Chapter 4 – Results and Discussion

4.1 Effect of Aeration (Air content) on the properties upon storage

The properties upon after supply of aeration, was observed as follows, the aeration rate is $3.75 cm^3/sec$

- Mechanical Stability Time (MST)
- Volatile Fatty Acid No: (VFA No)
- Alkalinity
- Viscosity
- pH
- Conductivity

4.1.1 Response to the MST

The result of influence of aeration is presented in Figure 1.1 and Figure 1.2 for two batches of Latex. The relevant data table is given in Appendix 2 – 1.1 and 1.2 for two batches of latex. For both sample MST is increasing continuously with maturation and aeration level respectively. But 2nd batch the increase is little less because the soap content in this batch is low compared to 1st batch. In both batches, at each maturity period, highest MST was obtained by the sample having highest aeration level (highest air content) i.e. 1125 cm^3/l

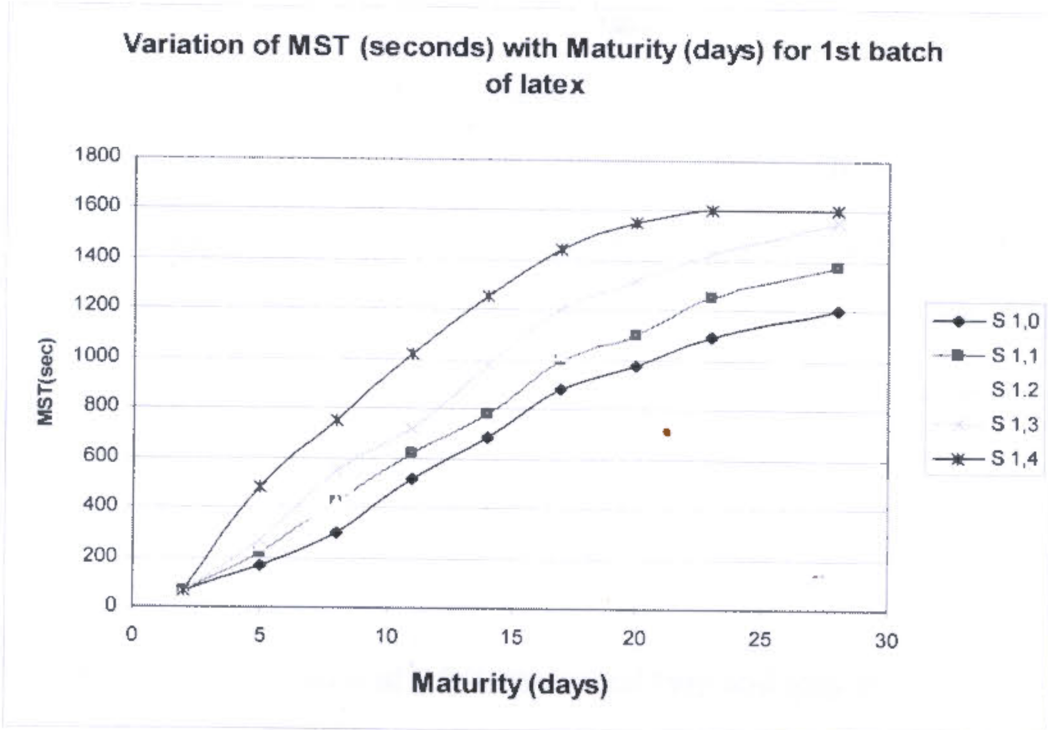

Figure 1.1 – Effect of aeration on MST upon maturation of 1st batch of latex

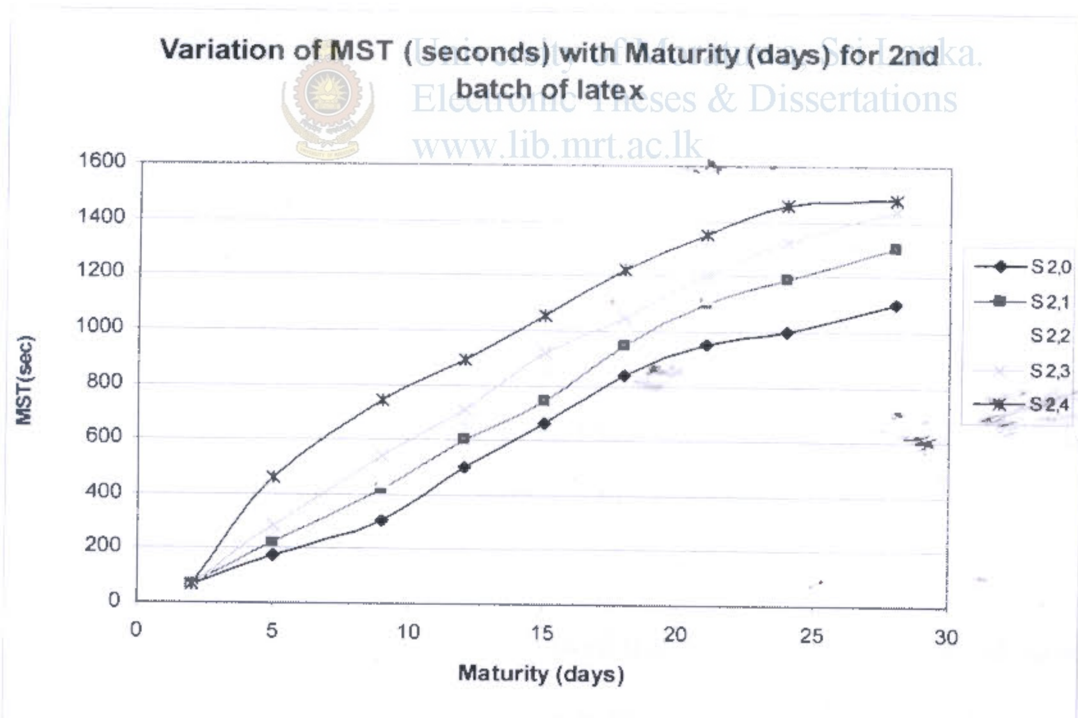

Figure 1.2 – Effect of aeration on MST upon maturation of 2nd batch of latex

It was observed the rate of increase in MST is more rapid in 3 - 12 days and then gradually rate will drop and after 25th day the MST is almost same. During 1st part of testing period it appeared that rate of lipid hydrolysis was a prominent reaction contributing higher fatty acids to the medium. These HFA may have contributed to the increasing stability of MST in the samples. Enhancement in MST could be due to the adsorption of this natural HFA at the rubber water interface. Stability power of this negatively charged HFA anions are apparently due to the resulting increasing in particle charge density and repulsive energy between the particles(Blackley D C , 1997).

