Impact refining

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ABSTRACT

The repeated action of compression-decompression pulses on a wet web of fiber, created by dropping a weight from a height, loosen the internal structure of the fiber. The impaction of fiber did not cause any change in average weighted fiber length, fine content or Canadian standard freeness. The sheet made from impacted fibers showed an increase in tensile and other strengths with increased number of impacts or impact intensity.

INTRODUCTION :

Wood Pulp produced in the pulp mill is unsuitable for making most grade of paper. A paper sheet made from virgin pulp without beating/refining will be characterised by low strength, bulkiness and rough surface. These undesirable charaeteristics can be changed to a large extent by treating the pulp mechanically. This mechanical treatment of fiber in water is termed beating refining.

The history of beating is as old as paper making itself No other process in paper manufacturing goes back further than beating. In early days, the papyrus fibers used to be literally beaten by wooden club, to be made suitable for paper making. Later on water driven stampper and Hollender beater came into use. Now a days pulp is treated in multi discs refiners.

The three main action of beating on fibers are :

1) INTERNAL FIBRILLATION : (I.F.)

The term internal fibrillation was first used by campbell[1] in 1933 to describe the structural change in the fiber. The I.F. is caused by the breakdown of fiber walls into separate lamellas. In pure I.F. no new external surface is generated. The flexibility of fiber increases due to I.F.

The forces responsible to creat I.F. in the fibers are the pulses of compression and decompression. The pulses of compression and decompression are generated in the refiner due to the passing of the rotating bars over the stationary bar. The pulp trapped in between the faces of bars is compressed when the moving bars approach stationary bars. The pulp is decompressed when the bars moves away from the stationary bars. The continues rotation of the bars give rise to compression-dacompression pulses. These pulses of compression-decompression loosen the internal structure of the fiber and delaminate the fiber walls.

2) EXTERNAL FIBRILLATION (E.F.)

The term external fibrillation is used to describe the creation and/or exposure of fibrills on the surface of the fibers The forces responsible for E.F. are the forces of shear. These forces are created by the relative movement of fibers in different layers and/or movement of the bars relative to the fiber layers.

3) GENERATION OF FINES :

The earlier defination of fines were based on fiber fractionation. A portion of fiber which pases through a certain wire mesh generally 150 mesh, were described as fines. After the invention of continuous type fiber analyzer such as Kajaani fiber Analyzer determination of fiber length distribution of pulp become very convenient and quick. So lately the fines are defined as

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the fibers shorter than 0 25 mm. Fines can be created both by compressive and/or shear forces. The repeated action of compression and decompression pulses or shear forces reduce the intrinsic strength of the fiber. When the fibers are no longer able to sustain these forces, failure and disintegration of fibers into fines and fragments take place.

The industrial or laboratory refining equipments give all the three main action to the fiber. The relative proportion of these actions on fibers depends on the type of equipment and operating conditions. So to study the refining model in depth, quantifying the actions and study the relative importance of these actions on pulp and paper properties, it is necessary to develop equipment which will give one and only one action at a time

The article deals with the creating of I.F. in fibers and its effect on fiber and paper properties. Dr. Hartman (2) in 1984 obtained internal fibrillation by passing wet web wrapped on a revolving roll and pressed against other roll. Dr. Harman named his equipment as roll refiner and so treated fibers as roll refined fibers.

The roll refiner suffered some inherent draw backs due to its design, so another equipment was used and termed it as impact refiner. This particular equipment was designed and fabricated in association with Dr. Peterson, Associate Professer at Western Michigan University, Kalamazoo Michigan USA. This equipment was used first time and it is not established beyond all reasonable doubts that the only action on fiber due to impact is internal fibrillation so it is termed the fiber as impact refined or impacted fiber instead of internally fibrillated fibers. Design and operation of the equipment is given in Appendix 'A'.

