A Comparison of Mechanical Micro-fibrillated Cellulose (MFC) Production with Different Refiner Types

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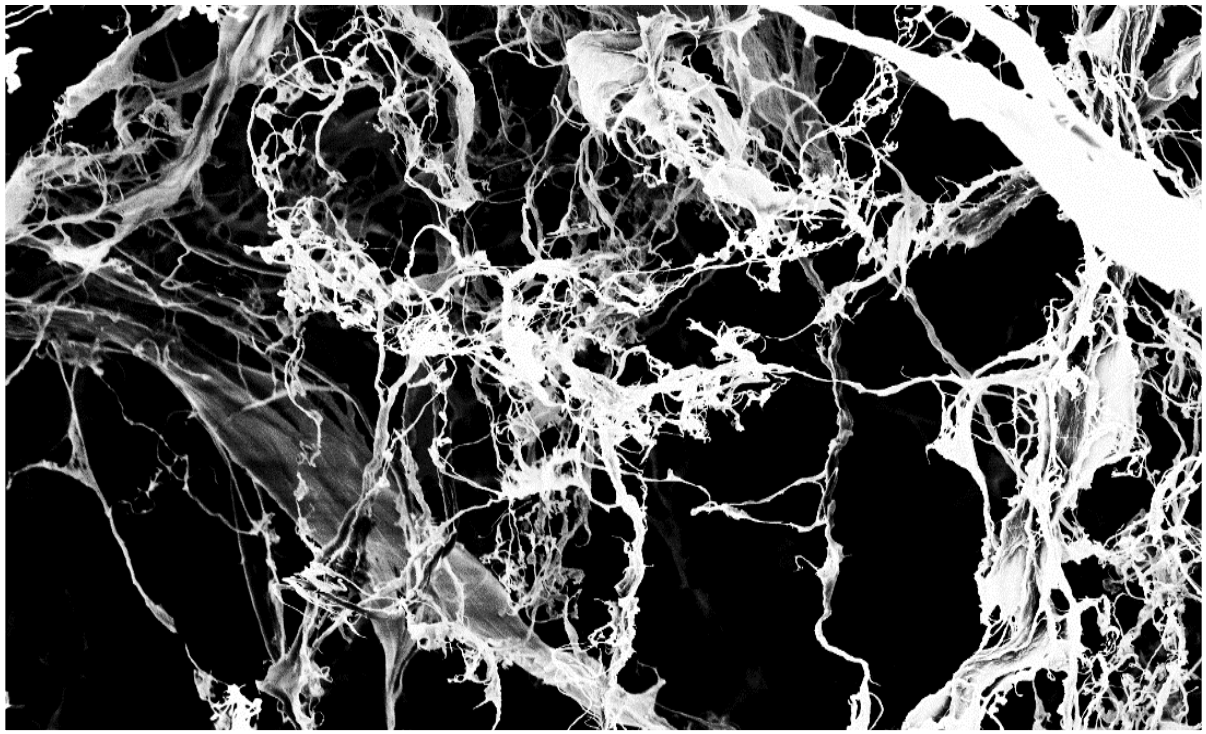
Micro-fibrillated Cellulose (MFC)

What is it and how do we define it?

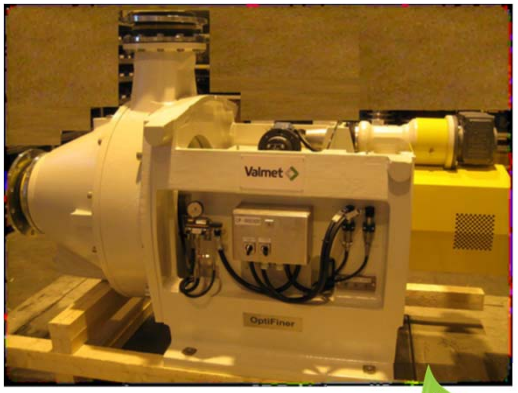


- MFC has been highly refined using mechanical energy only.
- Fiber is often defined by either %fines (% less than 0.2mm) or the energy imparted upon the fiber (kWh/T).

Micro-fibrillated Cellulose (MFC)

How do we produce MFC?

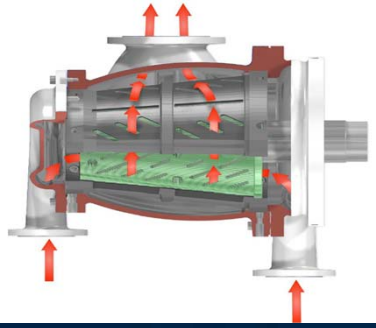
- This mechanical energy is supplied using one of three traditional refiner types specifically adapted to produce MFC.
  - Next Generation Conical Design
  - Double Disk Refiner
  - Traditional Conical Refiner



Refiner Features – A Quick Snapshot

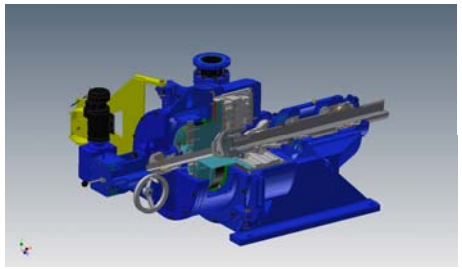
Next Generation Conical

- Unique flow-through technology
- Quick and precise gap control
- Able to have higher edge loads without fiber damage
- Touch point control



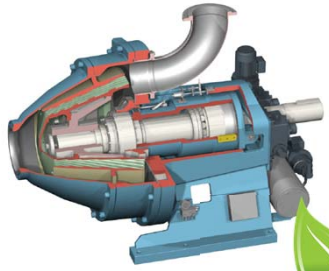
Double Disk Refiner

- Higher capacity & greater energy efficiency due to spline technology
- Fast refiner plate installation and/or changes
- Wide variety of fillings available