According to Seong-Fong Chen *et al* (1984) the natural fatty acid soap in NRL increases with time and reach a constant value in 3-6 weeks. This report has confirmed by Hasama (1971). They however, could not ascertain the factors which affect the future rise in MST after the specified period. According to Hasama the composition of lipids associated with the rubber particles changed on storage with ammonia. The most prominent changes were the decreasing levels of the glycolipids and phospholipids and increasing level of free HFA in the neutral lipid fraction. The membranes surrounding the rubber particles stored in ammonia can be visualized to certain extra negative charge imparted by the hydrolysis products of glycolipids and phospholipids, free HFA, located at the aqueous interface. The additional charges could render the rubber particle more stable to the externally applied mechanical forces.

Apart from lipid hydrolysis, results clearly showed that air content has enhanced stability of latex. According to Blackley D C (1997) the mechanical stability of ammonia preserved latex which has been stored for any length of time is thus a product of several factors, the most important of which are VFA formation, which tends to reduced the stability and hydrolysis to give long- chain fatty acid anions, which tends to enhance the stability. The final stability is largely determined by the balance between these two. It is significant that latex which has been stored under the nominal air- free conditions which prevail in an almost full sealed container suffers a progressive reduction in stability, whereas the stability of latex which has been stored under aerobic conditions in half full containers increases markedly and passes through a maximum. These observations are to be interpreted in the light of the fact that reducing conditions favour the formation of the anions of the volatile fatty acids.

The results shown that the MST of natural latex increased when there was an appreciable air space in the storage bottle but decreased when the bottles was full and air was excluded. And the results shown that aeration can influenced greatly the rate of development of MS in freshly concentrated latex. It is believed that aeration of NR can produce hydro peroxide group on the rubber molecule and those groups may be ionized to un stable ions and those ions promote hydrolysis of proteins and phospholipids. The former are degraded to polypeptides and amino acids, the later to various substances such as glycerol, fatty acids anions, phosphate anions are absorbed at the particle interface, and thus enhance the stability of latex. This may be the reason the aerated latex tends to increase during storage.

According to the results we can clearly show that MST was high in aerated samples with compared to close pack samples. As an example if we take MST is 600 second for non aerated sample, it took 12 days and for higher aerated sample it is only 7 days. The results shown that the MST of Natural Rubber Latex increased when there was an appreciable air content. For the 2nd batch of latex, for highest aerated sample took only 7 days to achieve MST up to 600 second and zero air gap sample took 13 days to achieve it.

If we take the MST value 1200 seconds the results were as follows. For close pack container it took more than 25 days and for higher aerated sample it took only 14 days. And in the second batch of latex sample for the highest aerated sample it took 16 days to achieve 1600 sec, but the close pack sample 1200 second not achieved up to 28 days.

Table 6 – No of days which take for achieve MST up to 600 second and 1200 second for 1st batch of latex

MST	Day(s)				
	Sample S 1,0	Sample S 1,1	Sample S 1,2	Sample S 1,3	Sample S 1,4
600 sec	12	11	10	8	7
1200 sec	25	22	19	16	13

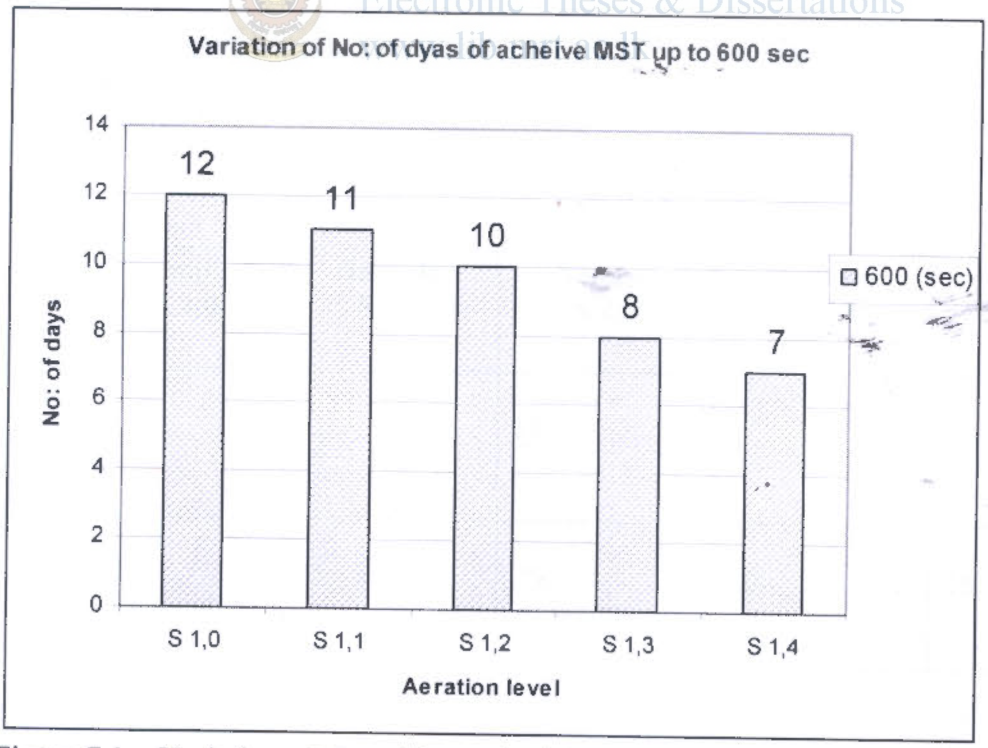

Figure 7.1 – Variation of No: of days of achieve MST up to 600 sec for 1st batch

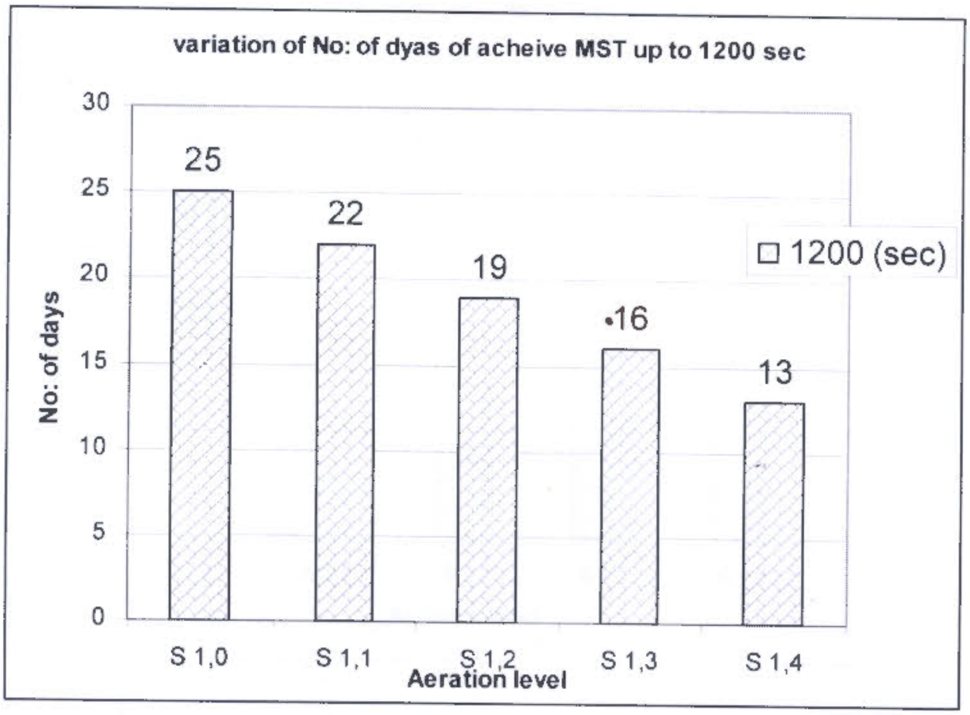

Figure 7.2 – Variation of No: of days of achieve MST up to 1200 sec for 2nd batch

