

Single-disc and double-disc rejects refiner comparison

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Varying the refining consistency and varying the specific energy resulted in several distinct differences in pulp physical and optical properties between single-disc and double-disc refiners.

The objective of the rejects refiner trials held at Abitibi-Price's Alma, Que., mill was to compare differences in pulp physical and optical properties between single-disc and double-disc refiners.

Previous work with wood chips has shown that double-disc refiners produce shorter fiber, more shives, lower tear strength, higher light-scattering coefficient, and use less energy in primary refining (1, 2). In these trials, refining was performed on reject fibers rather than on wood chips.

Previous work evaluated the effect of operational speed on pulp quality (3). In these trials, standard operating speeds are used on the single-disc and double-disc refiners. Process conditions such as applied horsepower, throughput, and consistency were varied.

Pulp quality and operational differences will determine the proper applications for single-disc and double-disc refiners when developing fiber. Insight is given on the effects of refiner design and the mechanisms involved in producing mechanical pulps.

Experimental

The groundwood rejects data was collected at Abitibi-Price's newsprint mill in Alma, Que. This mill operates Sprout-Bauer 42-1B single-disc and 412 double-disc refiners in parallel on the same furnish. The 42-1B has one 42-in. rotating disc and a 42-in. stationary disc. The 412 has two counter-rotating 40-in. discs. This is an ideal situation for mill site evaluation of single-disc and double-disc refiners because the mill is processing the same wood species on these machines.

The refiner plate pattern data for the single-disc and double-disc refiners is listed in Table I. Refiner plate pattern D13C031 was run in the single-disc machine, and pattern 40104 was run in the double-disc machine.

Refiner plate patterns for the two machines were similar in their number of inch cuts per revolution. This indicates

I. Refiner plate pattern data

	Single-disc	Double-disc
Model no.	42-1B	412
Disc size, in.	42	40
Plate pattern	D13C031	40104
Plate taper	0.005 in./in.	0.005 in./in.
Plate life, hours	172	265
Inch cuts per revolution	1.54×10^6	1.72×10^6
Rotational speed	1800 rpm	1200 rpm
Disc differential speed	1800 rpm	2400 rpm
Inch cuts per minute	2772×10^6	4128×10^6

II. Standard operation

	42-1B single-disc	412 double-disc
Consistency, %	18.1	26.7
Freeness, CSF	123	103
Bulk, cm ³ /g	2.79	2.83
Burst index, kPa·m ² /g	2.3	2.4
Tear index, mN·m ² /g	8.0	7.9
Tensile index, N·m/g	44.3	44.6
Stretch, %	2.15	2.29
Tensile energy absorption, J/m ²	39.2	39.2
Brightness, Elrepho	54.8	55.4
Opacity, %	94.3	94.2
Scattering coefficient, m ² /kg	56.3	57.0
TAPPI brightness pads	62.0	62.1
Shives, % (Pulmac 0.10 mm)	3.56	3.07
Fiber Classifications		
Percent on 14-mesh	11.0	11.6
Percent on 28-mesh	26.0	25.8
Percent on 48-mesh	19.8	19.5
Percent on 100-mesh	13.7	13.6
Percent on 200-mesh	5.7	5.5
Percent through 200-mesh	23.8	24.0
+ 28-mesh	37.0	37.4

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that the bar edge lengths available for refining were similar on each machine.

The single-disc machine has a rotational speed of 1800 rpm and a disc differential speed of 1800 rpm. The double-disc has a 1200 rpm rotational speed and a disc differential speed of 2400 rpm. Due to the difference in disc differential speed between the two refiner types, the inch cuts per minute were approximately 50% higher for the double-disc refiner.

Refiner plate life was similar for each machine at 7–11 days of operation. Identical refiner plate tapers of 0.005 in./in. were used for each machine.

Feed conveyor belt speed in feet per minute and the pulp mass per foot was measured. This information, along with the measurement of pulp feed consistency after the press, allowed the exact throughput and, therefore, specific energy for each refiner to be measured.

Refining consistency was varied from 15% to 31% to determine the effect on the pulp physical and optical properties.

Trials were performed to determine the effect of specific energy by varying the specific energy from 40 horse power days/oven dry metric ton (HPD/ODMT) to 60 HPD/ODMT in increments of 10 HPD/ODMT.