The following impact and sheet variables,

1) No. of impacts
2) Impact weight
3) Basis weight of sheet
4) Number of sheets
5) Intermittant reslushing

Were studied for their effects on

1) Fine generation
2) Canadian standard Freene s
3) Density
4) Tensile strength
5) Burst strength
6) Tear resistance
7) Scattering co-efficient

Height of weight fall, moisture in the sheet and hardness of backing material were kept constant. Drainage time, average fiber length and opacity were also measured but not used in analysis.

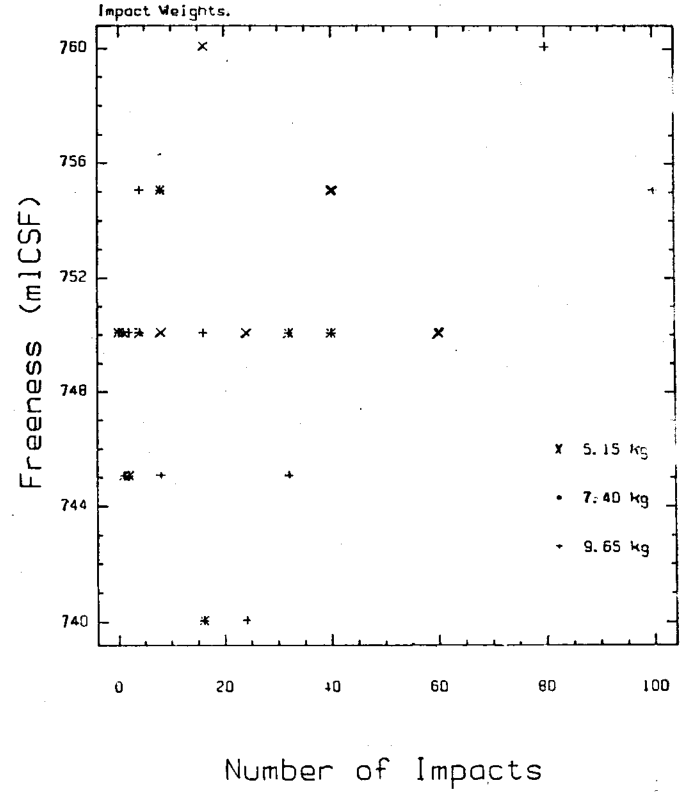
EFFECT OF IMPACT VARIABLES ON PULP AND HAND SHEET PROPERTIES :

1.0 Effect of number of impacts and impact weight :

1.1 **Fine Generation** : Amount of fines generated due to impact at all level of impact intensity and No. of impacts were found satistically non-significant.

1 2 **Canadian standard freeness :** Fig. 1 shows that the CSF almost remain constant with an increasing number of impacts at all impact weights. This

Fig. 1 Effect of Number of Impacts on Freeness at different Impact Weights.

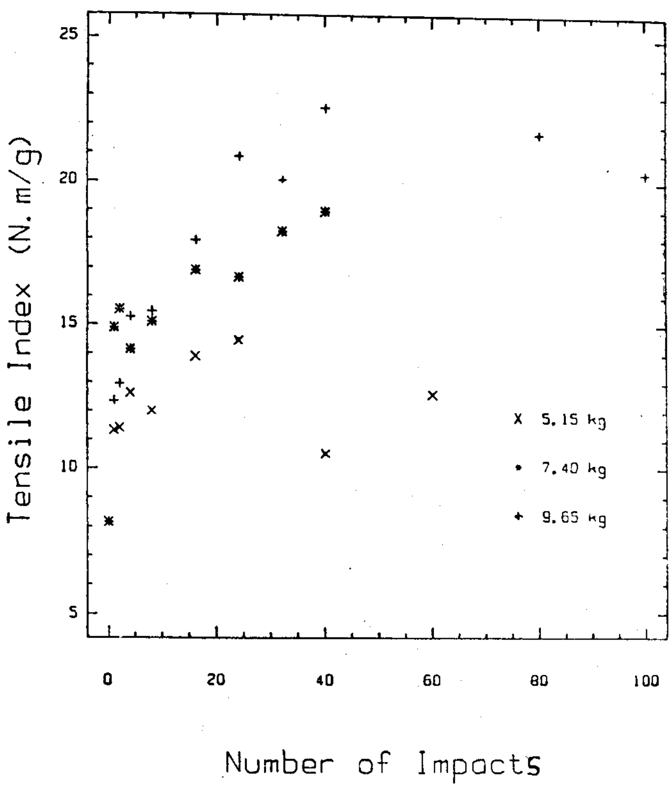


shows that impact does not create fines or any external surface and hence no change in freeness. Dr. Hartman (2) also did not notice any change in freeness of roll refined pulp.