Table 7 – No of days which take for achieve MST up to 600 second and 1200 second for 2nd batch of latex

MST	**Day(s)**				
	Sample S 2,0	**Sample S 2,1**	**Sample S 2,2**	**Sample S 2,3**	**Sample S 2,4**
600 sec	14	12	11	9	7
1200 sec	Not acheived	25	23	20	16

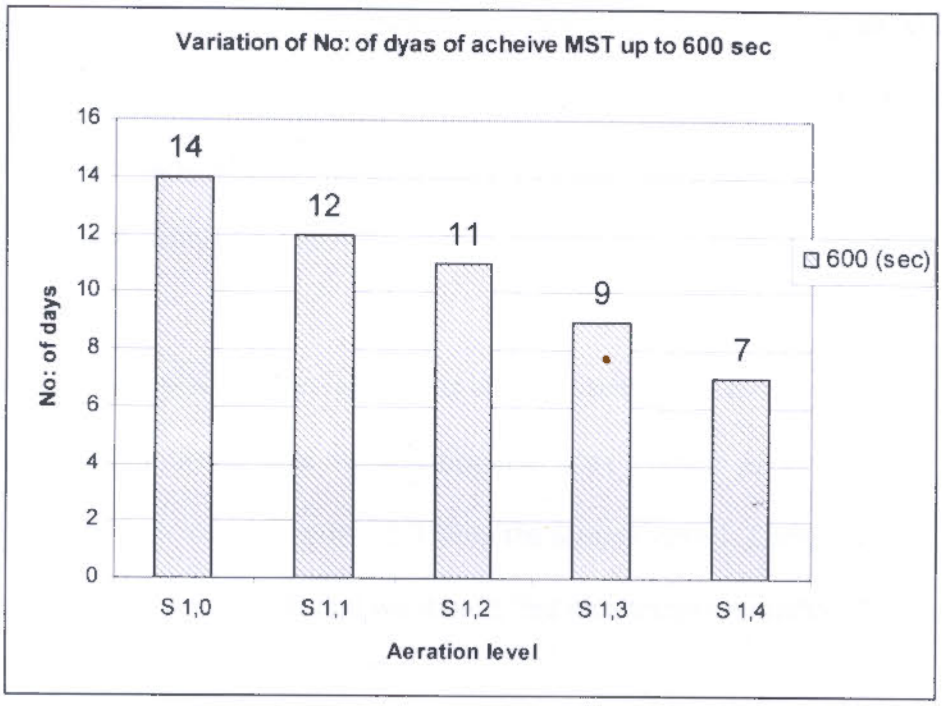

Figure 7.3 – Variation of No: of days of achieve MST up to 600 sec for 1st batch

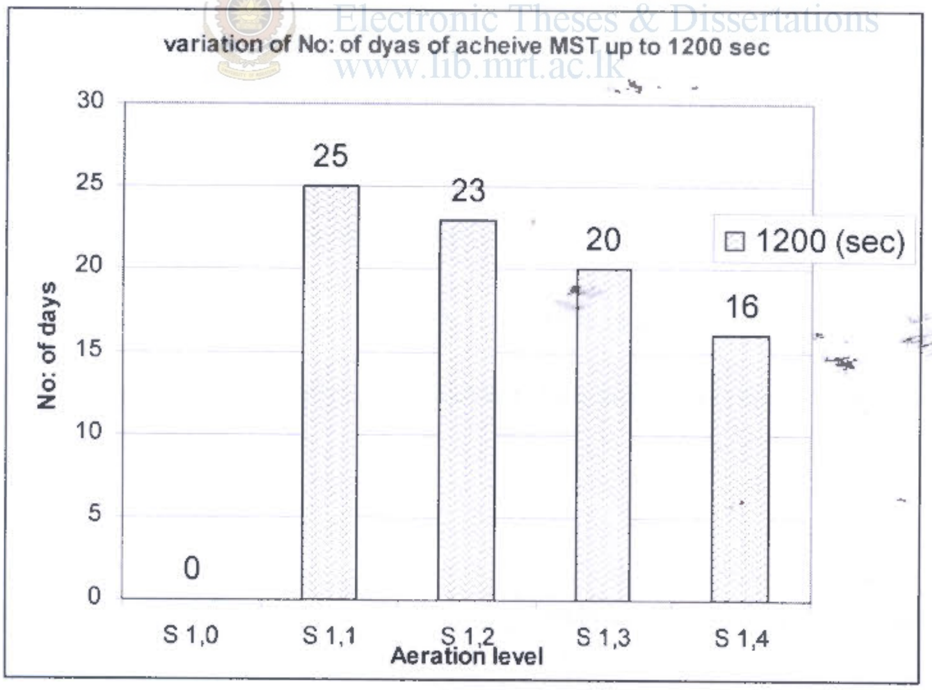

Figure 7.4 – Variation of No: of days of achieve MST up to 600 sec for 1st batch

According to the illustration of results it is clear that by increasing air content, MS will increase significantly. Therefore this is an successful alternative method for developing MS without soap addition. Mainly for the dipped- products soap addition may lead problems viz pin-holes on latex films. So this method may be very effective MS developing method for the industry

Accordingly to the practical set up of this research there was a one draw back. i.e. when we supply aeration we want large vessels because latex volume is increases with bubbles. In practical set up, latex volume is only 1/3 from the sample vessel. Therefore for the industry it is a huge wastage of storage tank, and we should find an alternative method for storing samples

During my studies, other properties of latex such as VFA No:, Alkalinity, pH, Conductivity and Viscosity were studied upon aeration. By considering those factors we should find an optimum level of aeration for the latex without lowering the quality of the latex.

4.1.2 Response to the VFA number

The result of variation of VFA number upon aeration is presented in Figure 2.1 and Figure 2.2 for two latex batches respectively. The relevant data table is given in Appendix 2- 2.1 and 2.2 for two batches of latex.

In 1st batch of latex VFA number is increasing, slowly and show some fluctuation patterns. But in 2nd latex batch the increasing pattern of VFA number show smooth shape.

