CLAIMS

1. A refiner plate segment comprising:

an inner arc;

an outer arc distally disposed from the inner arc;

a first end distally disposed from a second end, the first end and second end extending between the inner arc and the outer arc;

a substrate disposed between the inner arc, first end, second end, and the outer arc;

a refiner side and a backside distally disposed from the refiner side;

refiner bars engaged to the substrate on the refiner side, wherein the refiner bars have a refiner bar height, and wherein adjacent refiner bars and the substrate define a groove between the adjacent refiner bars; and

a protrusion disposed in the groove, the protrusions having a protrusion height, wherein the protrusion height is no more than 30% of the refiner bar height.

2. The refiner plate segment of claim 1 further comprising multiple protrusions, wherein the protrusions are disposed at regular intervals of between 6 millimeters to 25 millimeters within the groove.

3. The refiner plate segment of any of claims 1 to 2 further comprising multiple protrusions, wherein the protrusions are disposed at irregular intervals.

4. The refiner plate segment of any of claims 1 to 2, wherein the protrusion has a shape of a rectangular prism, wherein the protrusion has a leading face disposed at an angle relative to the substrate on the refiner side of the refiner plate segment, and

wherein the angle is an obtuse angle.

5. The refiner plate segment of any of claims 1 to 4, wherein the refiner bars have an initial bar height of 10 mm - 20 mm and the protrusion has an initial protrusion height of 2 mm - 5 mm.

6. The refiner plate segment of any of claims 1 to 5, wherein the refiner bar further comprises a reference bar volume comprising a volume of a portion of the refiner bar sharing a

length with the longest length of a protrusion and a reference bar base coextending with an adjacent protrusion base along the longest protrusion length,

wherein the protrusion further comprise a protrusion volume, and

wherein the protrusion volume is less than 40% of the reference bar volume.

7. The refiner plate segment of any of claims 1 to 6, wherein the refiner bars have an initial bar height of 12 mm - 15 mm and the protrusion has an initial protrusion height of 2 mm - 3.5 mm.

8. A refiner plate segment comprising:

an inner arc;

an outer arc distally disposed from the inner arc;

a first end distally disposed from a second end, the first end and the second end extending between the inner arc and the outer arc;

a substrate disposed between the inner arc, first end, second end, and the outer arc; a refiner side of the substrate and a back side of the substrate distally disposed from the refiner side;

refiner bars engaged to the substrate on the refiner side, wherein the refiner bars have a refiner bar height, and wherein adjacent refiner bars and the substrate define a groove between the adjacent refiner bars; and

protrusions disposed in the groove, the protrusions having a protrusion top, a protrusion base, and a protrusion height between the protrusion top and the protrusion base, and a side connecting the protrusion top and the protrusion base,

wherein a protrusion of the protrusions has a longitudinal cross-sectional area measured from a plane disposed along the longest length of the protrusion as measured from a portion of the protrusion disposed closest to the inner arc to a portion of the protrusion disposed closest to the outer arc,

wherein an adjacent refiner bar of the refiner bars has a lateral cross-sectional area measured from a plane intersecting the refining section transversely to a refiner bar length, and wherein protrusion longitudinal cross-sectional area is less than 20 % of the adjacent refiner bar lateral cross-sectional area.

9. The refiner plate segment of claim 8 further comprising a difference between the protrusion height and the refiner bar height, wherein the difference between the protrusion height and the refiner bar height is an effective groove depth.

10. The refiner plate segment of any of claims 8 to 9 further comprising dams, wherein the dams have a dam longitudinal cross-sectional area and wherein the dam longitudinal cross-sectional area is greater than 20% of a reference bar longitudinal area, wherein the reference bar longitudinal area comprises a length and a height, wherein the reference bar length coextends with a longest length of the dam.

11. The refiner plate segment of any of claims 8 to 10, wherein the protrusions are disposed at regular intervals of between 6 millimeters to 25 millimeters within the groove.

12. The refiner plate segment of any of claims 8 to 11, wherein the protrusions are disposed at irregular intervals.

13. The refiner plate segment of any of claims 8 to 12, wherein a protrusion of the protrusions has a shape of a trapezoidal prism, wherein the protrusion has a leading face disposed at an angle relative to the substrate on the refiner side of the refiner plate segment, and wherein the angle is an obtuse angle.

14. A refiner plate segment comprising:

an inner arc;

an outer arc distally disposed from the inner arc;

a first end distally disposed from a second end, the first end and the second end extending between the inner arc and the outer arc;

a substrate disposed between the inner arc, first end, second end, and the outer arc; a refiner side of the substrate and a backside of the substrate distally disposed from the refiner side;

refiner bars engaged to the substrate on the refiner side, wherein the refiner bars have a refiner bar height, and wherein adjacent refiner bars and the substrate define a groove between the adjacent refiner bars; and

a protrusion disposed in the groove between two adjacent refiner bars,

wherein the protrusion is a flow restrictor having a first restrictor end distally disposed from a second restrictor end,

wherein the first restrictor end engages a leading face of a first refiner bar of the two adjacent refiner bars, and

wherein the flow restrictor is disposed above the substrate of the groove.

15. The refiner plate segment of claim 14, the flow restrictor has a longitudinal cross-sectional area measured from a plane disposed along the longest length of the flow restrictor as measured from a portion of the flow restrictor disposed closest to the inner arc to a portion of the flow restrictor disposed closest to the outer arc,

wherein the first refiner bar of the two adjacent refiner bars has a lateral cross-sectional area measured from a plane intersecting the refining section transversely to a refiner bar length, and

wherein flow restrictor longitudinal cross-sectional area is less than 20 % of the adjacent refiner bar lateral cross-sectional area.

16. The refiner plate segment of any of claims 14 to 15, wherein a second restrictor end engages a trailing face of a second refiner bar of the two adjacent refiner bars.

17. The refiner plate segment of any of claims 14 to 16, further comprising multiple protrusions, wherein the multiple protrusions are flow restrictors.

18. The refiner plate segment of claim 14 to 17, wherein a first flow restrictor of the multiple flow restrictors is disposed at a first flow restrictor height, and wherein a second flow restrictor of the multiple flow restrictors is disposed at a second flow restrictor height.

19. The refiner plate segment of any of claims 14 to 18, wherein the first flow restrictor end is disposed at a different elevation than the second flow restrictor end.

20. A method for refining cellulosic material, the method comprising:

installing refiner plate segments in a refiner, each refiner plate segment comprising:

an inner arc;

an outer arc distally disposed from the inner arc;

a first end distally disposed from a second end, the first end and second end extending between the inner arc and the outer arc;

a substrate disposed between the inner arc, first end, second end, and the outer arc;

a refiner side and a backside distally disposed from the refiner side;

refiner bars engaged to the substrate on the refiner side, wherein the refiner bars have a refiner bar height, and wherein adjacent refiner bars and the substrate define a groove between the adjacent refiner bars; and

a protrusion disposed in the groove, the protrusions having a protrusion height, wherein the protrusion height is no more than 30% of the refiner bar height; and

operating the refiner to refine the cellulosic material.