishing the flow characteristic for phase of conveying, i.e. dense phase, dilute phase and build up the energy for the material to transfer through conveying zone.

The conveying zone

After the materials formed transfer phase from the acceleration zone, pellets with conveying medium enter the conveying zone that will redirect the conveying route for the conveying system. The conveying zone can have bends, and diverter valve to change flow direction to reception zone.

In the operation of conveying, it is necessary to purge the pipeline to clear of material at the end of a conveying run. Pipeline purging was done at the end of a conveying run by adding the large amount of air flow to purge the remaining particle in the transfer line.

The pipeline purging is the effective method to clean the pipeline to prevent the material deposition on the transfer line which could obstruct the conveying characteristic of transfer material. Line obstruction is one of the main cause for high pressure oscillation problem in pneumatic conveying system

Gas-solids separation zone

Materials from gas stream were conveyed to reception blender. Material falls to the reception blender, air float and leaves the top of the blender by the principle of inside higher pressure to outside lower pressure. Some of process require adequate gas-solid separation system.

2.3.3 Phase of transfer

Phase of transfer are formed at the feeding, mixing and acceleration zone, the classification is based on the average particle concentration in the pipeline to provide the characteristic of transfer system: dilute phase and dense phase. Both dense-phase or dilute-phase can be operating by any pressure and vacuum systems.

Dilute phase

A dilute-phase system has a high air-to-material ratio. In this system, the materials are suspended in the airstream, and move at a relatively with high velocity and low pressure gas flow. The dilute-phase system constantly supplies the material at the pickup point and conveys it to the system's discharge end without interruption, with no waves or plugs of material and no air pockets.

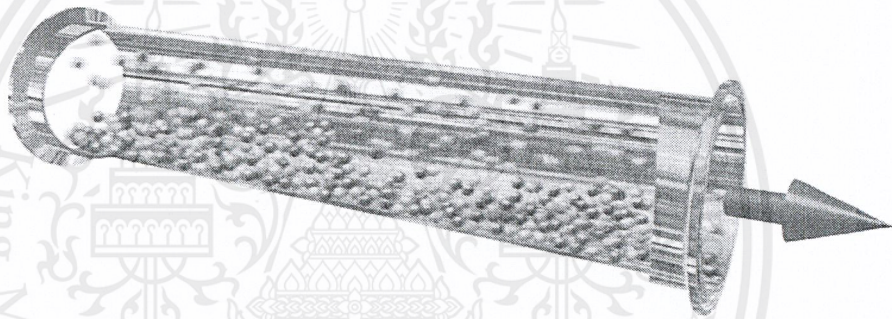


Figure 2.5 Schematic of dilute phase pneumatic conveying

Flow patterns in the dilute phase is the particles completely suspended in the pipe and move as a continuous as suspension with high velocity air results in turbulent flow, the high velocity of particle can release high momentum that can violate the pipeline and transfer equipment or else with the luxurious material could be damaged by the high velocity transfer.

Dense phase

Dense phase system has a low air-to-material ratio. The conveying velocity is below the saltation level, the critical velocity at which particles fall from suspension in the airstream. The dense-phase system moves the material through the conveying line in plugs, at high-pressure, low-velocity gas flow with discrete material waves or plugs separated by air pockets.

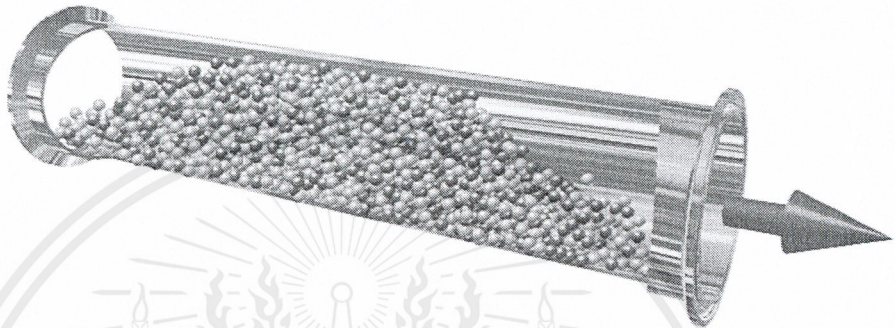


Figure 2.6 Schematic of dense phase pneumatic conveying

Flow patterns in the dense phase is the particles completely pack the pipe and move as a continuous dense plug to situations where the solids on the bottom of the pipe move as a series of dunes with a dilute phase layer of solids flowing above the dunes. The stable flow of dense phase system situations results in a smooth conveying that would gentle to the transfer material.

For dense phase system the minimum velocity at the feed point will depend on a wide range of parameters which makes it difficult to determine. Ultimately, it is the velocity below which blockage of the pipeline occurs. The materials that convey in plugs, the minimum transport velocity will occur when there is insufficient air flow to move the plug.

2.2.4 Parameter influences

The pneumatic conveying system behavior can be influenced by many parameters. For examples, pressure of conveying air stream flow, velocity, quality of air control, material feeding rate, material properties, material special characteristics.

Transfer pressure

On focusing the dense phase pneumatic conveying system is the system using the pressure to transfer materials instead of velocity from dilute phase, the main controlling factor is the transfer pressure. Transfer pressure need to be controlled in the proper value. If the transfer pressure is too high the the transfer line, equipment and product could be damaged and broken. In the other hand the transfer pressure if the transfer pressure is too low, the materials could not be transfer resulting the material plugging in transfer line. Which means that the transfer pressure need to be controlled in appropriate value.