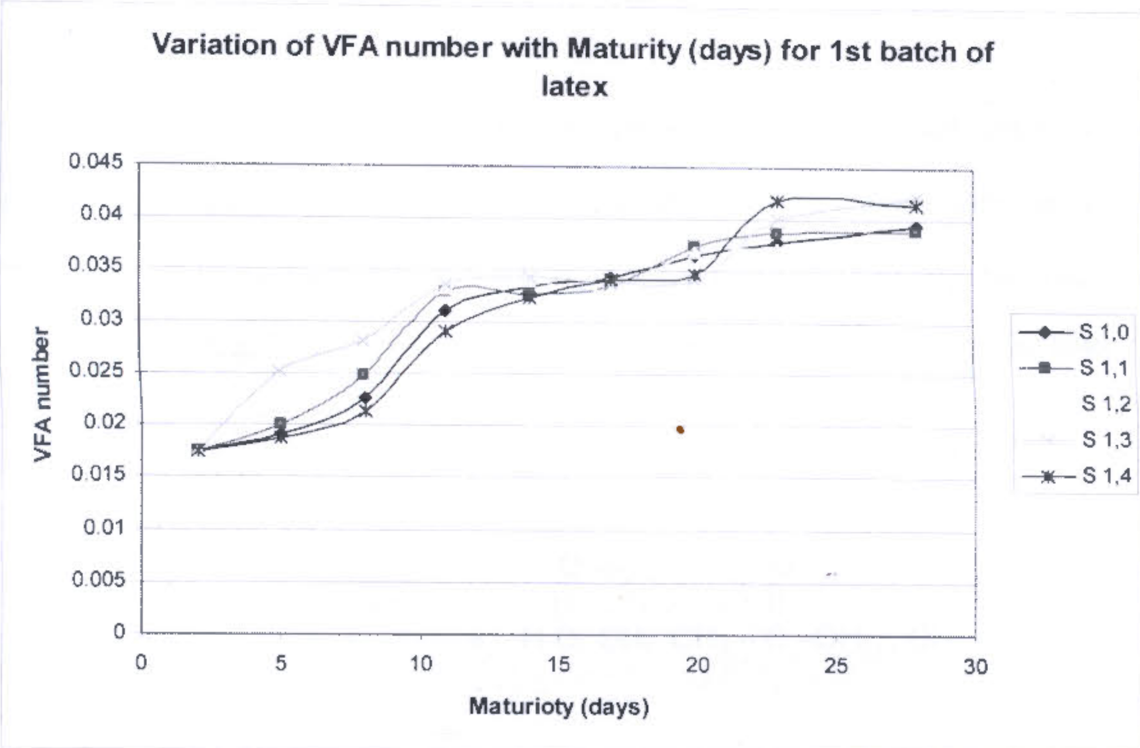

Figure 2.1 Effect of aeration on VFA number upon maturation of 1[st] batch of latex

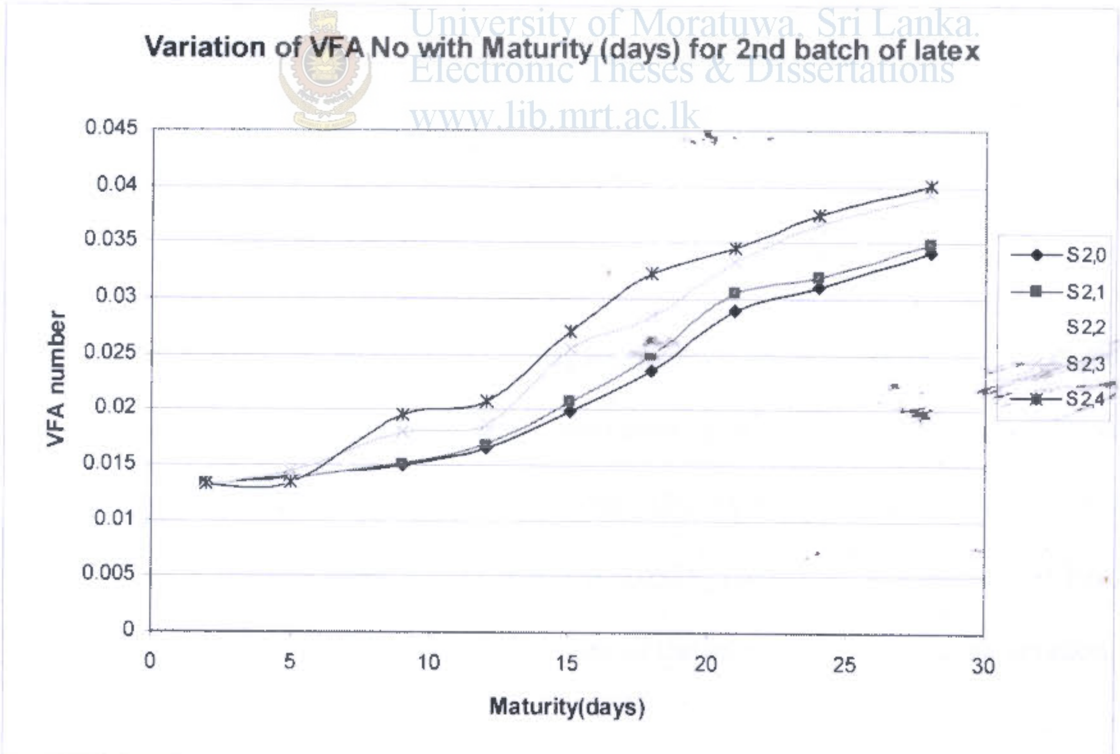

Figure 2.2 Effect of aeration on VFA number upon maturation of 2[nd] batch of latex

The volatile fatty acids, the anions of which are gradually formed in natural rubber latex, are so called because they can be steam distilled. These fatty acids are formic, acetic and propionic. These fatty acids are formed by the action of micro organism specially bacteria, upon the carbohydrate such as L- methyl inisitol, which are present in aqueous phase in the latex

$$\text{L- methyl inisitol} \xrightarrow[\text{oxidation}]{\text{Microbial}} H\text{-}\overset{\overset{\displaystyle O}{||}}{C}\text{-}OH,\ CH_3 - \overset{\overset{\displaystyle O}{||}}{C} - OH,\ CH_3 - CH_2 - \overset{\overset{\displaystyle O}{||}}{C} - OH$$

The Figure 2.1 and Figure 2.2 shows on maturation, VFA gradually increase on the 1st half of the test up to day 20. After that it seems to be constant up to 28 days. And only other hand in latex batch one, the VFA No increase show some fluctuation, i.e sudden increase in days around 8 and 11

According to the results, the samples which supply high aeration, the VFA No development is little bit high compared to closed pack containers. But when comparing MST increase by supply aeration the VFA increase is negligible. The VFA of air tight container in day 24 is 0.031 and the maximum aerated container it is 0.0375. There for the increase in VFA No is not severely effect from aeration. Therefore quality of the latex is not lowered by aeration.