Traditional Conical

- Long refining zone, longer retention time and larger refining surface area
- Wide variety of fillings available
- Usage of special materials possible – nontraditional wood pulp

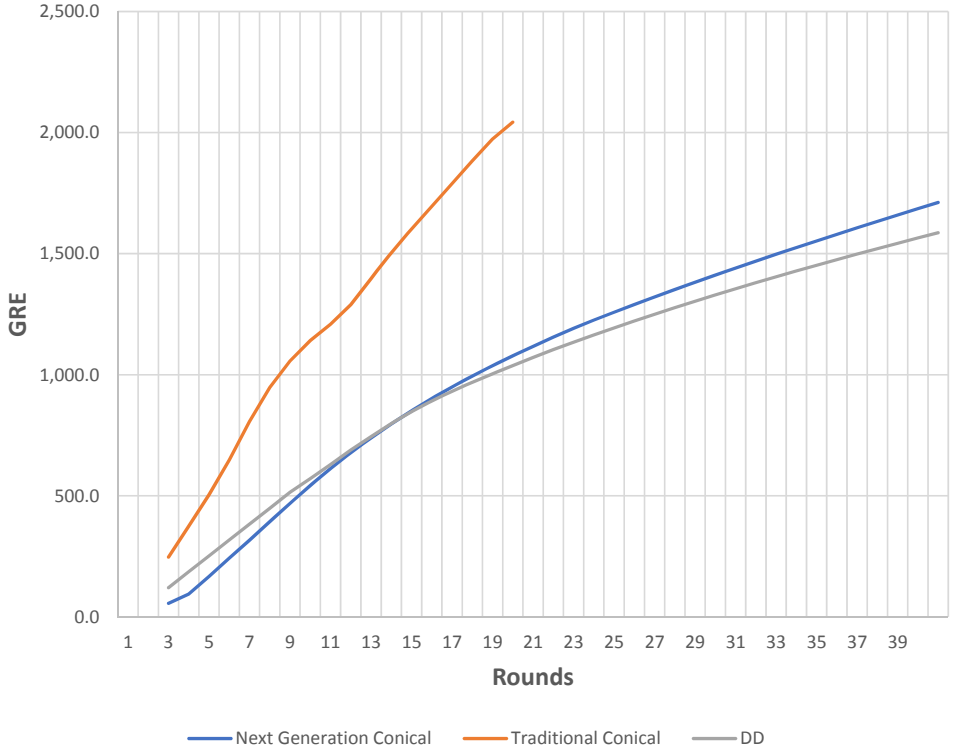


Refining Results

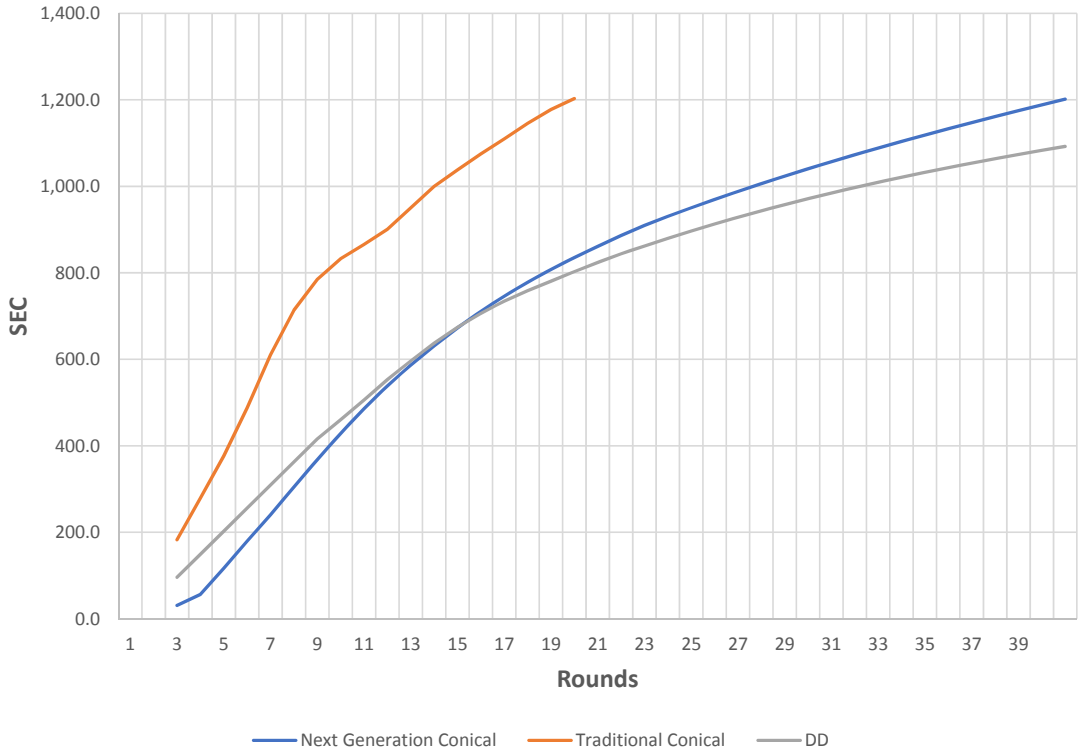
Evaluation Parameters

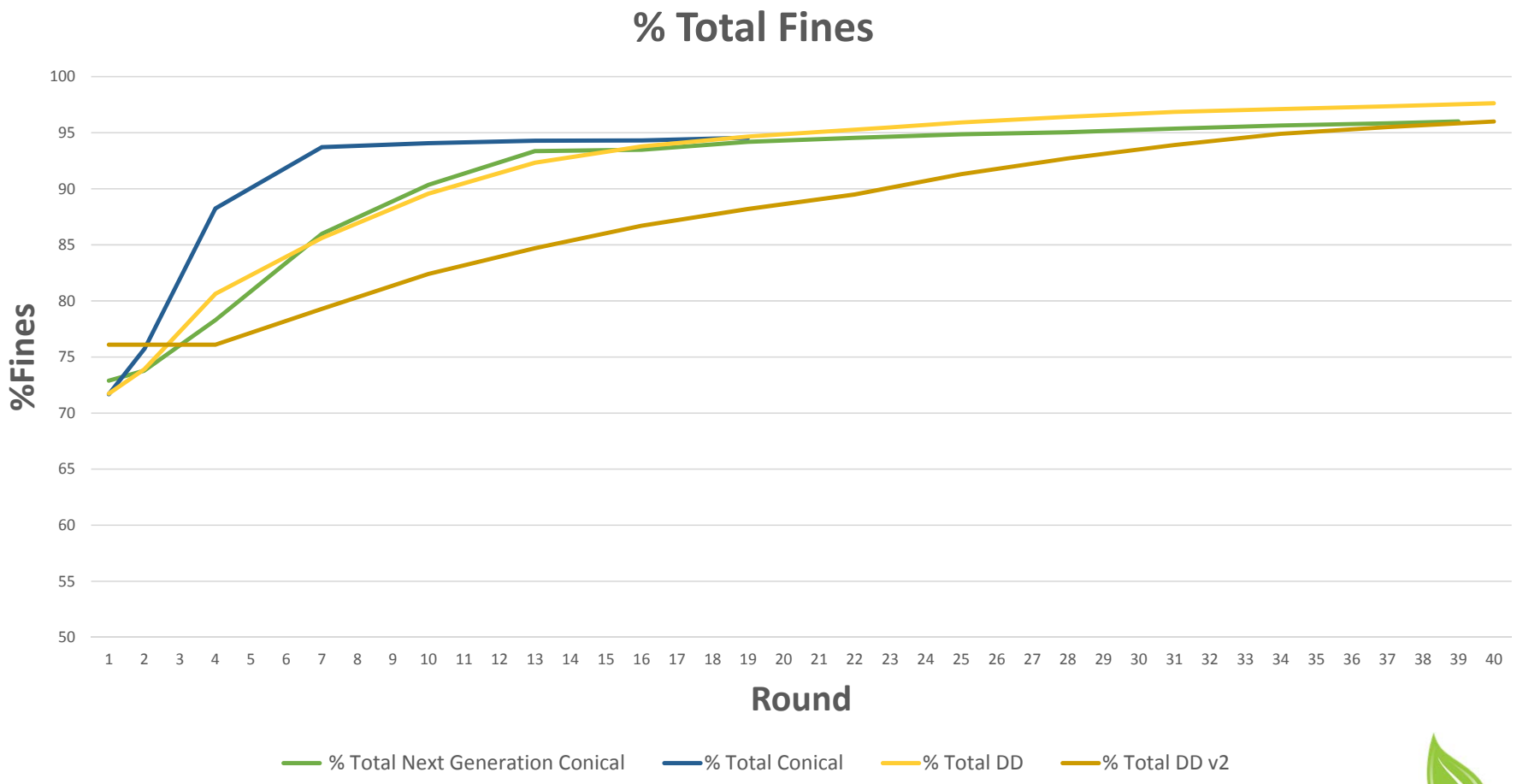
- Pulp used was UPM Uruguay market bleached eucalyptus pulp
- Consistency range 4.0 – 4.5 %
- Batch Process - up to 40 Rounds or passes of pulp turnover
- Power used, fiber morphology (Total, A & B fines) and handsheet results