Transfer pressure can be easily influenced by many factor in the transfer system, the air flow rate, solids flow rate, pressure drop, equivalent length of the pipeline, solids concentration.

Solid loading ratio

Solid loading ratio is a dimensionless to determine the mass flow rate of material to be conveyed to mass flow rate of the air used for conveying. The solids loading ratio is a useful parameter for describing the amount of material in the air in pneumatic conveying system pipelines.

The pressure drop in the conveying line is primarily dependent upon the concentration of the material in the pipeline, or the solids loading ratio. If too much material is fed into the conveying line it is possible that the pipeline could become blocked from insufficient of the conveying gas flow, resulting the higher transfer pressure requirement.

Velocity

The velocity of conveying gas is an important parameter. The transition of dense phase conveying and dilute phase conveying condition. The high velocity of conveying gas drives the transfer system to the dilute phase area which implemented in turbulent flow characteristic.

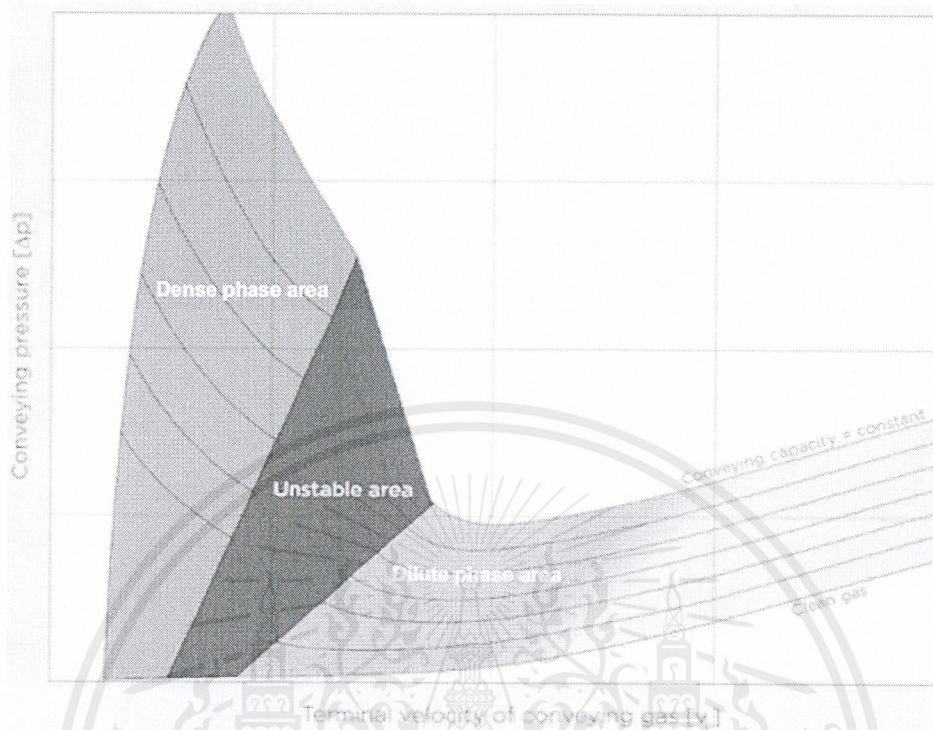


Figure 2.7 Relation of conveying phase with conveying velocity and conveying pressure

By reducing the velocity of conveying gas will shift the transfer mode to dense phase. The concerning condition is the unstable area in transition phase from dilute phase to dense phase. Unstable conveying creates non-uniform plug size which causing high oscillation of conveying pressure to convey the different size of plugs and can damage to the equipment, pipeline and products.

2.2.5 Plug size effect

The main consideration of dense phase pneumatic conveying system is the plug forming system. As the material is conveyed in dense phase by a number of short plugs, separated by air gaps, then the pressure requirements can be reduced substantially. On the non-linear relationship between pressure and plug length, the pressure required to convey a number of short plugs is significantly less than that required to convey a single plug of equivalent length.

The initial air flow rate of the conveying system is the determining variable to determine the pathway of the particles to transfer in dense phase or dilute phase. The low air flow will shift the transfer phase to dense phase.

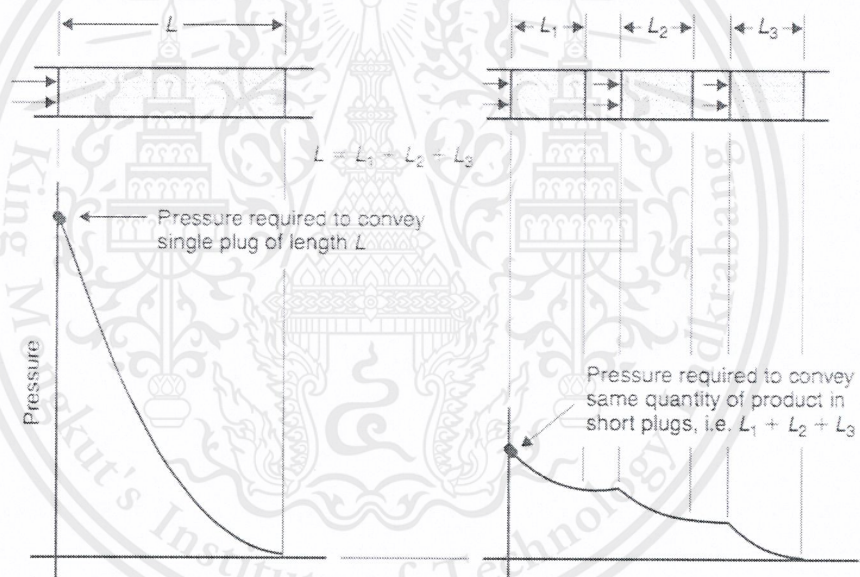


Figure 2.8 Relationship between pressure and plug length for continuous and pulse phase conveying

To operate the proper dense phase pneumatic conveying system, the transfer pressure should not be too high. High transfer pressure can damage and break the equipment and transfer line.