And in latex 1st batch the VFA No fluctuation can be seen. This may be due to the initial state of preservation of plastic bottles i.e. sample were kept in different plastic bottles. First set of bottles were not sterilized. There for different bottles may have different level of bacteria concentration which can give different VFA number. But in the 2nd batch the bottles were cleaned clearly with detergents and NH_3 solution. i.e why the 2nd batch of latex, the results not show severe fluctuation only show a smooth increase in VFA No:

4.1.3 Response of the Alkalinity

The result of variation of alkalinity upon aeration is presented in Figure 3.1 and Figure 3.2 for two latex batches respectively. The relevant data table is given in Appendix 2- 3.1 and 3.2 for two latex batches.

Alkalinity of all aeration levels decreases with storage. And the results show that control sample with zero air content show very little decrease in alkalinity. The decrease in alkalinity may be due to acid radicals formed. It is clear that when VFA No increases i.e. acid formation is increases. Then alkalinity is decreases in latex during storage. And there is a relation ship between the results of alkalinity and pH also. As pH decreases, alkalinity also decreases. According to Blackly D C (1997), it is a proportional relationship. Therefore, for synthetic lattices the pH is used as an indirect measure of alkalinity instead.

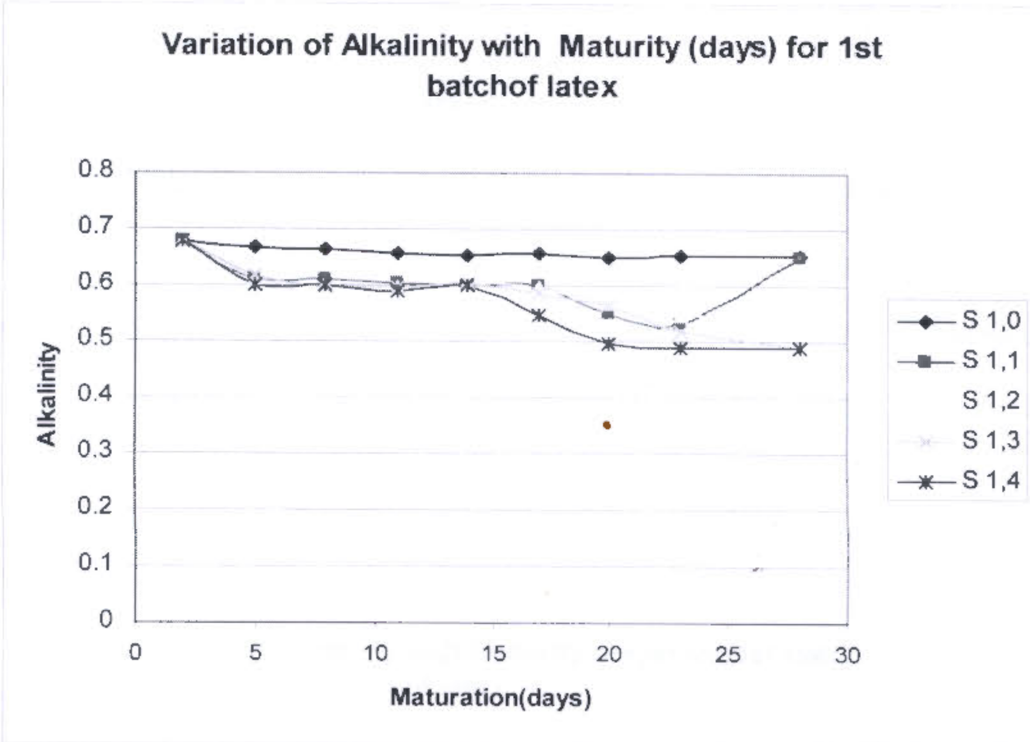

Figure 3.1 Effect of aeration on Alkalinity upon maturation of 1st batch of latex

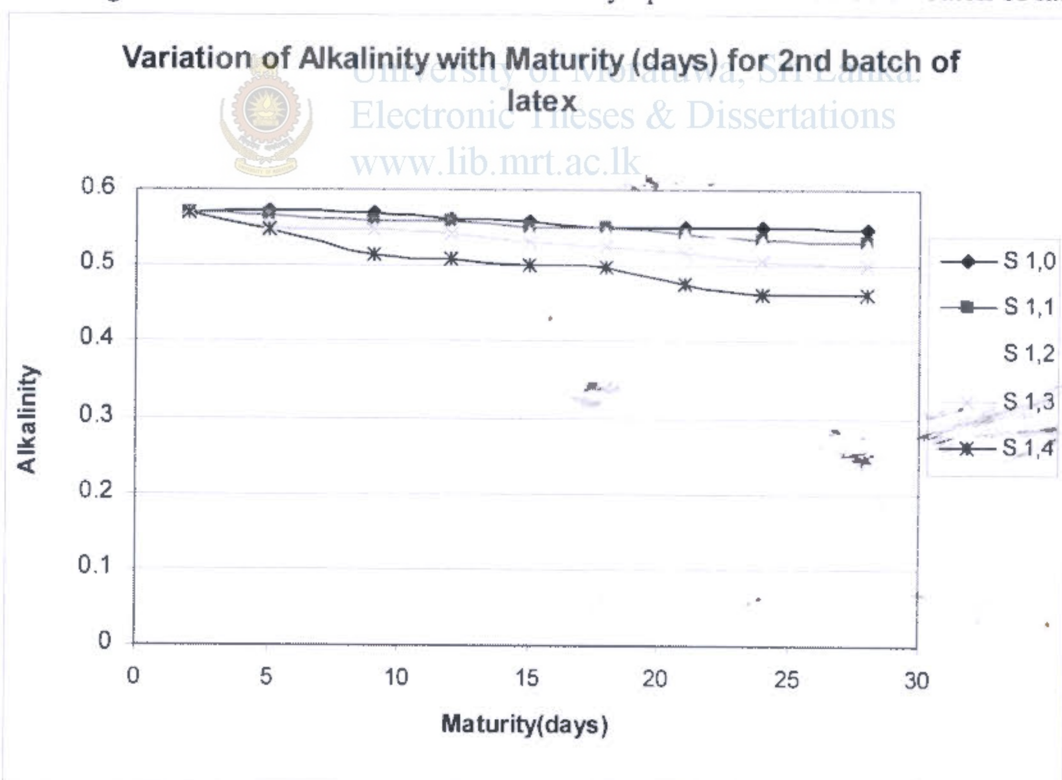

Figure 3.2 Effect of aeration on Alkalinity upon maturation of 2nd batch of latex

4.1.4 Response to the Conductivity

The result of possible role of aeration on conductivity is presented in Figure 4.1 and Figure 4.2 for two latex batches respectively. The relevant data table is given in Appendix 2- 4.1 and 4.2 for two batches of latex respectively. In both latex batches, conductivity of all aeration levels were increase during storage. But according to the results the increment of conductivity is not smooth. It shows some fluctuations.