1.3 **Density** : Density have a tendency to increase with an increase in number of impacts, but the points were scattered.

1.4 **Tensile Strength** : Fig. 2 shows the effect of the

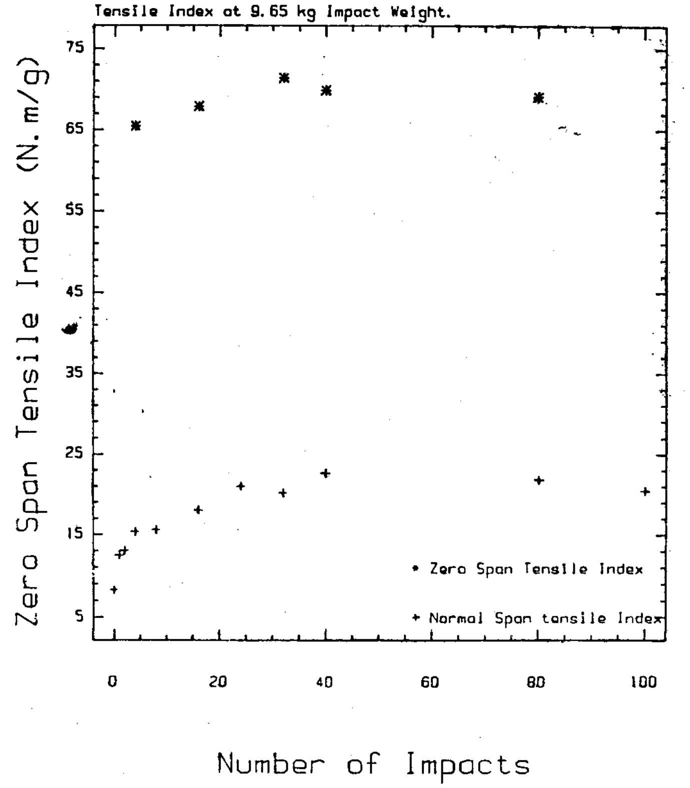
Fig. 2 Effect of Number of Impacts on Tensile Index



number of impacts on tensil index at three different impact weights. The figure shows that the tensile strength increased with an increasing number of impacts, reached a maximum and then started decreasing, for all impact weights. The higher impact weight gave higher strength for the same number of impacts. The point of Maximum strength shifted to a higher number of impacts for higher impact weights. The increase in the tensile strength might be contributed by the increase in flexibility of fiber due to loosening of its internal structure. A flexible fiber will bond more easily and strongly with the other fibers as compared to a rigid fiber. Increased number of impacts increase the fiexibitity of the fiber but simultaneously weakened the fiber after a certain limit.

Fig. 3 shows the effect of numb:r of impacts on zero tensile strength and normal span tensile

Fig. 3 Effect of Number of Impacts on Zero Span and Normal Span Tensile Index at 9.65 kg Impact Weight.



strength. The zero span tensile strength increased with increasing number of impacts to a maximum and then started decreasing. Clark (3) observed the same trend with valley beater treated pulp. The tensile strength of the paper sheet increased to the point upto which decrease in intrinsic strength of the fibers was lesser than the increase in bonding but after that tensile strength decreased.

1.5 **Bursting strength** : Bursting strength showed the same trend as shown by tensile strength.

Fig. 4 shows relationship between number of impacts and burst index at different impact intensity.

1.6 **Tear Resistence** : Fig. 5 shows the relationship between the number of impacts and tear index at different impact weights. Initially tear index shows an increase with increased number of impacts put asterward, the points are scattered. The tear index does not show any particular trend with number of impact. The tear index is more fiber strength dependent than fiber bonding.