Delayed plugging is the transition of dense phase to dilute phase that the particles neither establish the small plugs to transfer with dense phase nor completely suspended flow in lean dilute phase. Delayed plugging influenced by the improper initial air condition of solid to air ratio in dense phase conveying system. Too high initial air flow rate condition will disturb in acceleration zone resulting the system neither create the short plug nor delivered to the destination by dilute phase. The materials are blown and accumulated with undelivered pellets establishing large plug and build up the high transfer pressure.

In dense phase pneumatic conveying, the system need to avoid from creating large plug and unstable plug size that require high transfer pressure. The too large plug size establishing can lead to more severe problem pipeline blockage.

2.4 Pipeline blockage

One of the most difficult problems encountered in the pneumatic conveying system operation is pipeline blockage. The pipeline blockage makes the system unable to convey the material and require the cleaning process to clear the transfer line. The pipeline blockage can cause a lot of production loss to the business on cleaning process.

As the large pipeline blockage may require more pressure to push the large blockage material plug which can break the material or equipment. The pipeline blockage can be caused by the insufficiency of conveying air stream to the large materials or the obstruction in the pipeline from material deposition by adhesive force from wet material, or the specialty properties of the material for example, sticky additive added materials. The solution of pipeline blockage is depending on the cases of the operation.

2.4.1 On commissioning blockage

The pipeline blocks during commissioning trials with the pneumatic conveying system, it could indicate that there is either a serious design fault with the system, or some simple adjustment needs to be made to the plant. The problem of pipeline blockage on commissioning could be caused by several reason.

Incorrect air mover specification

If the air flow rate is insufficient or the velocity is too low, the pipeline is likely to block. For materials conveyed in dilute phase, or suspension flow, it is necessary to maintain a minimum velocity, the specification of the conveying system needed to be rechecked for the compatible condition.

Over feeding of pipeline

If a pipeline is over fed, the pressure required may exceed that available from the blower or compressor and the line will block. Reducing the material feed rate to match the capability of the air mover is necessary to be done.

Non steady feeding of pipeline

If the pipeline blocks only occasionally, it is possible that this may be due to surges in the material feed rate. For a system that is operating close to its pressure limit, a momentary increase in feed rate could raise the material concentration to a level that may be sufficient to block the line.

For another minor causes of pipeline blockage on commissioning, the preliminary solution on commissioning is shown in appendix A1.

2.4.2 On start up blockage

If a pipeline has a tendency to block when the system is started up after a shut down period, some transient situation may be responsible. It is quite possible that the system will operate satisfactorily under normal load conditions. The transient situation may be caused by several reason:

Moisture in line

If material is blown into a cold pipeline it is possible that the inside surface could be wet as a result of condensation. The wet line would resist the conveying of material in the pipeline that require more air speed to flow throughout the conveying line. The moisture in line is needed to be eliminated before start up the operation.

Material in pipeline

If the plant is shut down and the pipeline was not purged, a quantity of material could be left in the pipeline. If the conveying line incorporates a long vertical lift section, sufficient material could accumulate in the bend at the bottom causing blockage of the pipeline during start up. If the pipeline is already blocked it will considerably aggravate the situation if more material is blown into the pipeline.



Chapter III

Research Methodology

Polyethylene products in Siam Polyethylene Company Limited is produced different properties by their different reactor condition, co-monomer and additives results in numbers of product grade. And for each operation of product grades has different possibility to face the problem. To understand more about the problem. The data needed to be collected to analyze to determine the detailed of the problem.

3.1 Analysis of historical data

To identify and study for the root cause of the problem, historical data was collected in the interval time since November, 2015 to September, 2016

Operating trends

Study and collect operation trends of the operating parameters in each pellets transfer batches i.e. conveying pressure, rotary feeding rate, air flow, HUH weight.

Products properties

Study the properties i.e. density, additives content of each product grade.

Retained sample

Collect the retained sample. Study for the changed of pellet size, pellets shape and dimensions.

3.1.1 Determine the percent occurrence for all product grade

Collaborating the historical process data to analyze for statistical data of problem with product grades. Determine the frequency of problem occurrence by counting the number of fail operation and success operation for each product grade with the standard operating condition shown as Table 3.1.

Table 3.1 Historical analyzation counting table

Exp.no.	Result	Count
1	[Success/Fail]	[0/1]
2	[Success/Fail]	[0/1]
3	[Success/Fail]	[0/1]
...	[Success/Fail]	[0/1]
n-1	[Success/Fail]	[0/1]
n	[Success/Fail]	[0/1]

Where the result column in results table determined by the operation with high oscillation problem will be marked as fail, the value in column “count” will be marked as 1. In the other hand, the success operation will be marked for the operation with no problem which the value in column “count” will be marked as 0.