Pulp samples were collected and sent to the Sprout-Bauer Pilot Plant Research and Development Laboratory in Springfield, Ohio for analysis.

Results and discussion

Normal operational conditions at the mill produce identical pulp quality from both refiners (Table II). Under standard operation, the 42-1B single-disc refiner runs at 18% consistency and the 412 double-disc refiner at 26.7% consistency.

Effect of refining consistency on single-disc and double-disc rejects refining

Varying the refining consistency from 15% to 31% resulted in several distinct differences in pulp physical and optical properties between the single-disc and double-disc refiner. Specific energy was held constant at 52 HPD/ODMT.

Effect on tear index. The double-disc machine produced pulp with a higher tear index (Fig. 1). The tear index for the double-disc was 5% higher at 30% consistency and 18% higher at 21% consistency.

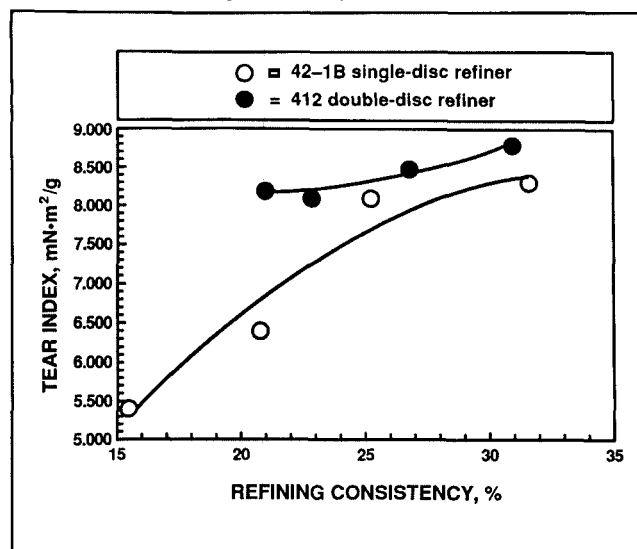
Over a consistency range of 20% to 31% the tear index for the double-disc refiner remained relatively unchanged. On the other hand, large changes in tear index are observed by varying the consistency in the single-disc machine.

Effect on long-fiber fraction. The large changes in tear index observed by varying the consistency in the single-disc machine can be explained by observing the +28-mesh long-fiber fraction (Fig. 2).

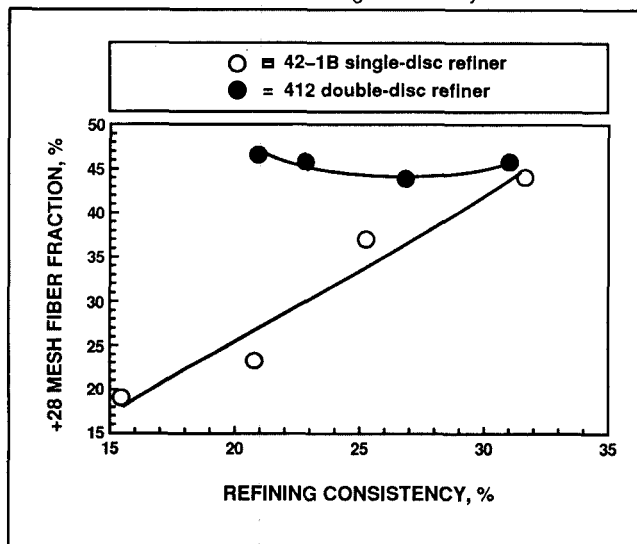
The +28-mesh fiber fraction dramatically decreases for the single-disc machine as the operating consistency goes below its preferred range of 25% to 30% consistency. Therefore, the single-disc machine will cut more if operated at less than optimum consistency.

The double-disc refiner can be seen to produce more long fiber, and therefore higher tear index, with an insensitivity to refining consistency in the 20% to 31% range.