Fig. 4 Effect of Number of Impacts on Burst Index at different Impact Weights.

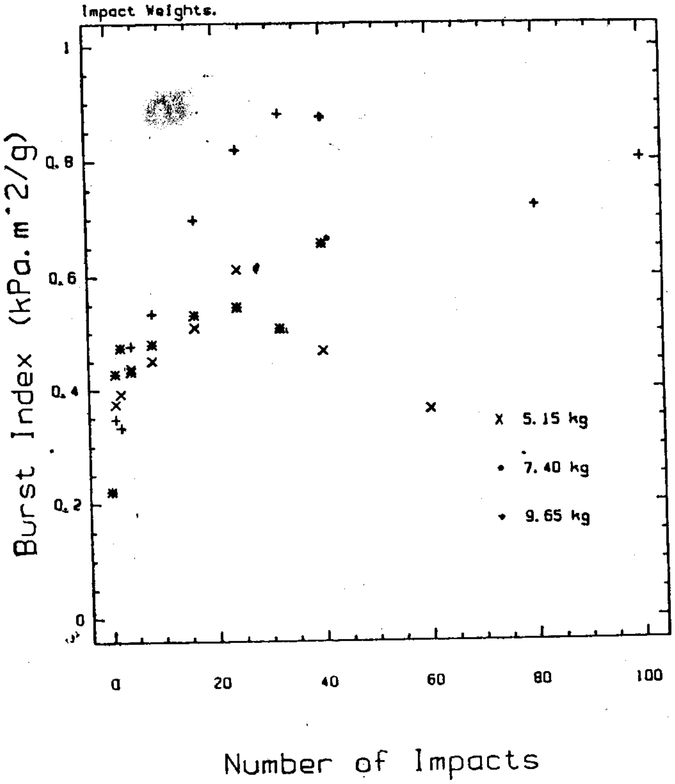
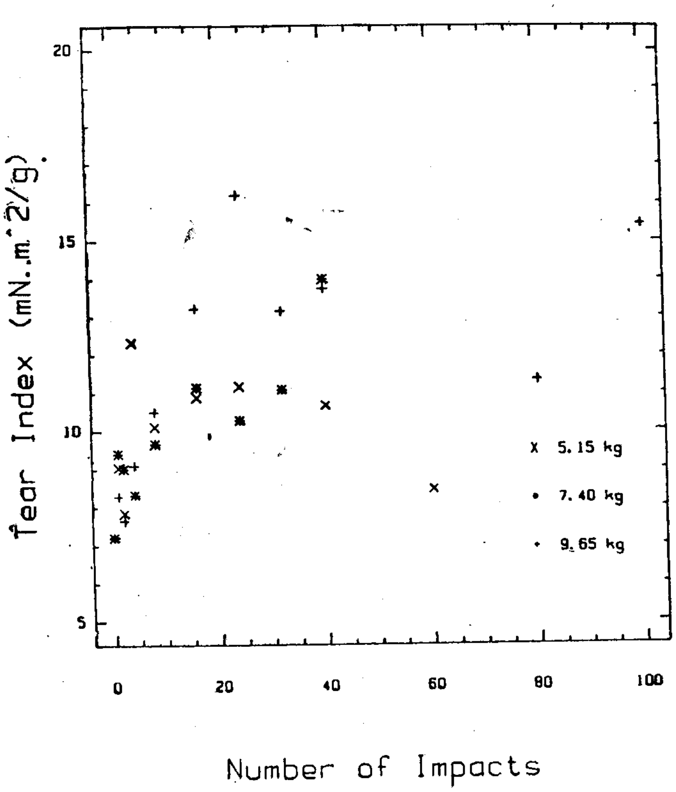