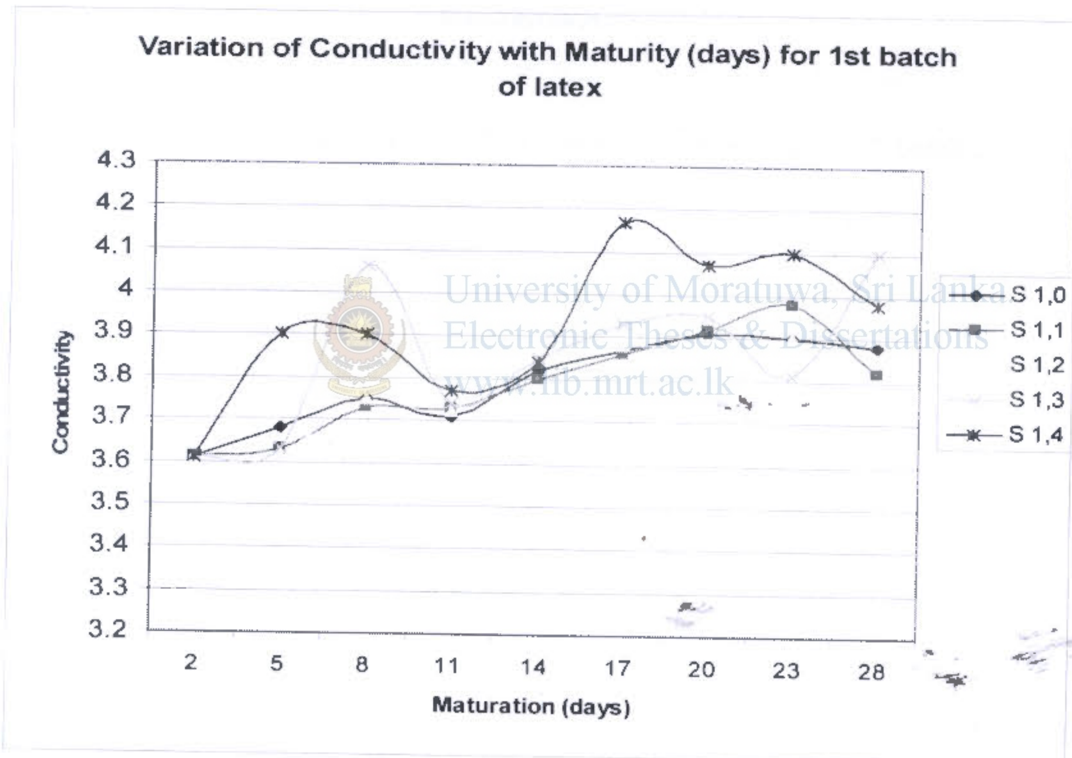

Figure 4.1 Effect of aeration on Conductivity upon maturation of 1st batch of latex

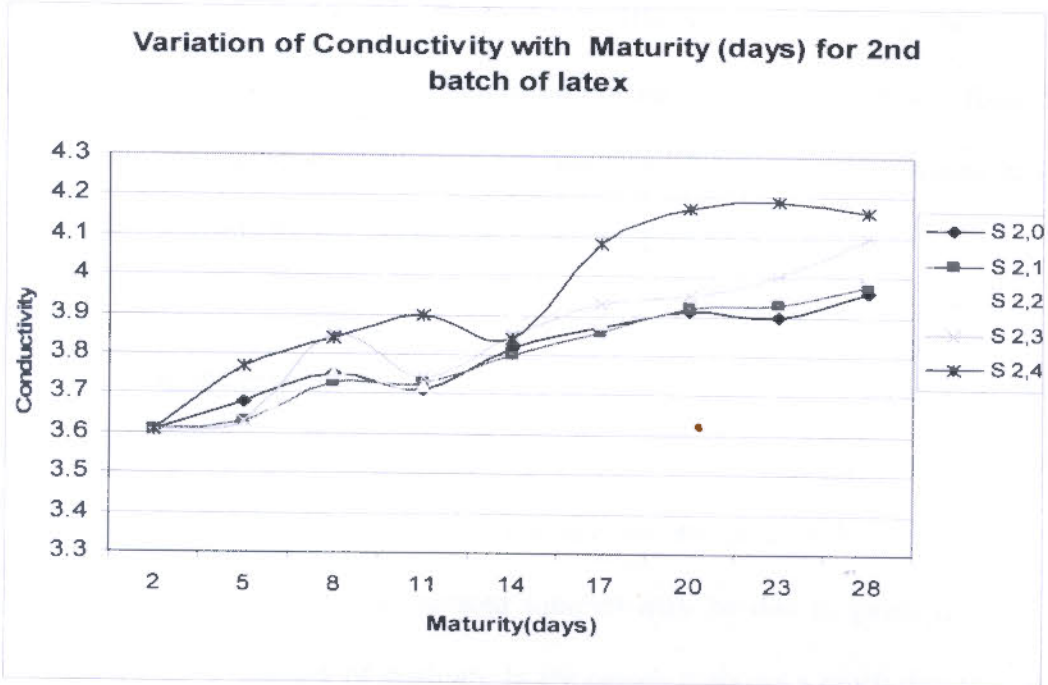

Figure 4.2 Effect of aeration on Conductivity upon maturation of 2[nd] batch of latex

Vehoar (1959) has reported the influence of hydrolysis in increasing conductivity upon storage. Chin *et al* (1979) has confirmed this with the aid of his slowly increased conductivity results upon storage.

Conductivity is a composite quantity attributed to overall ionic strength basically nature and concentration of all dissolved ionic species. Surface active substances in the medium may be present as monomolecular from as well as micellar, whether these substances are ionized or not. Contribution from the electrophoretic mobility of the particle is usually assumed to be negligible (Blackly, 1997). Contribution from surface can be ignored, as rubber particle do not conduct electricity. Therefore dissolved ions in the aqueous phase are attributed for the conductivity.

Conductivity of both hatches shows little different patter during the storage. It shows increasing pattern but with many fluctuation of increases and decreases. Results suggest that hydrolysis offering ions to the medium contribute for the rapid increases in ionic strength, which is responsible for the increase in conductivity during storage.

By comparing the results we see a relation ship of VFA no and conductivity. Both parameters are increases according to same pattern. That shows the fatty acids anions will increase the ionic strength also. When we compare the aeration samples, with close pack sample (zero air gap), conductivity is higher in aerated samples may be due to gases like CO_2 and O_2 will increase the ionic strength of medium. In the results it shows a much deviated value in day 14 in both set. It may be due to some fault in Vessels that use in 14^{th} day. Other wise rest of the results will show a increasing trend.