The percentage of problem occurrence for the product grade will be defined by Equation 3.1.

$$\% \text{ problem occurrence} = \frac{\text{The summation of the value in column "count"}}{\text{number of experiment (n)}}$$

Equation 3.1 Percentage of problem occurrence calculation

Calculate the percentage of problem occurrence and summarize with the product properties to expand the data to identify the problem case.

3.2 Experimental setup

The pellets transfer system operation sequence follow the schematic of equipment set up by the Figure 3.1.

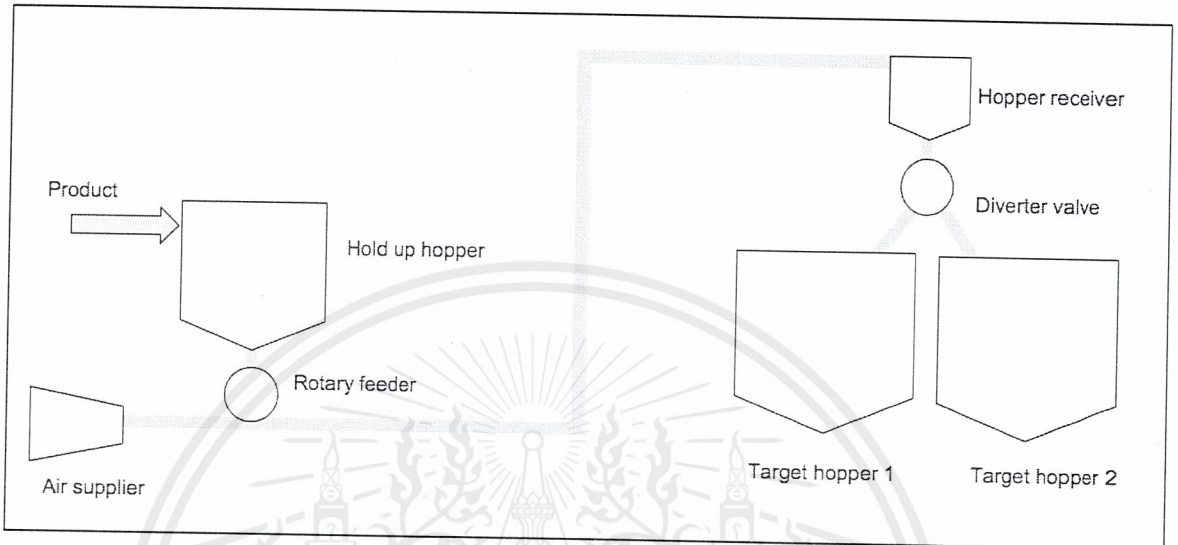


Figure 3.1 Schematic of equipment set up in pellets transfer system

Pellets transfer operation steps

1. Hold up hopper receives pellets from pelletizer and feeds the pellets to conveying line by rotary feeder.
2. Pellets fed to conveying line by rotary feeder and mixed with air flow stream from air supplier
3. Pellets conveyed with air throughout the conveying line to hopper receiver.
4. The delivered pellets in hopper receiver pass the diverter valve to fill the 1st target storage hopper.
5. As the targeted storage hopper full, the pellets transfer operation needed to be postponed for a several minutes for switching the target storage hopper process.
6. Stop rotary feeder, increase air flow to purge the remaining pellets in transfer line.
7. After the transfer line was completely purged, switch the the diverter valve direction to 2nd target storage hopper.
8. Start rotary feeder at 100%.

3.3 Experimental procedure

The step of work in operation was done by the Figure 3.2.

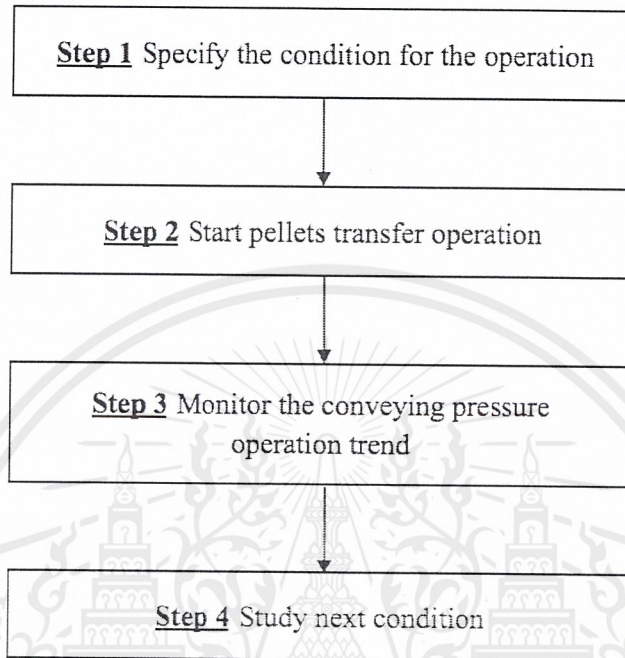


Figure 3.2 Experimental procedure flow chart

3.3.1 Specify the condition

A standard operating condition in pellets transfer operation shown following the Table 3.2. (Since the details of operating parameters are considered “Dow confidential information”, the real values are replaced with alphabetic symbolic such as “A” pellet per gram (ppg), “Z” metric ton (mt), “T” minutes (min) or “B” standard cubic meter per hour (scmh))

Table 3.2 Standard operating condition of pellets transfer system

Operating parameter	Standard condition value
Rotary feeding rate (%)	100%
Initial HUH weight (mt)	Z
Purging time (min)	T
Pellet size (ppg)	A
Initial air flow rate (scmh)	B

By the operation of pellets transfer system was connecting with the main production line, the operating condition needed to be control in the range that would not affect to the production. The operating parameters to be apply in the experiment is shown in Table 3.3.