1. Tear index vs. refining consistency



2. +28-mesh fiber fraction vs. refining consistency



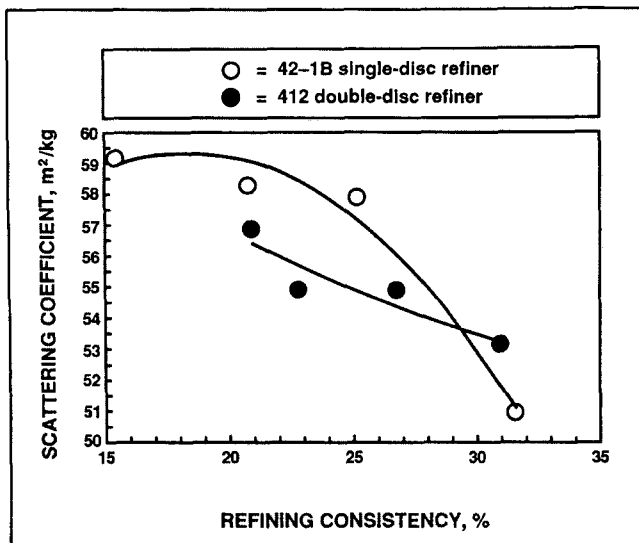
Effect on light scattering coefficient. The single-disc refiner produces a pulp with a higher light-scattering coefficient than the double-disc refiner (Fig. 3). Lowering the consistency from 31% to 20% produces a 14% increase in light-scattering coefficient in the single-disc refiner.

The same decrease in consistency in the double-disc refiner produces an insignificant effect on light scattering. This indicates that the single-disc machine has more versatility in controlling light-scattering coefficient.

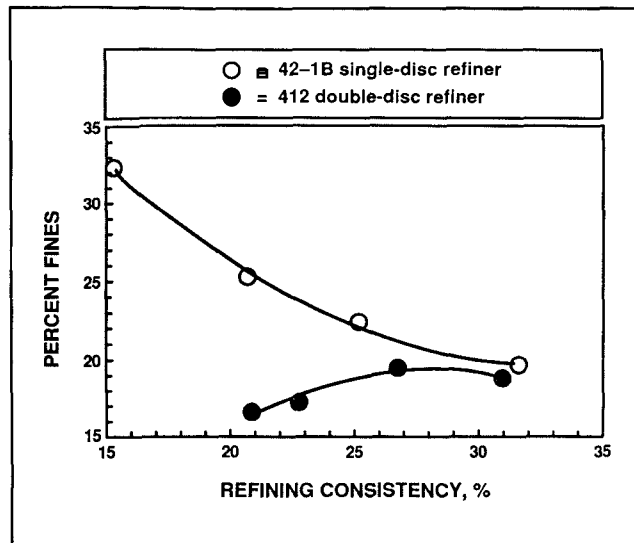
Effect on fines content. The higher light-scattering coefficient from the single-disc refiner can be explained by the fact that it produces more fines as the consistency is lowered. As the consistency in the single-disc refiner was lowered from 32% to 15%, the amount of fines increased by 62%.

As the consistency was lowered in the double-disc refiner the amount of fines remained relatively unchanged (Fig. 4).

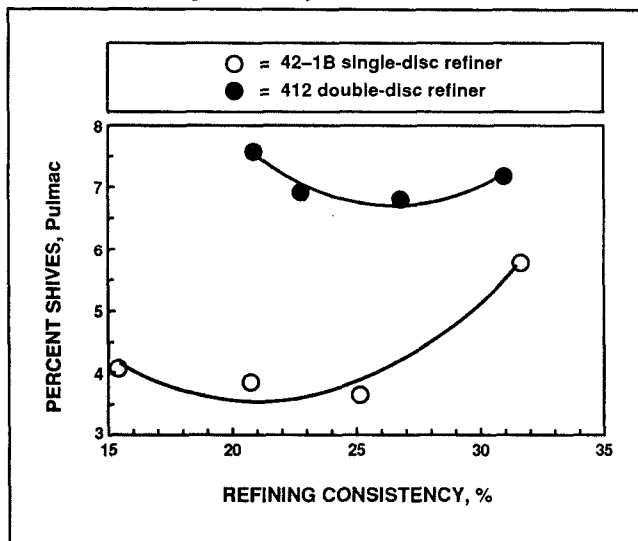
3. Scattering coefficient vs. refining consistency



4. Fines vs. refining consistency



5. Shives vs. refining consistency



Effect on shive level. The single-disc refiner produced lower shives than the double-disc refiner at all consistencies (Fig. 5). At 31% consistency, the shive level for the single-disc was 19% lower. At 21% consistency, the shive level for the single-disc was 53% lower.

Effect on tensile and burst index. The single-disc produced a higher tensile index and higher burst index than the double-disc machine in the 26% to 31% consistency range (Figs. 6 and 7, respectively). At 30% consistency, the tensile index and burst index for the single-disc refiner was 20% and 11% higher, respectively, than the double-disc refiner.