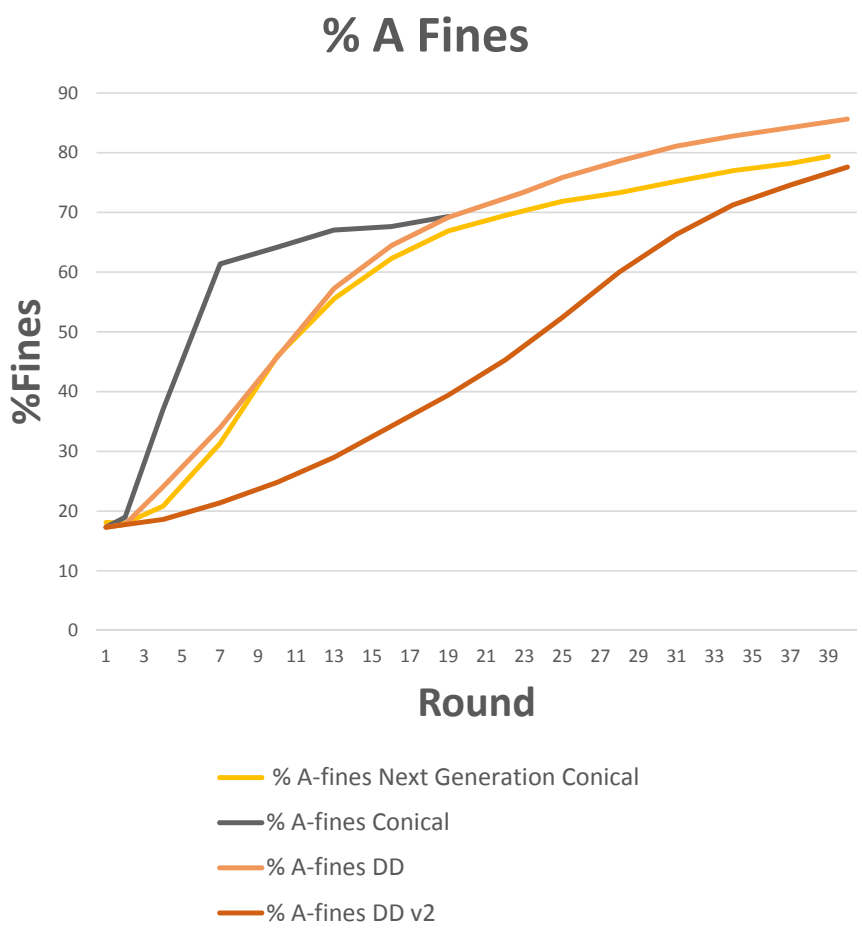
Gross Energy Comparison kWh/T

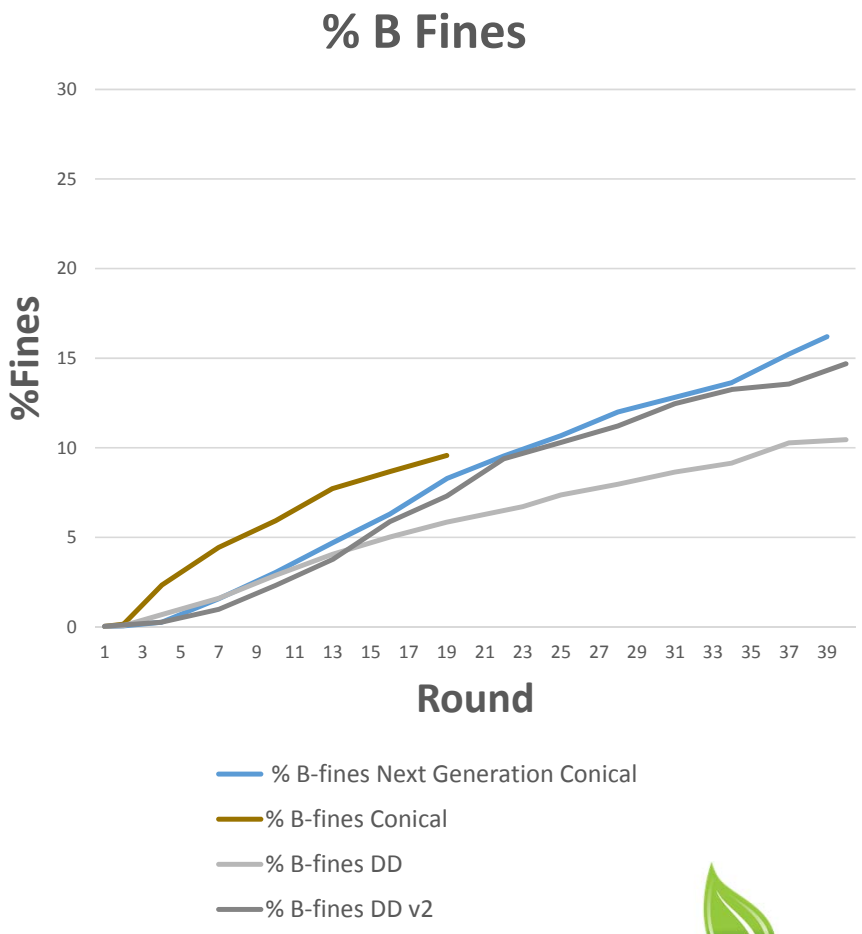


Net Energy Comparison kWh/T

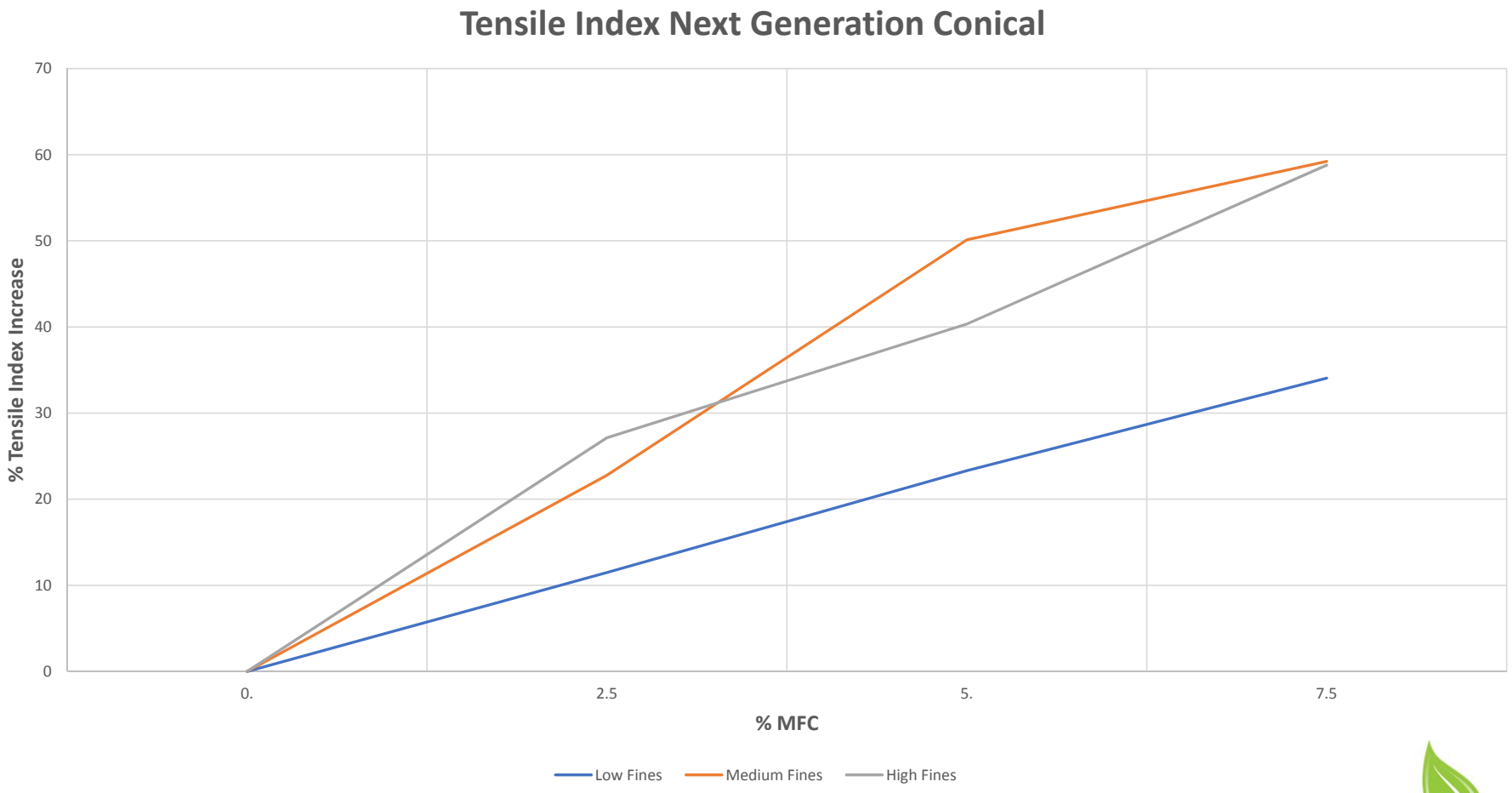