Table 3.3 Process operating parameters control range and applied value

Parameter	Standard value	Control range	Applied value
Purging time	T	$T < T+30\%$	T, T+30%
Pellet size	A	$A \pm 10\%$	A, A-5%, A-10%
Initial air flow rate	B	$B \pm 10\%$	B, B-10%

3.3.2 Start pellets transfer operation

Operate the pellets transfer system follows the pellets transfer operation at step 6.

3.3.3 Monitor the conveying pressure operation trend

Monitor the conveying operation trends and record the operating parameter and operation results on a Table 3.4 and Table 3.5 respectively.

Table 3.4 Operating condition table

Operating condition		Unit
Product		-
Initial air flow rate		scmh
Initial HUH weight		mt
Pellet size		ppg
Purging time		min
Rotary feeding rate		%

Table 3.5 Operating result table

Exp.no.	Result
1	[Success/Fail]
2	[Success/Fail]
3	[Success/Fail]
...	[Success/Fail]
n	[Success/Fail]

Where the result column in Table 3.5 is determined by the oscillation of conveying pressure operation trends. The criteria for problem operation shown in Figure 3.3 which will be marked as fail and the success operation is shown in Figure 3.4.

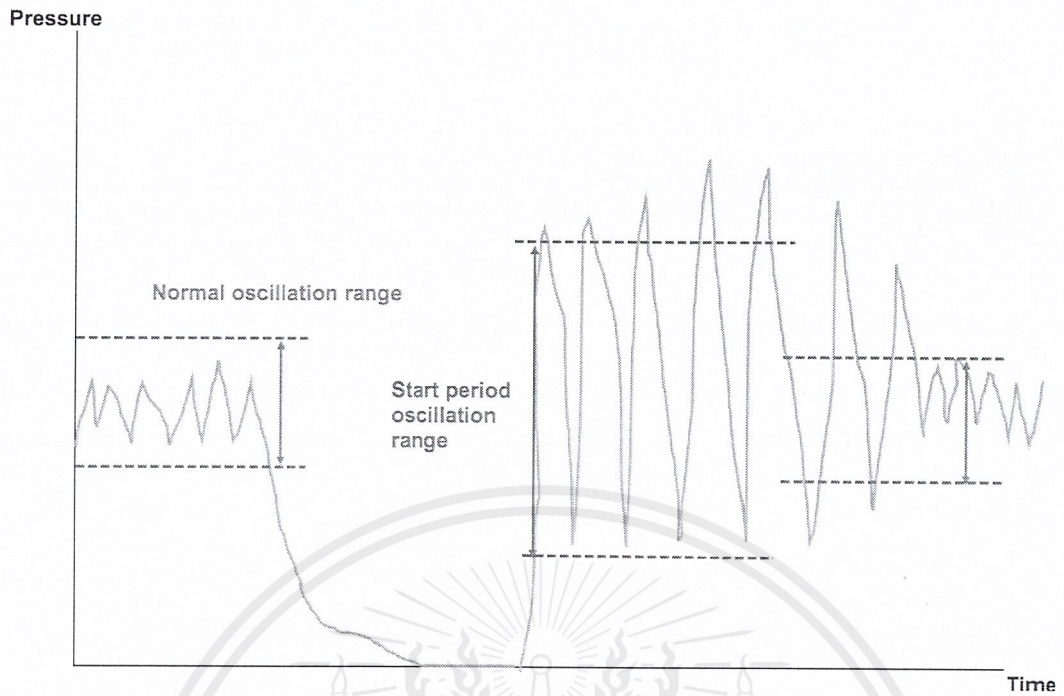


Figure 3.3 Operation trends for fail operation

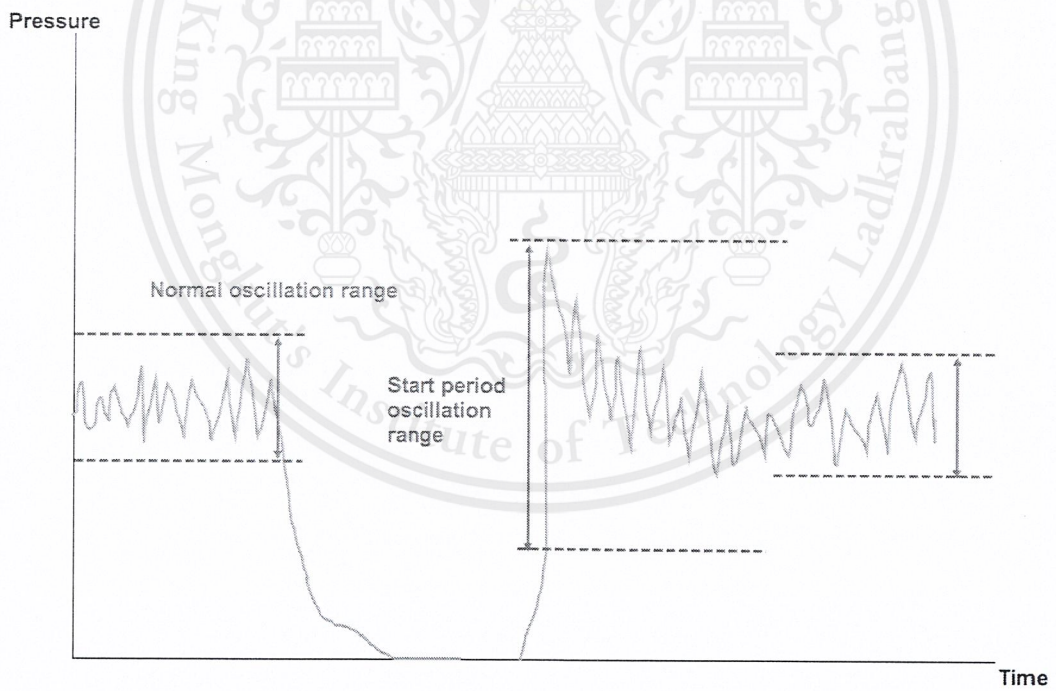
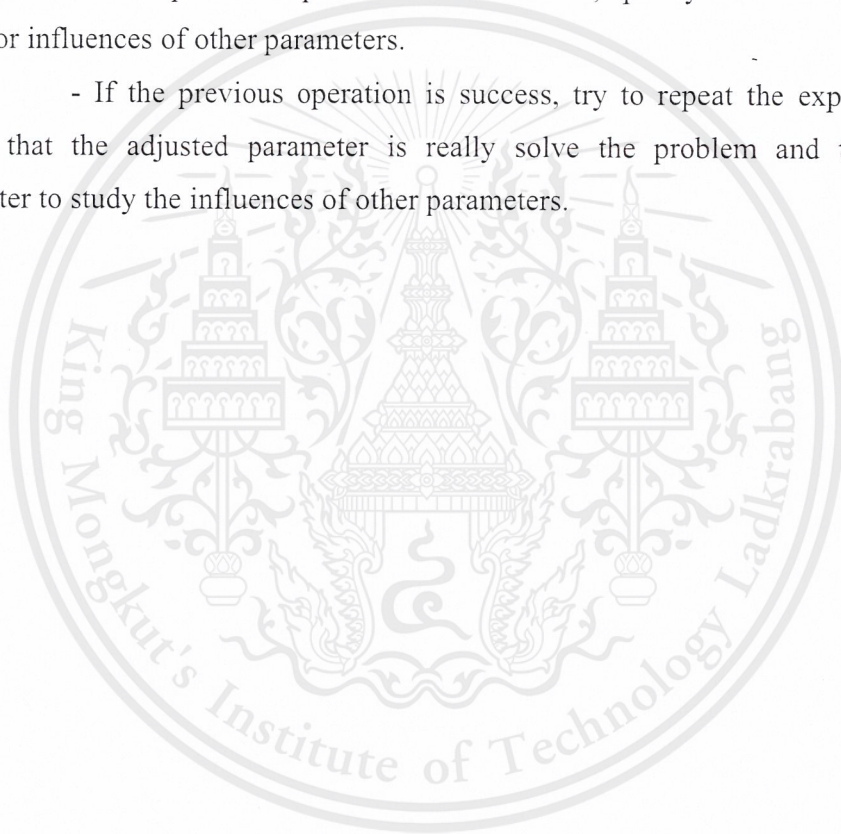


Figure 3.4 Operation trends for success operation

From Figure 3.4, The criteria for the the successful operation is determined by the operation trends of conveying pressure. If the conveying pressure is oscillated out of the standard range will be considered as fail operation. In the other hand, the operation trends of conveying pressure that oscillated within the standard range will be considered as success operation.

3.3.4 Study next condition

- If the previous operation result was fail, specify the next condition to study for influences of other parameters.
- If the previous operation is success, try to repeat the experiment to ensure that the adjusted parameter is really solve the problem and then other parameter to study the influences of other parameters.