Fig. 5 Effect of Number of Impacts on Tear Index



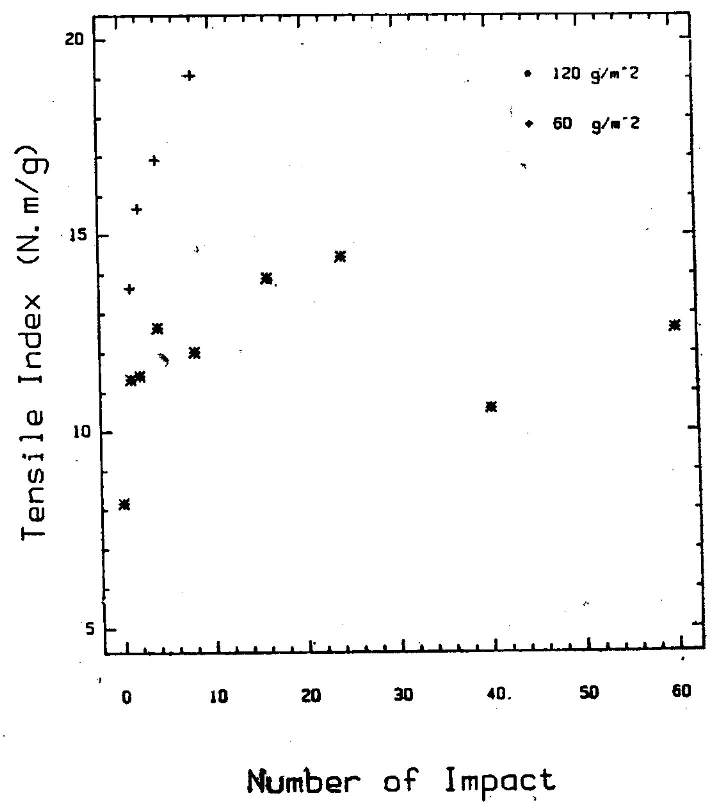
1.7 Scattering co-efficient : Scattering co-efficient did not show any particular trend with number of impacts at any impact weights. Points were found scattered all over the graph, which is not shown.

2) Effect of the basis weight of the impacted sheet :

Here only one figure is given to represent the effect of number of impact on tensile strength for 60 gm/m² and 120 gm/m² sheets.

Fig. 6 shows that 60 gm/m² sheet can develop the same strength with half the number of impacts as compared to the 120 gm/m² sheet.

Fig. 6: Effect of Number of Impacts on Tensile Index at 5.15 kg Impact Weight for 60 and 120 g/m^2 Sheets

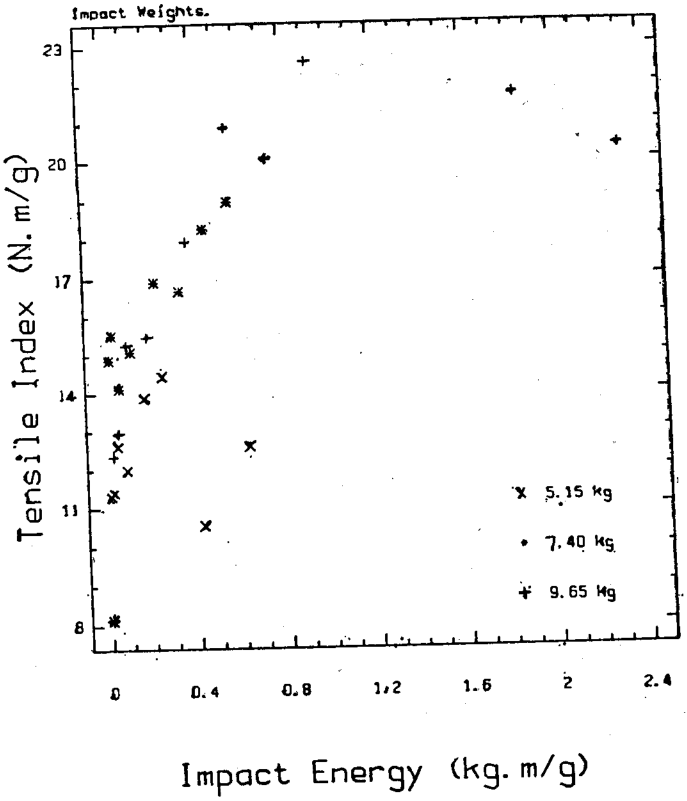


3) Effect of impact energy :

To determine the effect of net energy given to the fiber per unit weight, four impact variables such as number of impacts, impact weight number of sheets impacted and basis weight of the sheet are combined into a single variable, impact energy per gramme fiber.