Effect of specific energy on single-disc and double-disc rejects refining

Varying the specific energy from 40 HPD/ODMT to 60 HPD/ODMT resulted in several differences in pulp physical properties between the single-disc and double-disc refiner. Specific energy studies were performed at

optimum refining consistencies for the single-disc and double-disc refiners. The single-disc refiner was operated at 25.6% consistency, and the double-disc refiner was operated at 27.5% consistency.

Effect on tensile index. As specific energy was increased from 40 HPD/ODMT to 60 HPD/ODMT, the tensile index increased for the single-disc refiner. Higher tensile indexes were achieved with the single-disc refiner than with the double-disc refiner at equal specific energies (Fig. 8). The greatest difference was at 60 HPD/ODMT where the tensile index was 29% higher for the single-disc refiner.

The tensile index for the double-disc refiner remained unchanged in the 40–50 HPD/ODMT range. Tensile index increased 37% for the double-disc when the specific energy was increased from 50 HPD/ODMT to 60 HPD/ODMT.

Comparing pulps produced on the single-disc and double-disc refiner at the same freeness level also shows improvement in the tensile index for the single-disc refiner (Fig. 9).

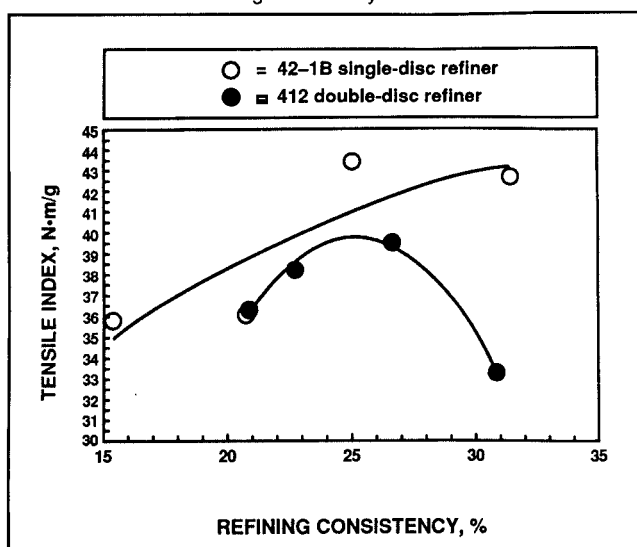
Effect on burst index. The burst index increased for both the single- and double-disc refiners as the specific energy was increased. The single-disc refiner produced pulp with a higher burst index than the double-disc refiner at equal specific energies (Fig. 10). At 60 HPD/ODMT, the burst index for the single-disc refiner was 26% higher.

Effect on tear index. The double-disc refiner produced a 3–18% higher tear index than the single-disc refiner at equal specific energies (Fig. 11). Increasing the specific energy above 40 HPD/ODMT caused a decrease in the tear index on the single-disc machine. On the double-disc refiner, specific energies above 50 HPD/ODMT decreased the tear index.

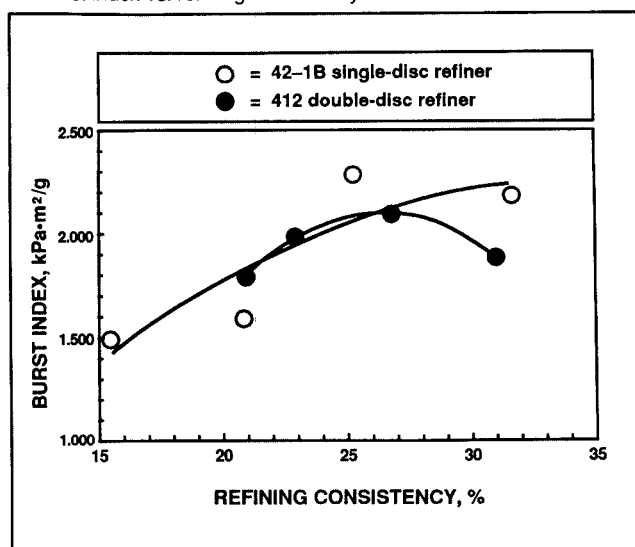
Effect on shive level. The single-disc refiner produced a lower shive level than the double-disc refiner at equal specific energies above 47 HPD/ODMT (Fig. 12). At 60 HPD/ODMT, the shives were 67% lower on the single-disc machine.

