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# **LACTOSE SMEARING IN TRANSPORT LINES**

**A Thesis presented in partial fulfilment of the requirements for the degree of  
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## ABSTRACT

The smearing of lactose in pneumatic conveying lines, leads to cakes of lactose building up within the lines. This is an undesirable situation as it leads to reduced throughput, caused by the narrowing of the lines and the increase in downtime required to unblock and clean the pipes. This study was carried out to investigate the causes of smearing and identify solutions to this problem.

Impact testing was carried out, to look at the breakage behaviour of lactose. This identified that energy of impact is the main consideration for the breakage of lactose in pneumatic conveying. This is not only the energy contained before impact, but also the way in which the energy is dissipated during contact. The use of rubber proved an effective technique in lowering the amount of breakage, due to its ability to adsorb and disperse the impact energy during contact.

Testing was carried out looking at the ability of sliding contact to cause the adhesion of lactose to a surface. The results showed that combination of the frictional forces and the sliding velocity can provide enough energy to cause the lactose to adhere. The conclusion drawn was the same as that for impact testing, with energy being the main consideration in the breakage and adhesion of lactose to surfaces.

A link between amorphous lactose formation and the smearing was found, with the build up in the conveying lines having a higher amorphous concentration than was found on the free flowing lactose powder. An attempt to show a change in the amorphous concentration of  $\alpha$ -lactose crystals after impact proved unsuccessful, although the use of a polarised microscope showed the formation of amorphous lactose on the impact surface. Calculations looking at the amount of amorphous lactose that would have formed after impact, identified that the concentrations were below the levels measurable using the methods available.

Following on from impact testing work, a rubber lined bend was placed in a section of the conveying line at Lactose New Zealand. Monitoring of this bend showed it to be successful in preventing the adhesion of lactose to walls of the conveying pipe. However, there was a small amount of wear observed at the entrance of the bend. This was concluded to be due to a design defect as the rubber was raised above the level of the main line. More testing needs to be done, with a change in design, to allow a conclusion on the applicability of rubber for preventing lactose buildup to be drawn.



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# Chapter 1 Project Overview

## 1.1 Problem Definition

Pneumatic conveying is the transport of solid materials through vertical and horizontal pipelines by the conversion of kinetic energy in the air stream to dynamic pressure and aerodynamic lift (Kraus, 1980). As a method of conveying lactose powder the pneumatic option provides a transport system with the advantages that it is enclosed, dust free and enables easy distribution throughout the plant.

The problem to be addressed here is that, using pneumatic conveying lines to transport lactose often results in lactose depositing and building up on the pipe walls. This can lead to large cakes of lactose building up in pipelines, with the end result that, the lines eventually become blocked. This is an undesirable situation, as it results in decreased throughput, caused by the narrowing of the lines and the increase in downtime required to unblock and clean the pipes.

A review of literature highlighted the following points that are of interest in attempting to understand the parameters involved in causing the smearing to occur. The details of this literature review are expanded further in chapter two.

- How a material behaves in a pneumatic transport line is dependent on the properties of its particles.
- Lactose cakes often form in areas where significant impacts between crystals and surfaces occur.
- High particle velocities in pneumatic transport systems cause particle degradation to occur and alter the physical properties of the materials being conveyed.
- Where moisture and amorphous lactose are present, caking in lactose is increased.
- Amorphous lactose is formed during intensive mechanical breakage of lactose crystals.
- Buildup in pneumatic conveying lines is often prevalent at bends, an area where impact is more likely.

- The type of bend used in a pneumatic transport line has a strong effect on how the system behaves.

The above points highlight that understanding solids deposition requires that a knowledge of the properties of the powders being conveyed, combined with a knowledge of the conditions that occur within pneumatic conveying lines. This means that this work has two areas of interest. The first requires that, an understanding of the properties of lactose and the conditions under which it will adhere to itself and other surfaces is developed. The second requires that the conditions that particles are exposed to, during pneumatic conveying, are studied to determine the role they play in causing solids deposition.

## **1.2 Adhesion of Lactose**

Adhesion of lactose has been showed in previous studies to be a function of both, the physical properties of the powder, and also the conditions to which it is exposed (Bronlund, 1997, Brooks, 2000). The physical properties relate to factors such as, particle size, shape and the condition the powder is in.

### **1.2.1 Amorphous Caking**

Amorphous caking can occur when some or all of the lactose powder is in the amorphous form. The caking occurs as a result of the conditions enabling the amorphous lactose to transform from the solid glass phase into a less viscous rubber state. In this less viscous rubber state the molecules are capable of flow. This permits bridges to form between the particles and other surfaces. The formation of these bridges generates strong adhesion forces that cause the particles to lump together.

Amorphous caking is of particular interest to this work, as previous work has shown that amorphous lactose can be formed when crystalline lactose undergoes intensive mechanical treatment (O'Donnell, 1998, Lerk *et al.*, 1984). The mechanical processing typically involves impact and breakage of the lactose crystals. It is in the areas where significant impacts between crystals and other surfaces occur that lactose cakes tend to form. This suggests that there is a link between impact, breakage and the buildup that occurs in pneumatic conveying lines. The observation also suggests that

these conditions may result in the formation of amorphous lactose, and also allow for transition of the amorphous lactose from the glass phase into the rubber phase.

### **1.3 Problem Areas in Pneumatic Conveying**

In order for changes in particle properties to occur certain conditions have to be met. The two factors which seem to effect particle properties in pneumatic conveying the most are, velocity and bends.

#### **1.3.1 Particle velocity**

Achieving the optimum particle velocity in a pneumatic transport pipeline is a difficult task. Too fast and you risk high levels of particle degradation. Too slow and particles fall out of the gas stream, deposit at the bottom of the pipe and cause blockages. Velocity is a critical variable influencing the way a material behaves in a pipe, with high velocities resulting in, not only particle degradation, but also having an effect on the way the solids interact with the walls of the pipe line (Thorn *et al.*, 1998).

#### **1.3.2 Bend Structure**

Examination of where the buildup occurs in the pipelines at Lactose New Zealand, identified that it is at the bends where a large amount of the problems occur. Due to the changing flow direction, the bend is the point where the particles are subjected to the greatest impact. Work in the literature identifies that the type of bend used in a pipeline has a role in the level of damage done to the particles. Also a bend in a pipeline can also have the effect of lowering the flowrate of the material being transported, causing particles to fall out of the gas stream, deposit and result in a blockage.

### **1.4 Overall Project Aims**

The overall aims of this research were to:

- Develop an understanding of what mechanism(s) resulted in lactose depositing on the pipe walls.
- Investigate the effect of impact on the physical properties of lactose crystals

- Provide solutions which allow pneumatic transport systems to be designed and operated in a manner that prevents lactose buildup occurring in the pipes.