Fig. 7 is given as a representative to show the

Fig. 7 Effect of Impact Energy on Tensile Index at different Impact Weights.



relationship between impact energy and tensile index.

4) Effect of number of sheets :

To study the effect of the air interface between the sheets, two sheets were placed one over the other and impacted.

Fig. 8 shows the effect of impact energy on tensile strength for single and double sheet. Figure shows that the points for single sheet and double sheet lie close for same impact energy. This indicates that the same energy develops equal strength irrespective of number of sheets or air interface.

5) Effect of intermittant reslushing :

Intermittant reslushing was carried out after half of the total number of impacts to study whether the location of fibers matter in the treatment.

Fig. 9 shows the relationship between impact energy and tensile index with and without intermittant

Fig. 8 Effect of Impact Energy on Tensile Index for Single and Double Sheet at 9.65 kg Impact Weight.

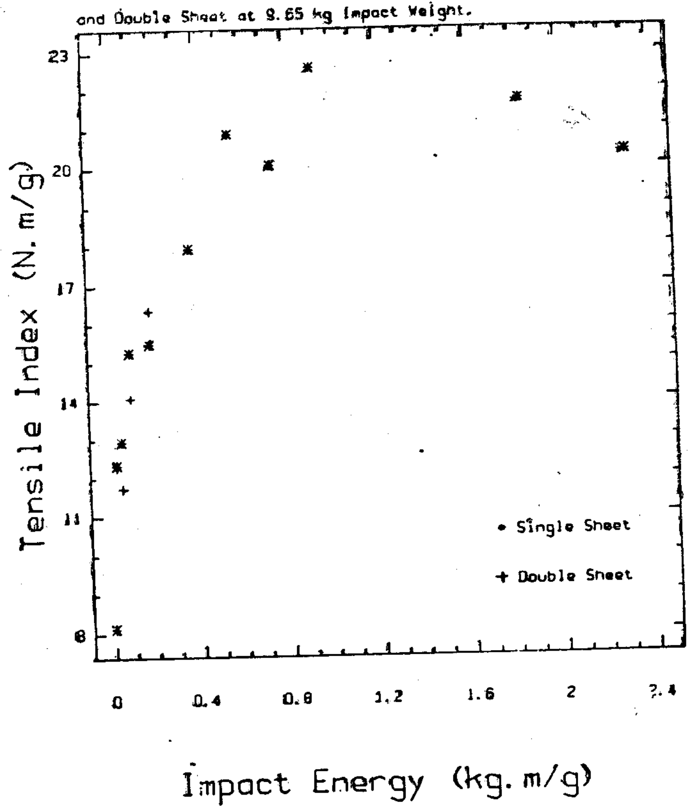
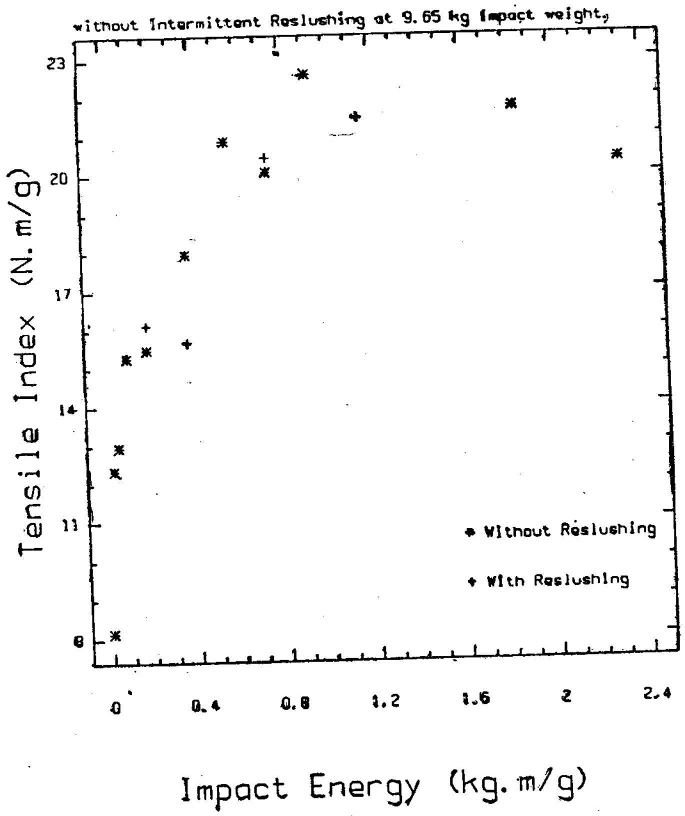