Chapter IV Results and Discussion

4.1 Analysis of historical data results

4.1.1 Percentage of problem occurrence

The percentage of problem occurrence for each of product grade were analyzed shown in appendix A. and summarized as the table 4.1.

Table 4.1 Summary of historical data analyzation for product specification and percentage of problem occurrence

Product	Additives		Melt index	% Problem occurrence
	A1	Other additives		
P1	/		X	90%
P2	/		2X	10%
P3	/	/	X	40%
P4	/	/	2X	5%
P5		/	X	0%
P6		/	2X	0%

(Since the details of product properties are considered as “Dow confidential information” the real value of results and the product name are replaced as the alphabetic symbols and the providing of insignificant information were removed)

From table 4.1, the product with additives A1 and low melt index (in term of “high density product reactor condition”) has significantly high value of percentage of problem occurrence. The product P1 was chosen for a representative product grade to apply on experiment.

4.2. Experimental result

4.2.1 Standard operation

The standard condition was operated by product P1 follow the Table 4.2. Since the operation trends are considered as “Dow confidential information” the operation trends are replaced as the operating results shown in Table 4.3

Table 4.2 Operating condition for standard operation

Operating condition		Unit
Product	P1	-
Initial air flow rate	B	scmh
Initial HUH weight	Z	mt
Pellet size	A	ppg
Purging time	T	min
Rotary feeding rate	100	%

Table 4.3 Operating results for standard operation

Exp.no.	Result
1	Fail

The operating result for standard condition is considered as fail. The result for the standard operating condition was used as reference operating condition.

4.2.2 Purging time effect

The purging time effect was studied by increasing the purging time by 30% to ensure that the material in conveying pipeline was completely purged as follow the operating condition in Table 4.4 and the result shown in Table 4.5.