4.1.5 Response to Viscosity

The result of possible role of soap on viscosity during storage is summarized in Figure 5.1 and Figure 5.2 for both batches of latex. The relevant data table is given in Appendix 2- 5.1 and 5.2 for two batches of latex respectively. Viscosity of all four samples of both sets was observed to decrease progressively on storage. But it shows some fluctuations as in previous case (conductivity)

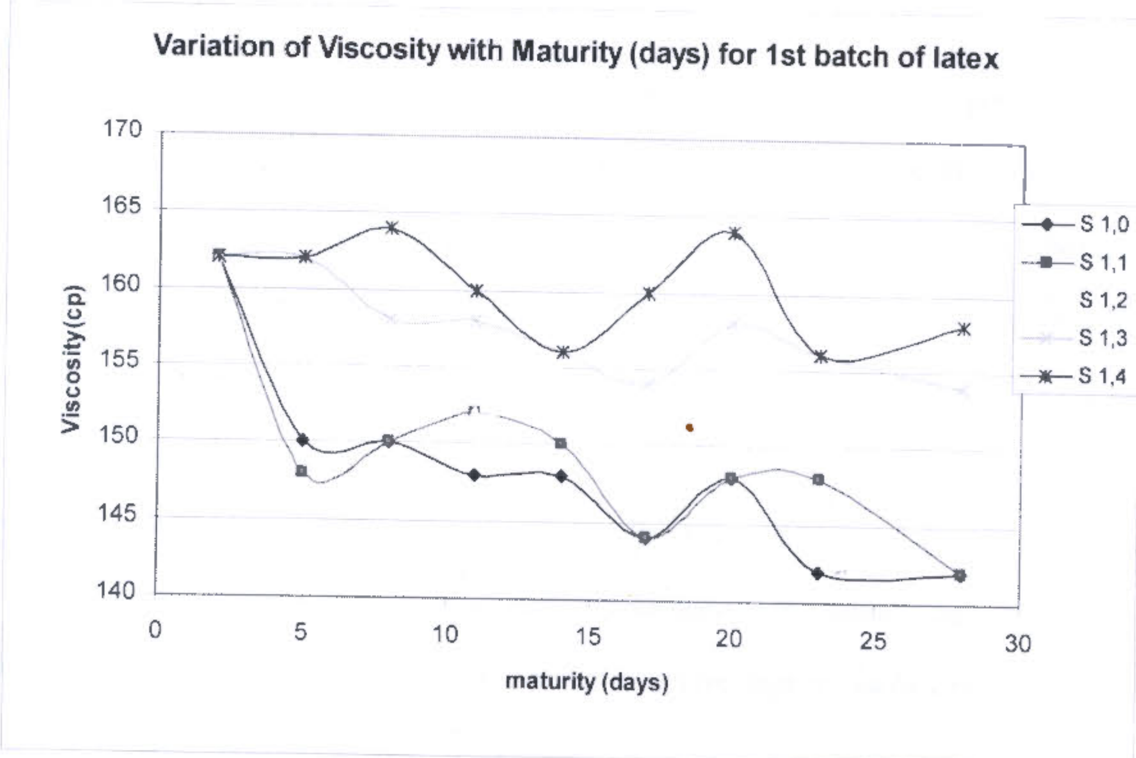

Figure 4.2 Effect of aeration on Viscosity upon maturation of 2nd batch of latex

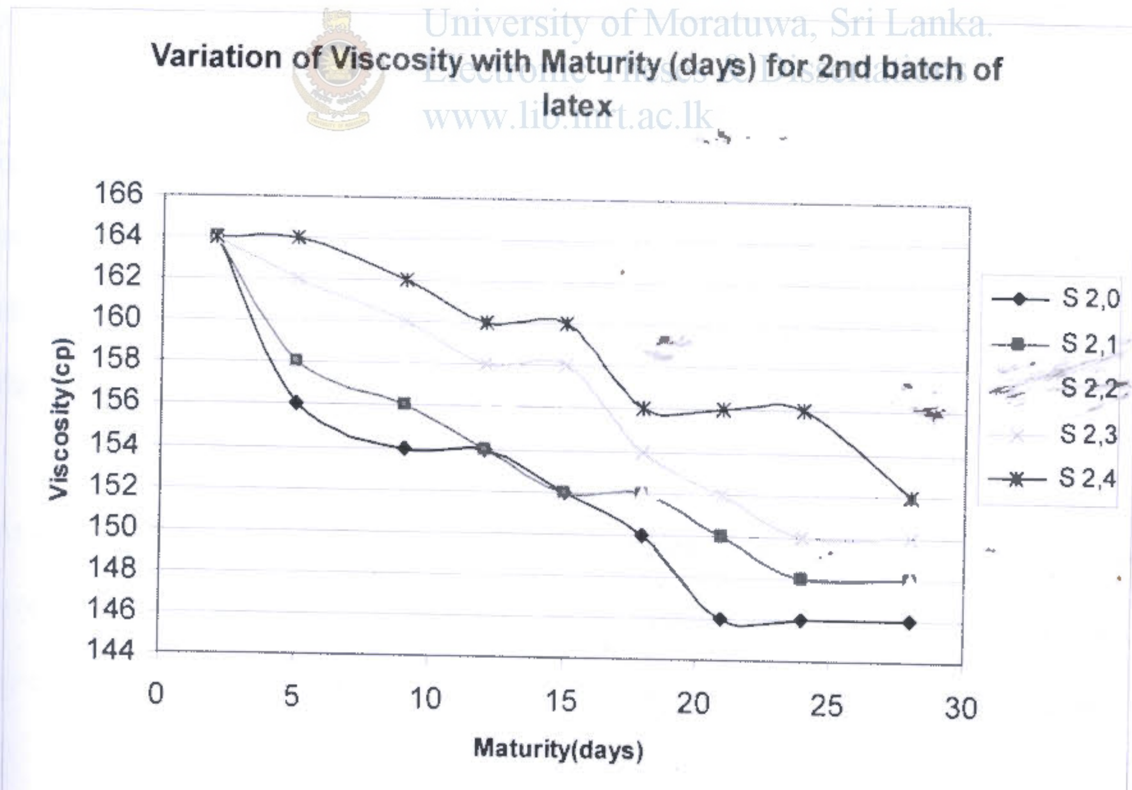

Figure 4.2 Effect of aeration on Viscosity upon maturation of 2nd batch of latex

Vehar (1954) has reported that the occurrence of structural viscosity is generally caused by formation of structure in the sol, and a hydrodynamic influence on the orientation of the dispersed particles, in relation to their shape and size. According to Atkins (1994) molecules has to be escaped from the potential wells provided by neighboring molecules in order to the liquid to become more fluid. It can be considered that, one of the factors contributing to the colloidal stability of latex is a structure with water mantle of different number of water molecules around each particle that prevent free Brownian movement of these molecules. This structure will be destroyed by hydrodynamic influence. At the initial stage of samples, water will be immobilized in an appreciable amount and give higher viscosities. Consequently the rupture of the bond between water mantle and rubber particle to a certain extent will be caused by, hydrodynamic influence of occasional stirring during storage. This rapture will destroy the internal structure of the latex to certain extent and therefore lowering the viscosity upon storage. Furthermore adsorption of indigenous soap molecules (as a result of lipid hydrolysis on storage and protein hydrolysis) will further change the original structure in solution. Further more, protein hydrolysis may have altered the medium and reduced the potential well, there by allowing the molecules to escape from the neighboring molecules and thus increasing the fluidity.