Effect on freeness. At specific energies greater than 45 HPD/ODMT, the single-disc refiner produced a lower-freeness pulp than the double-disc refiner at equal specific

6. Tensile index vs. refining consistency



7. Burst index vs. refining consistency



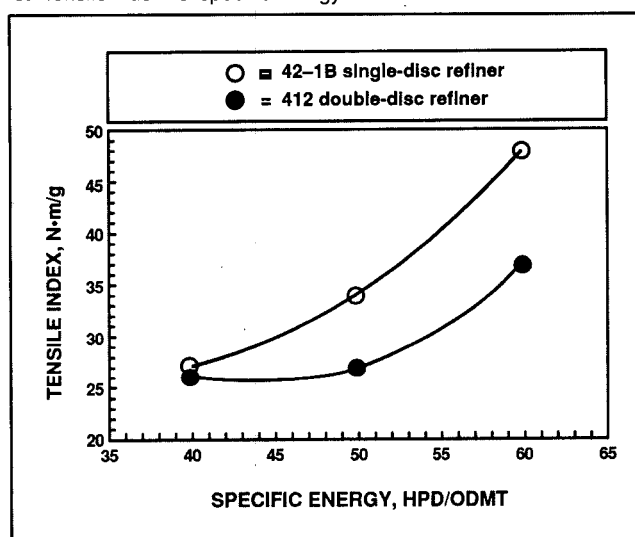
energies (Fig. 13). This explains the higher tensile and burst indexes and lower shive levels achieved with the single-disc refiner. It also is indicative of the increased fiber shortening with the single-disc refiner and, therefore, the improved tear with the double-disc machine.

Conclusions

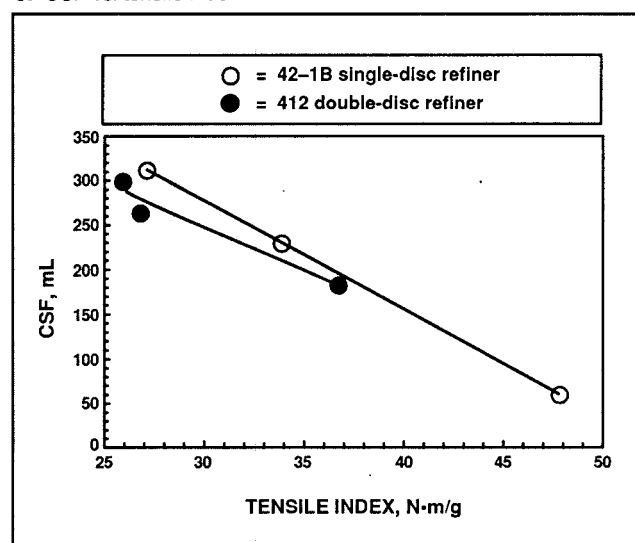
Based on the results of these mill trials, the following conclusions can be made regarding the operational and pulp physical and optical property differences between the single-disc and double-disc refiners:

1. The double-disc produces better tear at equal specific energies.
2. The double-disc retains more long fiber across a wide operating consistency range.
3. The single-disc cuts more if operated at lower than optimum consistency.
4. The single-disc produces higher tensile, burst, and light scattering, and lower shives at the same specific energy.
5. The single-disc refiner is a better machine from the standpoint of optimizing strength and optical properties.
6. The 412 double-disc refiner has an optimum operating consistency of 27%.
7. Increasing the consistency in the double-disc refiner from 25% to 30% will not improve pulp quality.
8. Raising the 42-lb single-disc consistency from 18% to 25-26% will improve pulp properties.
9. Pulp quality can be varied to a greater degree by varying the consistency in the single-disc refiner. □