Table 4.4 Operating condition for studying of purging time effect

Operating condition		Unit
Product	P1	-
Initial air flow rate	B	scmh
Initial HUH weight	Z	mt
Pellet size	A	ppg
Purging time	T+30%	min
Rotary feeding rate	100	%

Table 4.5 Operating results for studying of purging time effect

Exp.no.	Result
1	Fail

The result of increasing the purging time from T to T+30% did not effectively reduce the pressure oscillation in transfer system. The result of the operation is considered as fail. And the conveying pressure before the operation of pellets transfer are not different from the standard operation condition of purging time T minutes, shows that purging time in standard condition was sufficient for the complete pipeline purging.

4.2.3 Pellet size effect

The effect of pellet size was studied by increase the pellet thickness in term of reducing the number of pellet per gram by 5% and 10% as follow the operating condition in Table 4.6 and the result shown in Table 4.7

Table 4.6 Operating condition for studying of pellet size effect

Operating condition		Unit
Product	P1	-
Initial air flow rate	B	scmh
Initial HUH weight	Z	mt
Pellet size	A-5%, A-10%	ppg
Purging time	T	min
Rotary feeding rate	100	%

Table 4.7 Operating results for studying of pellet size effect

Exp.no.	Result
1	Fail
2	Fail

The result of increasing pellet size by reducing the number of pellet per gram by 5% from A-5%, A-10% respectively. The results did not significantly reduce the pressure oscillation in transfer system but the test for reducing number of pellets per gram could not proceed because of the control range specification was reached.

4.2.4 Air flow rate effect

The effect of air flow rate was studied by reduce the initial air flow rate by 10% that will shift the phase of transfer to the dense phase area was applied product P1 as follow the operating condition in table 4.8 and the results shown in table 4.8

Table 4.8 Operating condition for studying of initial air flow rate effect

Operating condition		Unit
Product	P1	-
Initial air flow rate	B-10%	scmh
Initial HUH weight	Z	mt
Pellet size	A	ppg
Purging time	T	min
Rotary feeding rate	100	%

Table 4.9 Operating results for studying of pellet size effect

Exp.no.	Result
1	Success
2	Success
3	Success
4	Success
5	Success
6	Success
7	Success
8	Success
9	Success
10	Success
11	Success
12	Success

The initial air flow rate of operating condition was reduced to B-10% to eliminated the delayed plugging effect from too high air velocity and found that the oscillation out of limited range was totally eliminated. The experiment was repeated with the product P1 for 12 pellets transfer batches with the result of 100% success with the transfer pressure oscillation within the control range.

The reducing of initial air flow rate was applied to the operating condition with other product, P2, P3, and P4 transfer and found that the conveying pressure oscillation out of range has been totally solved. And the result are summarized in chapter 4.2.5.

4.2.5 Summary

The study of the effect of operating parameters was summarized shown in Table 4.10

Table 4.10 Summary of the study of the effect of operating parameters results

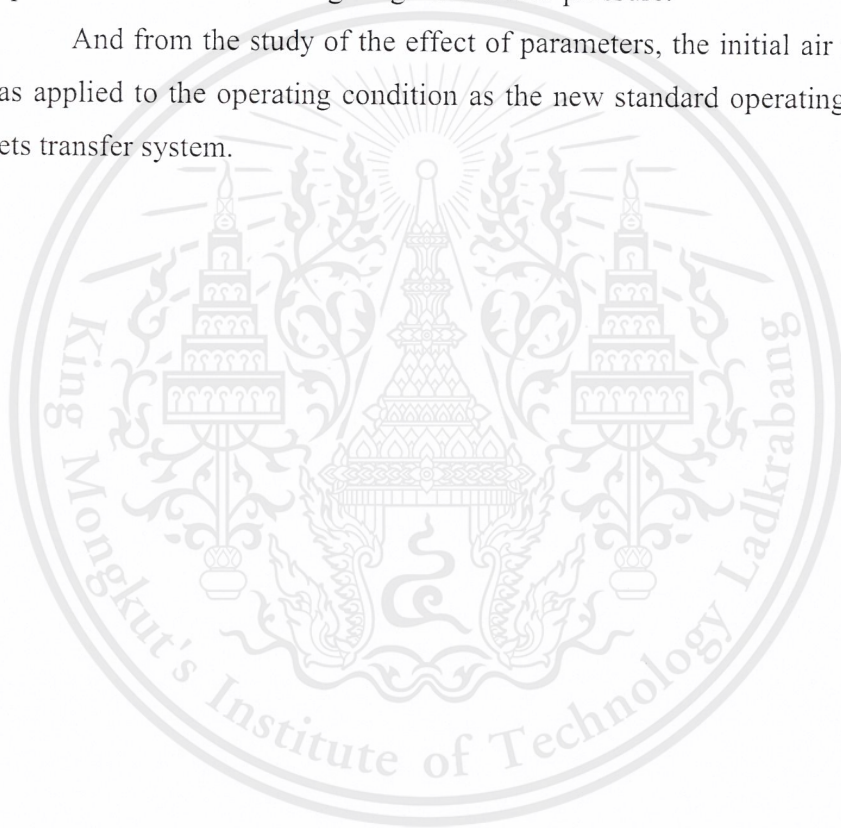
Experiment number	Number of replication	Parameter				Results		
		Product grade	Purging time (min)	Pellet size (ppg)	Initial air flow rate (SCMH)	Pressure oscillation		Operating result
						within range	out of range	
1	1	P1	T	A	B	0	1	Fail
2	1	P1	T+30%	A	B	0	1	Fail
3	1	P1	T	A-5%	B	0	1	Fail
4	1	P1	T	A-10%	B	0	1	Fail
5	12	P1	T	A	B-10%	12	0	Success
6	20	P2	T	A	B-10%	20	0	Success
7	18	P3	T	A	B-10%	18	0	Success
8	14	P4	T	A	B-10%	14	0	Success

The solution of reducing the initial air flow rate was selected to apply to all other product grade which lower percentage of problem occurrence and found that the result was 100% success operation. While the application of other study of the parameters such as purging time and pellet size cannot solve the oscillation problem in this study scope.