Fig. 9 Effect of Impact Energy on Tensile Index with and without Intermittent Reslushing at 9.65 kg Impact weight.



resulshing. Figure shows that the points lie very close for same energy input, with or without intermittant reslushing. This indicates that intermittant reslushing does not effact the sheet properties in one way or the other. The effecct of reslushing if any, might be offset by losing some fines in the reforming of the sheet or the impact energy might be equally distributed with all the fibers irrespective of their location in the sheet.

SUMMARY OF RESULTS ;

As discussed earlier, the impacting of fiber did not create fines at least not detectable or satistically significant. Impacting did not change the freeness. also The increase in impact energy input to the fiber either by increasing the impact weight or number of impacts increased such sheet strength properties as tensile and burst. The strength properties increased with increasing number of impacts, reached to a maximum and started decreasing. The increase in impact weight gave higher strength for the same number of impacts. The point of maximum strength shifted to a higher number of impacts for higher impact weights. Density and tear resistance had a tendency to increase intially with increasing number of impact but at higher impact numbers, no specific trend was visible.

The changing of weight of fibers impacted either by charging grammage of the sheet or number of sheet did not show any change in properties, for same impact energy input per unit weight of fibers. The intermittant reslushing also did not affect the properties.

CONCLUSIONS :

Within the limitation of impacting weights and number of impacts ;

a) The impacting of fiber did not create fines.

b) Impacting of fiber did not affect the freeness.

c) Impacting loosened the internal structure of the fibers and increased their flexibility.

d) Impacting increased the tensile and burst strength of the sheet by increasing the bonding potential of the fibers and

e) Pure impacting will fibrillate the fiber internally.

APPENDIX—'A'