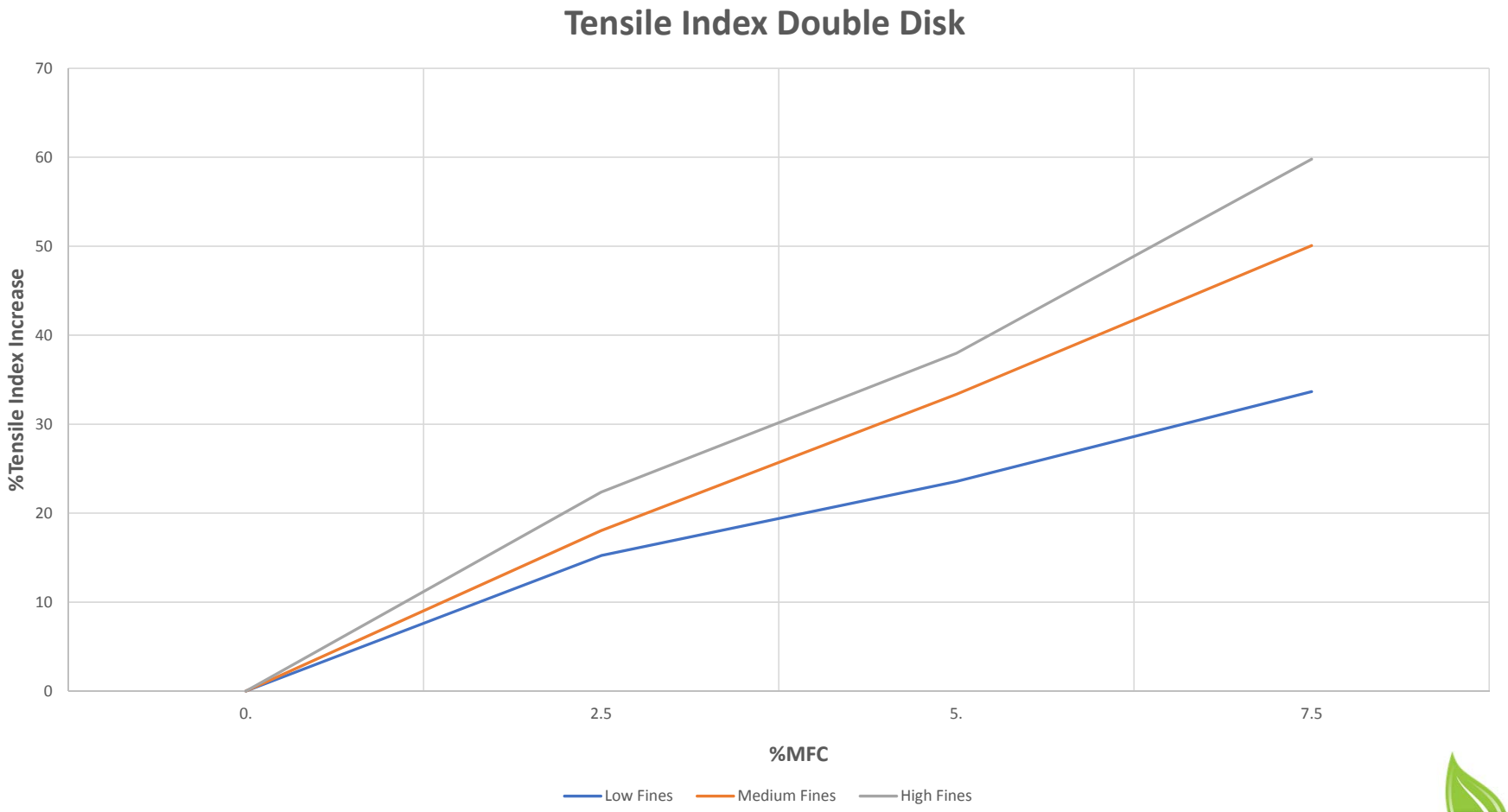

% Total Fines
%Fines
100
95
90
85
80
75
70
65
60
55
50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Round
% Total Next Generation Conical
% Total Conical
% Total DD
% Total DD v2