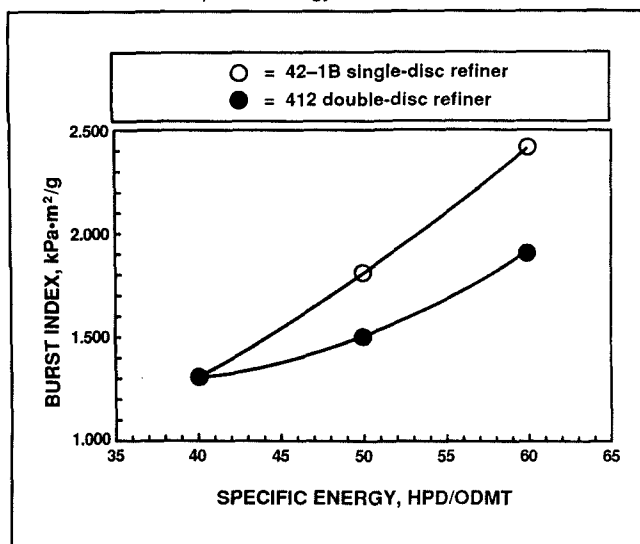
8. Tensile index vs. specific energy



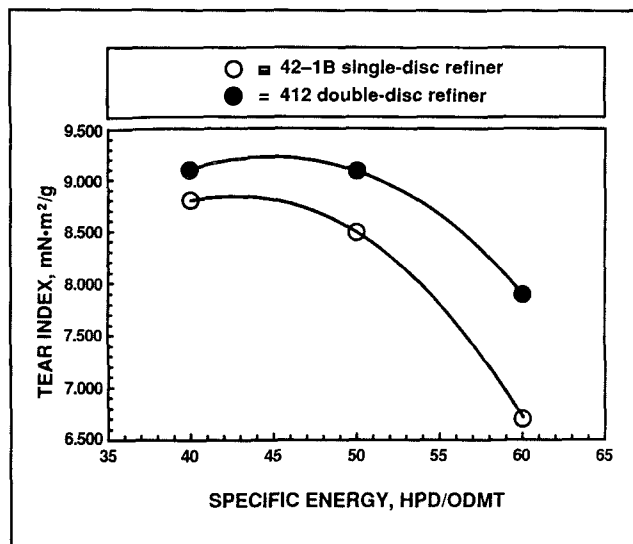
9. CSF vs. tensile index



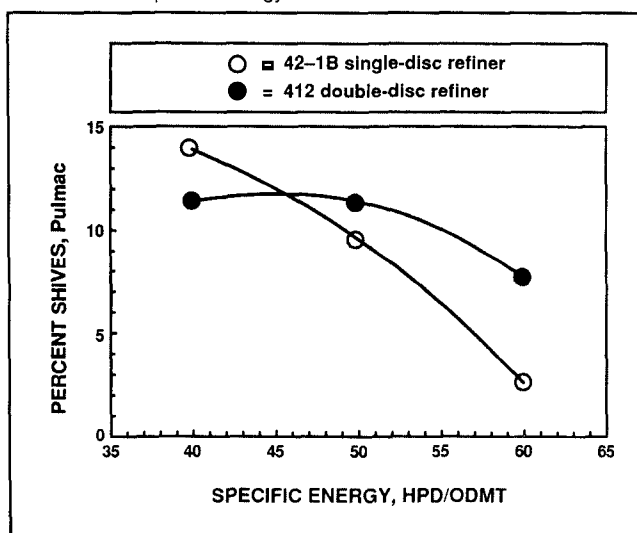
10. Burst index vs. specific energy



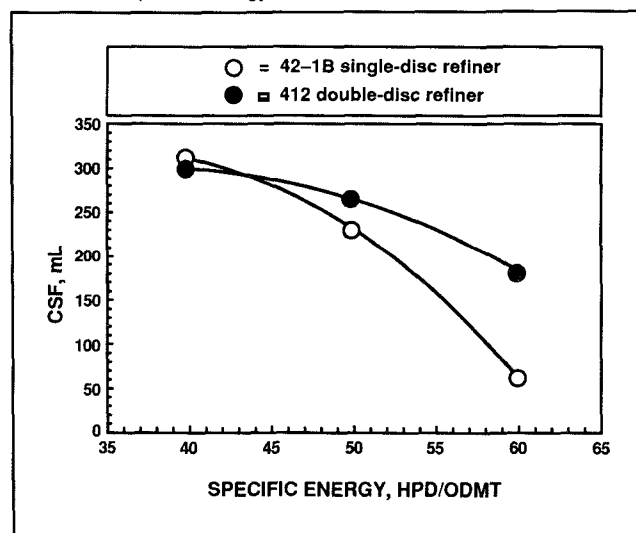
11. Tear index vs. specific energy



12. Shives vs. specific energy



13. CSF vs. specific energy



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