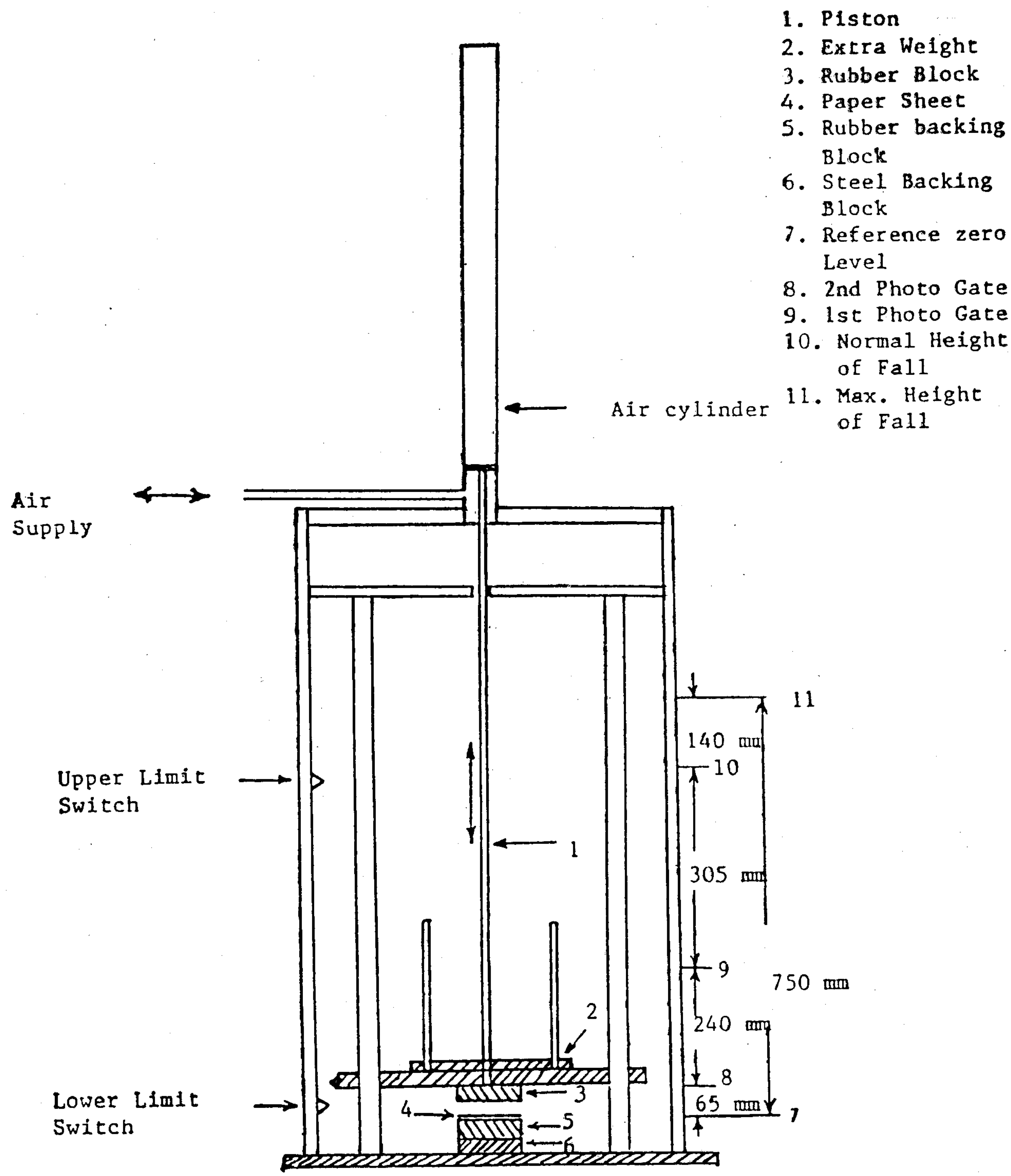
Impact Refiner : A press simulator,, available in the paper laboratory of Western Michigon University was modified to use as impact refiner. A Schematic diagram is shown below.

The impacting weights were lifted and lowered pneumatically. The weight moved between two limit switches. As the weight impacted the web, it also activate the lower limit switch. Activation of lower limit switch closed the air outlet valve and opened air inlet valve to the air cylinder and keep it open till the weight touches the upper limit switch and activate it. The upper limit swicth on activation opened the air outlet valve and closed inlet valve and keep it in this position till the weight hit the web and touch the lower limit switch. To stop the impacting, air supply is to be switched off.

EXPERIMENTATION :

A commercial grade bleached Kraft southern pine pulp applied by III Rayonier Inc. USA, was used. The air dry lap of pulp was soaked overnight and disintegrated by mild agitation for 15 minutes at a consistency of 0.5%. The hand sheets of the required basis weight were made on the Noble and Wood sheet making machine. The sheet were pressed without applying any extra load. The moisture content of the sheet was approximately 60%. Four circular discs of 90 mm diameter were cut from each 200×200 mm Noble and wood sheet.

The discs were impacted for a predetermined number of times with a certain weight. Sufficient number of sheets were impacted to get enough pulp to form seven hand sheet of 1.2 gm each on the British sheet molding machine. The discs after impaction were mixed with water and disintegrated by very mild agitation at 0.3% consistency to ensure minimal effect of agitation on fiber structure. The number of impact varied from 0 to 100. The impact intensity was studel at three weights of 5.15, 7.40 and 9,65Kgs. The number of sheet impacted at a time was either one or two. In certain cases, intermittant reslushing was also carried out by slushing the discs after one half of the total discs. The fiber were reformed into sheets and impacted for the remaining number of impacts.



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