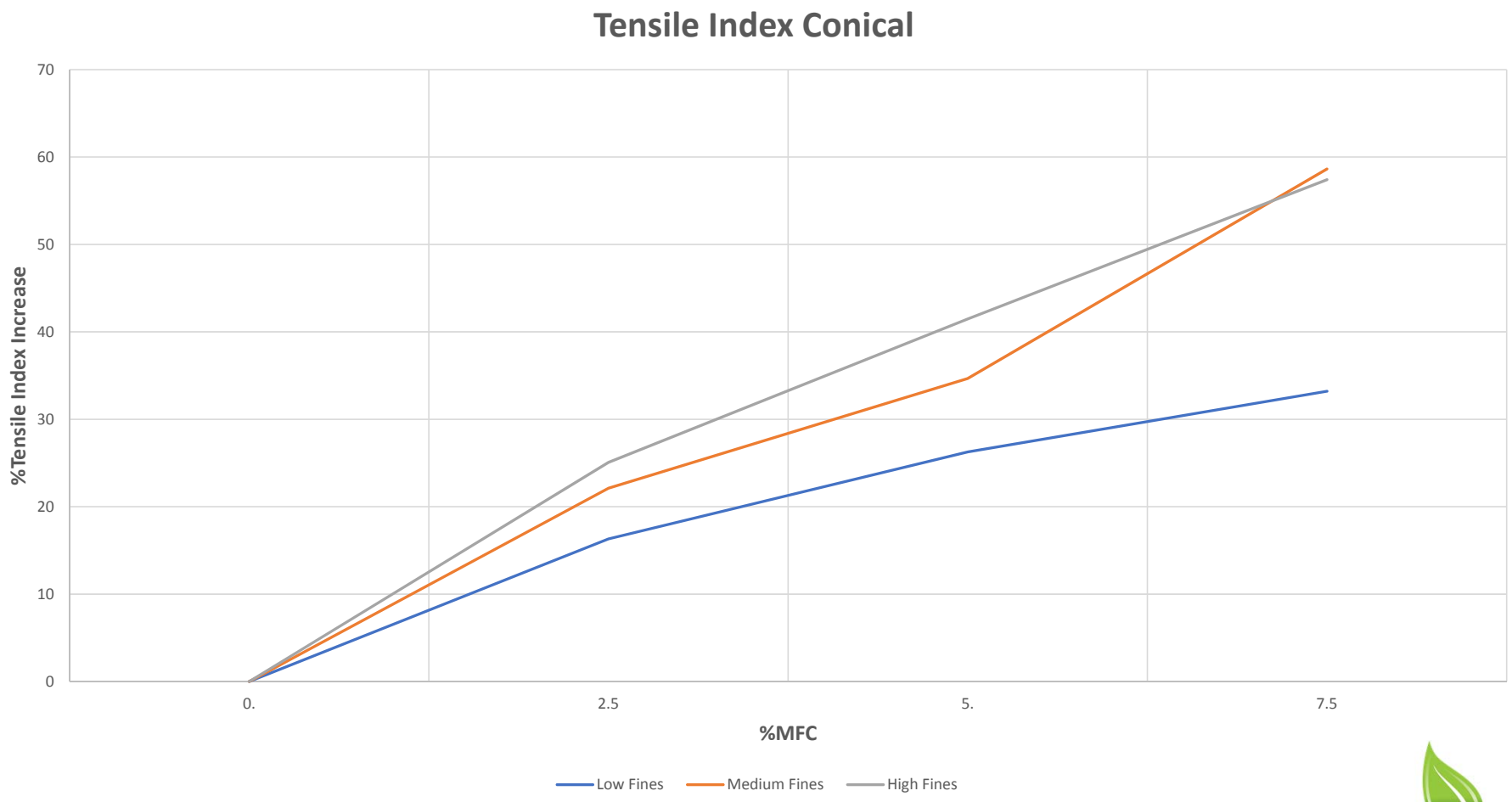

% A Fines
%Fines
90
80
70
60
50
40
30
20
10
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Round
% A-fines Next Generation Conical
% A-fines Conical
% A-fines DD
% A-fines DD v2