The initial air flow rate of the old standard condition was too high for the establishing of short plugs. Too high initial air flow rate condition disturbs the transfer characteristic in acceleration zone resulting the system neither create the short plug nor delivered to the destination by dilute phase. The materials are blown and accumulated with undelivered pellets established the large plug and build up the high transfer pressure.

Reducing the initial air flow rate leads the transfer material to establish the earlier short sized plugs to transfer as dense phase. The shorter plugs require lower transfer pressure reduced the swing range of transfer pressure.

And from the study of the effect of parameters, the initial air flow of B-10% was applied to the operating condition as the new standard operating condition for pellets transfer system.



Chapter V

Conclusion

The effect of variable in the pellets transfer system was studied and found that the too high initial air flow caused delayed plugging which influenced the unstable flow characteristic phase by the sign of pressure oscillation out of the standard range. The new standard transfer condition was determined by reducing the initial air flow set point by 10% totally solve the pressure oscillation problem which are applicable to all product grades.



References

1. Perry, H.R. and Green D.W. *Perry's Chemical Engineer's Handbook*. 8th ed. McGraw-Hill: New York, 2008.
2. David Mills. *Pneumatic conveying design guide*, 2nd ed; Elsevier Butterworth-Heinemann: Massachusetts, 2004.
3. R.D. Marcus, L.S. Leung, G.E. Klinzing, F. Rizk. *Pneumatic conveying of solids*, 1st ed; Chapman & Hall: London, 1990.
4. Priscilla Lepoutre. The manufacture of polyethylene.
<http://nzic.org.nz/ChemProcesses/polymers/10J.pdf> (accessed Dec 8, 2016)
5. Enppi Co. Ltd. Polyethylene production technology.
<https://www.researchgate.net> (accessed Dec 8, 2016)
6. Aptech (Powder Systems) Limited. Advances in pneumatic conveying.
<http://www.aptech.uk.com/file/2015/06/Aptech-Advances-in-Pneumatic-Conveying-Editorial.pdf> (accessed Dec 8, 2016)



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Appendix A. Operation results

A.1 Result table for product P2, P3, P4

Table A.1 Operating condition for studying of initial air flow rate effect on P2

Operating condition		Unit
Product	P2	-
Initial air flow rate	B-10%	scmh
Initial HUH weight	Z	mt
Pellet size	A	ppg
Purging time	T	min
Rotary feeding rate	100	%

Table A.2 Operating results for studying of initial air flow rate effect on P2

Exp.no.	Result	Exp.no.	Result
1	Success	11	Success
2	Success	12	Success
3	Success	13	Success
4	Success	14	Success
5	Success	15	Success
6	Success	16	Success
7	Success	17	Success
8	Success	18	Success
9	Success	19	Success
10	Success	20	Success

Table A.3 Operating condition for studying of initial air flow rate effect on P2

Operating condition		Unit
Product	P3	-
Initial air flow rate	B-10%	scmh
Initial HUH weight	Z	mt
Pellet size	A	ppg
Purging time	T	min
Rotary feeding rate	100	%

Table A.4 Operating results for studying of initial air flow rate effect on P3

Exp.no.	Result	Exp.no.	Result
1	Success	11	Success
2	Success	12	Success
3	Success	13	Success
4	Success	14	Success
5	Success	15	Success
6	Success	16	Success
7	Success	17	Success
8	Success	18	Success
9	Success		
10	Success		

Table A.5 Operating condition for studying of initial air flow rate effect on P4

Operating condition		Unit
Product	P3	-
Initial air flow rate	B-10%	scmh
Initial HUH weight	Z	mt
Pellet size	A	ppg
Purging time	T	min
Rotary feeding rate	100	%

Table A.6 Operating results for studying of initial air flow rate effect on P4

Exp.no.	Result	Exp.no.	Result
1	Success	11	Success
2	Success	12	Success
3	Success	13	Success
4	Success	14	Success
5	Success		
6	Success		
7	Success		
8	Success		
9	Success		
10	Success		

Bibliography

Name: Jirayu Lochanachai

Date of Birth: 25th June 1995

Address: 688/401 Srinakarin Road, Nongbon, Pravet, Bangkok, Thailand 10250

E-mail: lochanachai.p@gmail.com

Academic Background:

- 2010-2012: High School at Bunyawat Wittayalai School, Lampang
- 2013-Now: Bachelor Degree (Petrochemical Engineering) at King Mongkut's Institute of Technology Ladkrabang

Working Experience:

- 1st June - 29th July 2016: Training student in process operation PPT Global Chemical Public Company Limited
- 8th September – 29th November 2016: Student in Co-operative Education Program training in Siam Polyethylene Co. Ltd., Dow Chemical (Thailand) Limited