assembly may comprise several annular sector-shaped segments secured to a backing structure to form the circular disc, annular disc, conical frustum, or cylinder. The refiner sides of the opposing refining assemblies face each other and a narrow refining gap separates the opposing refining assemblies. At least one of the refining assemblies is a rotor configured to rotate around the axis. As the rotor refining assembly rotates at high speeds, operators feed lignocellulosic material or other feed material through the refining gap to separate, develop, and cut the component fibers. As the mechanical refiner breaks down lignocellulosic material, some water may be released in the form of steam.

[0006] The inlet of the refining gap is disposed nearer to the center of rotation than the outlet to the refining gap. As the rotor refining assembly rotates, the feed material passes radially outward through the refining gap.

SUMMARY OF THE INVENTION

[0006a] According to a first aspect of the present disclosure, there is provided a refiner plate segment including: 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.

[0006b] According to a second aspect of the present disclosure, there is provided a refiner plate segment including: 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.

[0006c] According to a third aspect of the present disclosure, there is provided a refiner plate segment including: 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.

[0006d] According to a fourth aspect of the present disclosure, there is provided a method for refining cellulosic material, the method including: 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.

[0007] The problem of increased energy usage in mechanical refiners over the working life of a mechanical refiner is mitigated by the use of an exemplary refiner plate segment having a refiner side and a back side distally disposed from the refiner side, refiner bars engaged to a substrate of the refiner side, wherein the refiner bars have a refiner bar height, and wherein adjacent refiner bars and the substrate define grooves between the adjacent bars, and protrusions disposed in the grooves, wherein the protrusions have a protrusion height, wherein the protrusion height is 25% or less of the refiner bar height and wherein the protrusions are configured to wear over time.

[0008] A problem with low-consistency refining is that new refiner plate segments can have excessive flow capacity due in part to the initial volume of the grooves. This is particularly true with tall refiner bars, which in turn create grooves of greater volume. Refiner plate segments with greater flow capacity allow more dilute feed material to pass through the refining section over a given amount of time. If the flow capacity exceeds the refining capacity, the refiner will generate more pumping and the energy required to rotate the refiner will be higher, thereby resulting in energy losses that are greater than usual. The process may create a high-pressure outlet flow, which can cause further trouble downstream.