At each maturity period viscosity of all four samples of both areas decreases when aeration level increases. The reductions in viscosity of the samples are in accordance with respect to the air content, which may have caused by destroying the original structure in the solution

4.1.6 Response of pH

The result of pH aeration is presented in the following Figure 6.1 and Figure 6.2 for two batches of latex respectively. The relevant data table is given in Appendix 2 - 6.1 and 6.2 for two batches

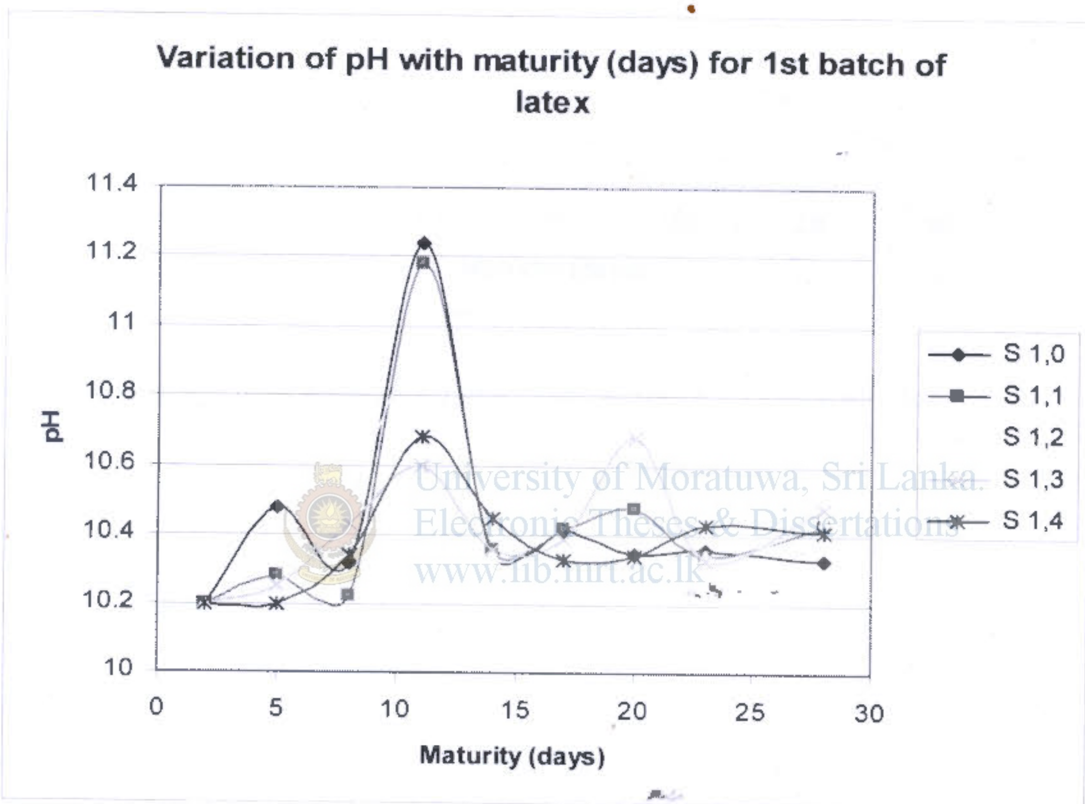

Figure 5.1 Effect of aeration on pH upon maturation of 1^{st} batch of latex

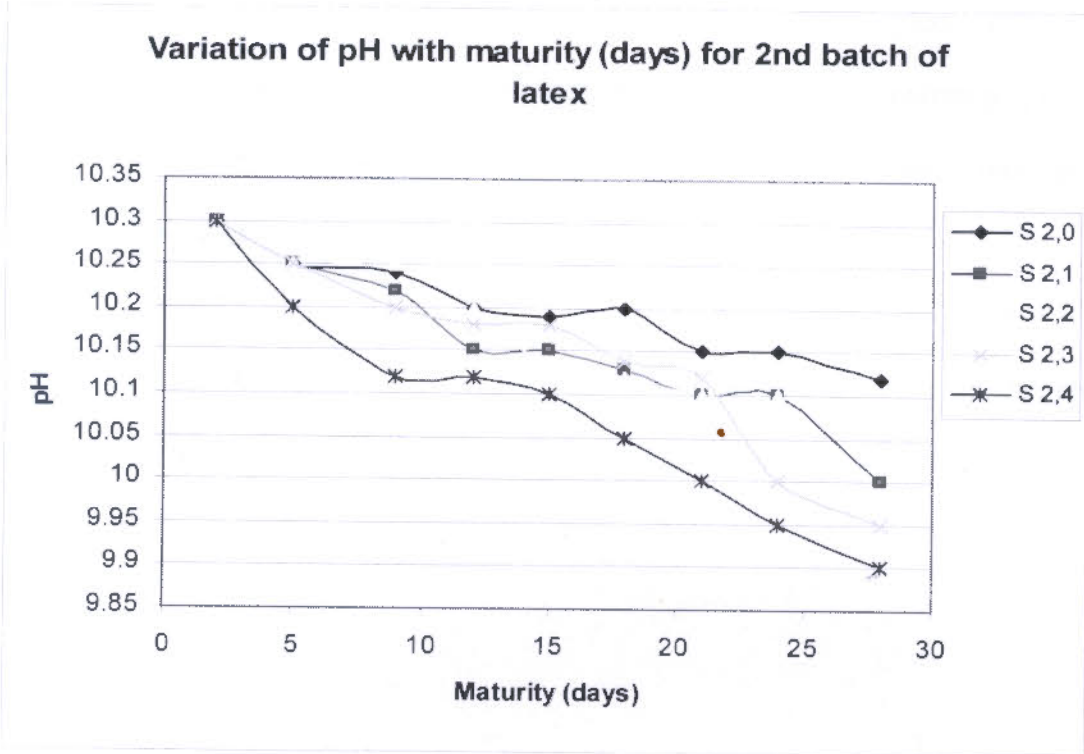

Figure 5.1 Effect of aeration on pH upon maturation of 2nd batch of latex

pH measurement was taken for all samples of aeration levels and plotted as above. In the results for set one latex there is a very huge fluctuation and no significant or may be due to pH meter. As described previously the plastic bottles are not cleaned by detergent and liquid NH_3 in 1st batch, but well cleaned in 2nd batch. It may be a one reason for results deviations. The pH meter used to get readings for 1st batch was very old and there may be some fluctuations in reading also.

Then in the 2nd batch of latex it is clearly show that pH of the latex during storage is reduced, and in the close pack sample with zero air gap show little decrease in pH and by increasing air pH decreases rapidly. The pH variation may be due to aeration. When the sample is bubbled, the little air drops are remain in the latex samples. When the aeration level is high, more air bubbles are remain. And by the time those air bubble dissolved in aqueous phase of the latex. The CO_2 gas in the air will dissolved in water phase of the latex will reduce pH in the medium. More and more aeration, more air bubbles and then more CO_2. Ultimately more pH reduction in higher aerated samples.

In the case of VFA No, VFA No also increases during storage. Those acids may also cause to pH reduction in the sample. That is why when VFA No: increases pH reduction is take place.