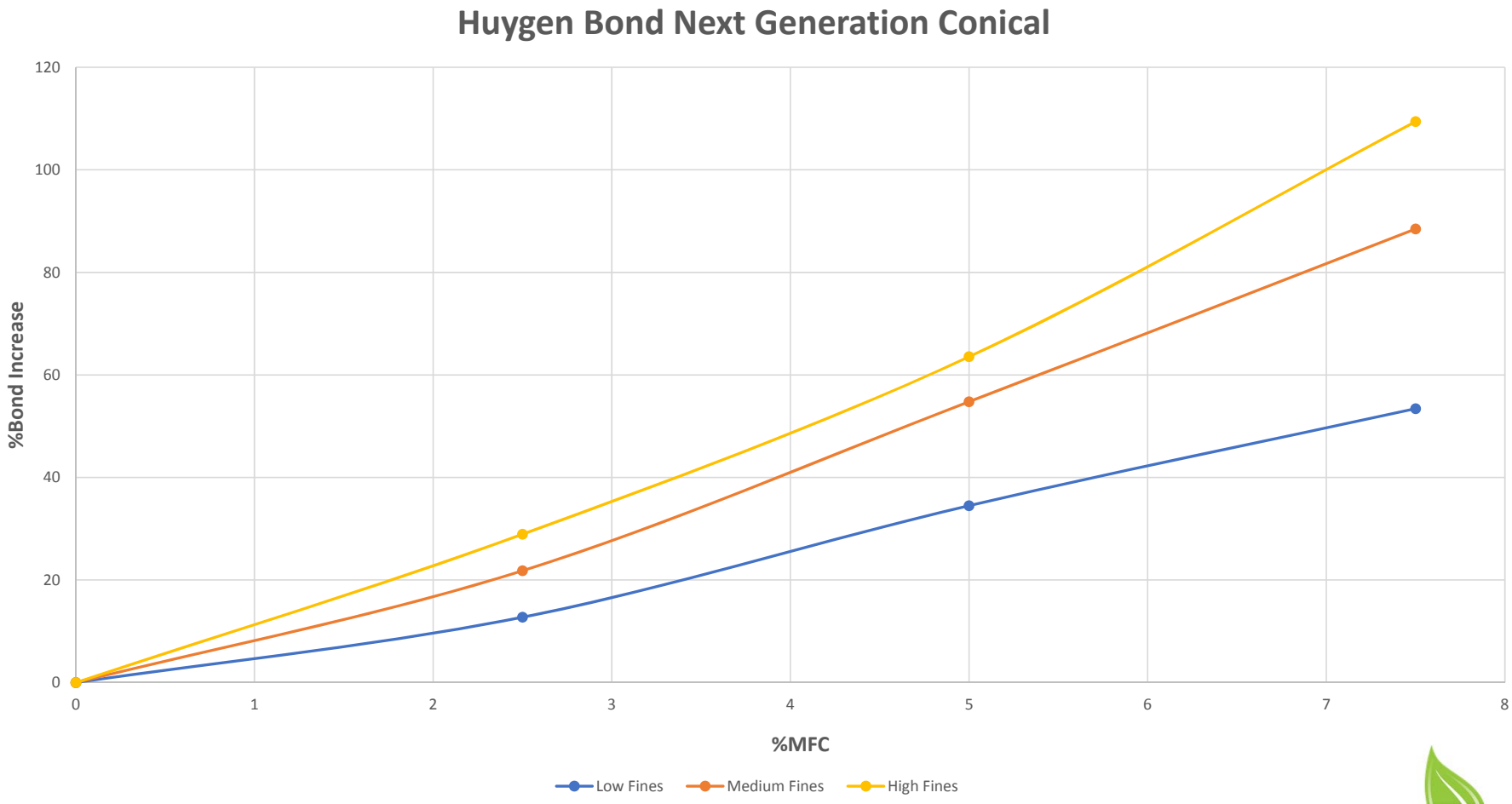

% B Fines
%Fines
30
25
20
15
10
5
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Round
% B-fines Next Generation Conical
% B-fines Conical
% B-fines DD
% B-fines DD v2

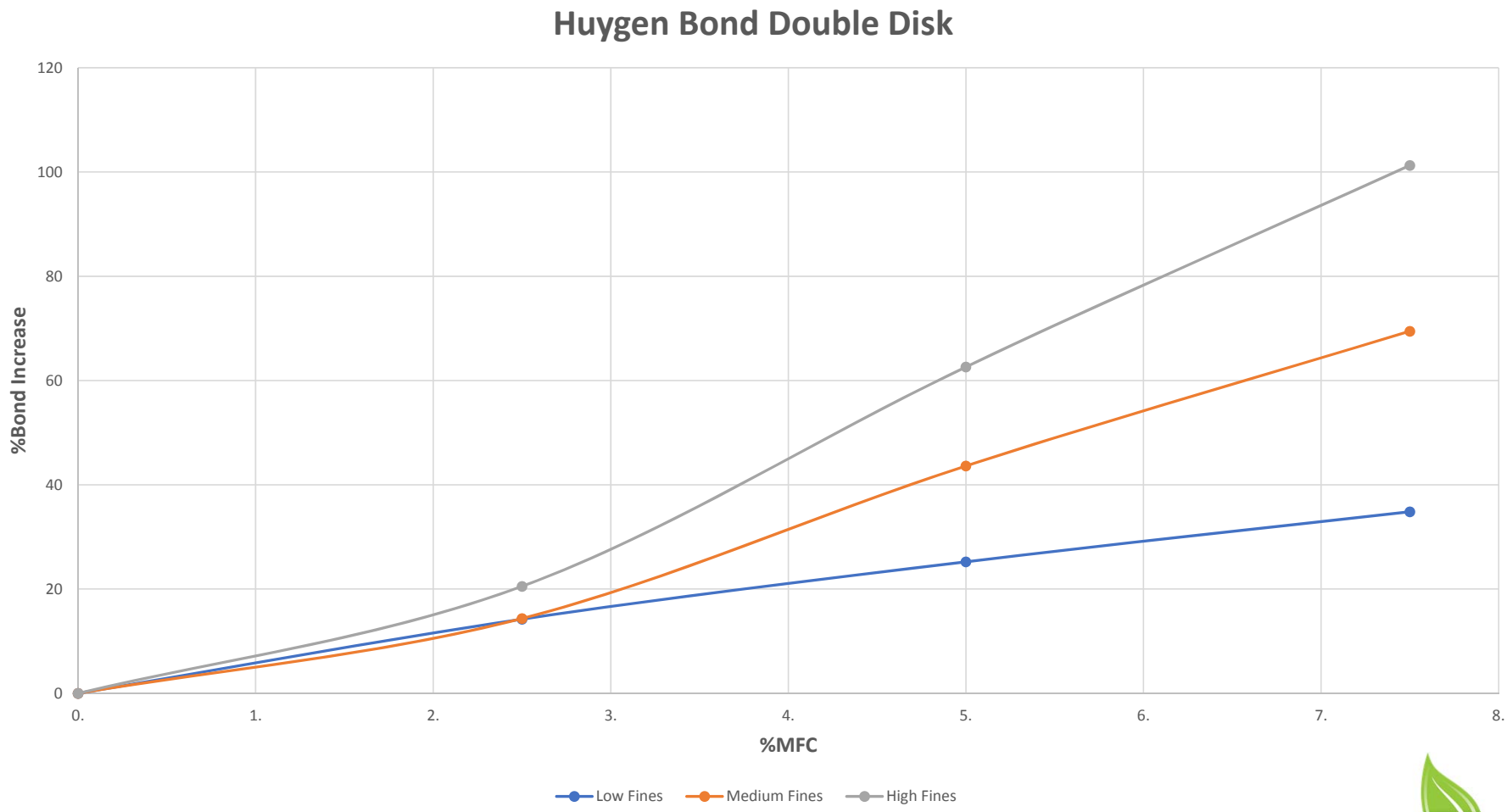
Handsheet Results

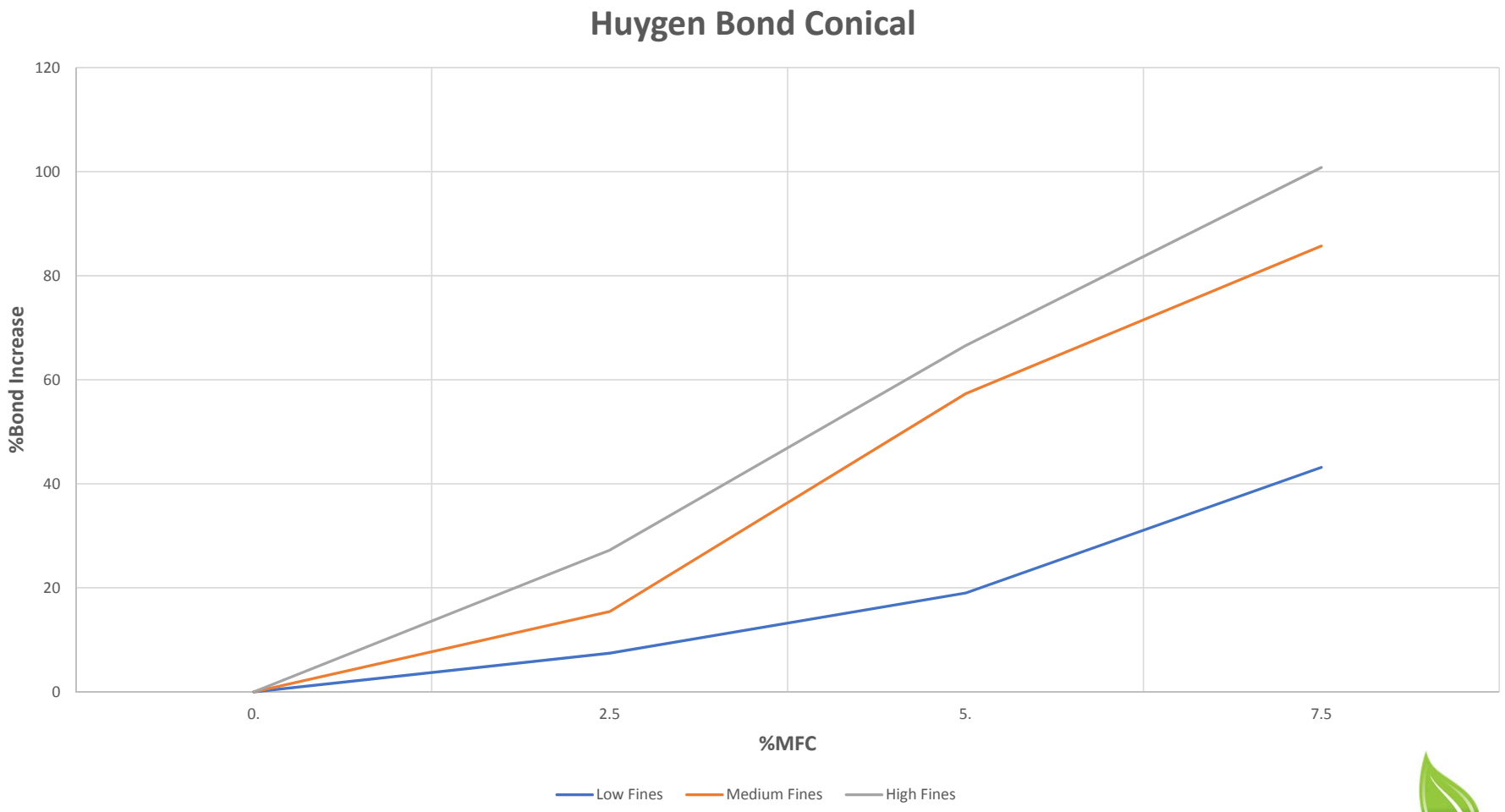

Tensile Index Next Generation Conical
% Tensile Index Increase
70
60
50
40
30
20
10
0
0.
2.5
5.
7.5
% MFC
Low Fines
Medium Fines
High Fines


Tensile Index Double Disk
%Tensile Index Increase
70
60
50
40
30
20
10
0
0.
2.5
5.
7.5
%MFC
Low Fines
Medium Fines
High Fines


Tensile Index Conical
%Tensile Index Increase
70
60
50
40
30
20
10
0
0.
2.5
5.
7.5
%MFC
Low Fines
Medium Fines
High Fines


Huygen Bond Next Generation Conical
%Bond Increase
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
%MFC
Low Fines
Medium Fines
High Fines


Huygen Bond Double Disk
%Bond Increase
120
100
80
60
40
20
0
0.
1.
2.
3.
4.
5.
6.
7.
8.
%MFC
Low Fines
Medium Fines
High Fines


Huygen Bond Conical
120
100
80
60
40
20
0
%Bond Increase
0.
2.5
5.
7.5
%MFC
Low Fines
Medium Fines
High Fines

Additional Physical Test Results

Next Generation Conical Refiner

- Burst Index
  - 32% - 150% Increase
- Gurley Air Resistance
  - 30% - 88% Increase
- Tensile Stiffness
  - 8.5% - 31% Increase

Double Disk Refiner

- Burst Index
  - 31% - 127% Increase
- Gurley Air Resistance
  - 24% - 84% Increase
- Tensile Stiffness
  - 10% - 30% Increase

Conical Refiner

- Burst Index
  - 30% - 128% Increase
- Gurley Air Resistance
  - 26% - 84% Increase
- Tensile Stiffness
  - 12% - 30% Increase

MFC Conclusions

Flexible

MFC for many different applications can be produced from a variety of pulps using any of the three types of refiners discussed, along with the special fillings.

Energy

At high fines content, final accumulated energy usage is generally similar with all three refiner types; at lower fines content there are more differences between the technologies that depend upon control strategies.

Property Development

Similar levels of sheet property development can be obtained using MFC produced by all three refiner types; however, there are some differences in the fines morphologies produced.