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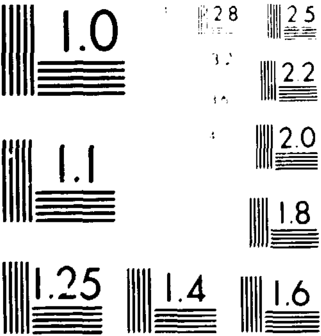

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PRESSURE GRINDING - A NEW MECHANICAL PULPING METHOD *

by

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Why PGW?

The total world capacity today for mechanical pulps is about 30 million tons per year. About two thirds of this amount is still made with stone grinders but groundwood has clearly lost space to refiner pulps during the 70's. Traditionally the price relation between mechanical and chemical pulps has caused a need to reduce the share of chemical pulp in the paper furnish. TMP has created relatively good possibilities for this because of its better strength properties over stone groundwood, even if in some cases the use of TMP might have been limited in different paper and board furnishes due to the lower quality of its printability and optical properties.

The oil crisis we faced in 1973, and the continuously rising energy prices and especially in this regard the price of industrial electricity have, however, narrowed the edge which TMP had over stone groundwood because of its strength properties.

Much work has been done in order to reduce the power consumption of TMP, but it seems that the electric energy consumption of the TMP process cannot be decreased but slightly.

When, however, every effort has been made to bring down or maintain the present paper making costs there yet remains a second alternative: the quality of stone groundwood should be so improved that its share in the final paper can be increased and the amount of chemical pulp can be reduced.

Construction of a PGW Grinder

With this as starting point we began to make trials in 1977 with pressurized grinding and as a result a new PGW grinder was designed.
The cross section of this grinder is shown in Figure No. 1.

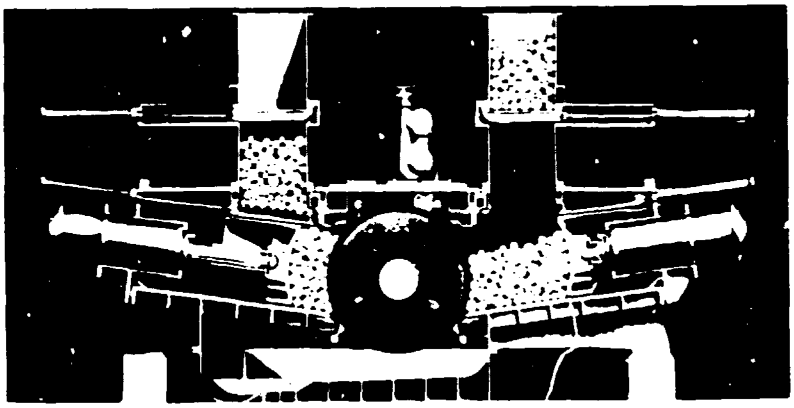

Fig. 1 Tampella PGW grinder

One of the starting points for the design was that the grinder should stand pressures up to 3 bar overpressure and temperatures up to 140°C.

The operation principle of a two-pocket grinder has been maintained and some of the parts used are identical to those in a conventional grinder.

Log batches are dropped from a gate into the pocket and logs are pressed against a grinding stone by a pressure show loaded by a hydraulic cylinder as earlier. Shower pipes and doctoring plow are the same as used in conventional grinders.

From the point of grinder manufacturing, the biggest change was the switch from cast iron over to plate construction in the grinder body. All the stock or steam contacted parts as well as sealing surfaces are of stainless steel.

Stone submergence can be adjusted and grinding with or without pit can also be made with a PGW grinder. Pulp from the grinder is exhausted through outlets at the side of the pit.

Log batches are fed into the grinder through two equalizing chambers which work as a pressure lock. The chamber is sealed with two gates operated by water hydraulic cylinders.

When logs from the equalizing chamber are dropped into the pocket the lower gate will be closed and the pressure from the chamber will be released to the exhaust system. The upper gate can now be opened providing that there is a new log batch waiting.

When the next log batch is in the chamber, the upper gate will be closed and the chamber will be pressurized. When the same pressure has been reached which is inside the grinder, the logs are ready to be taken into the pocket controlled by the automatic pocket charging system.

For wood feeding to the upper gate similar systems can be used which are in operation also today.

PGW Testing Facilities

The first new pressure grinder was taken into operation in May 1979 at Bure. That is slightly more than one year from the moment when all the results from the early trials had been analysed.

The second machine was started up at the end of July same year at Tampella's own Anjala paper mill.

Both grinders are full size units, the former using 1,2 m logs and the latter 1,0 m logs.

The Anjala installation is set for research and development purposes, and therefore the grinder is equipped with a more sophisticated instrumentation than is customary in a production unit, and there is also a computer.

The computer is normally used to follow a trial with calculated one minute and 15 minute averages. After a trial, average values and deviations can be computed for a trial period, and when we have wider material, also correlation and regression analyses as well as parametric variations can be prepared. A CRT-terminal, printer and plotter are used for reporting and print-outs.

Additionally, laboratory results are fed to and printed out from the computer.

Another purpose of the computer is that at a later stage it will be used to control the pressure grinder and the PGW process.

We have a separate crew to operate the grinder at Anjala so that the research and trial work which is done at daytime will not disturb the normal operation of the mill. There is also a separate wet laboratory, so samples can be taken in ample amounts and results rapidly analysed.

FGW Process

The actual pressure grinding process differs somewhat from the conventional grinding process under atmospheric pressure.

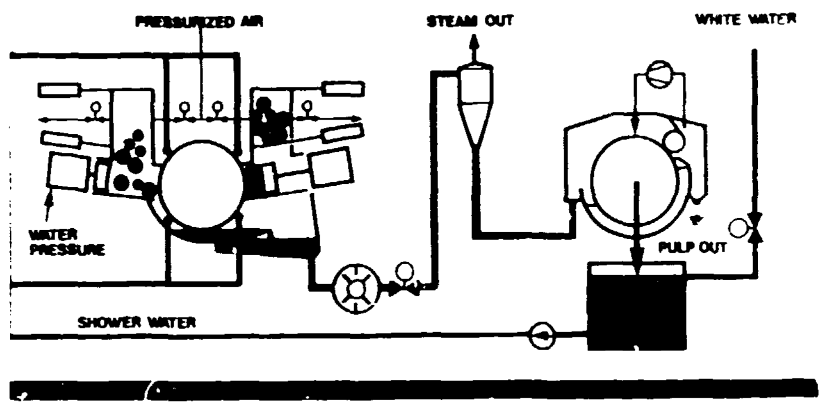

Fig. 2 Tampella PGW Process

The pressure grinding process starts with the afore described grinder, from where the pulp is led under pressure through a large diameter pipe down to a shredder, normally located in the basement. This shredder has been developed from a conventional hammer mill type shredder used for bull screen rejects to work under pressure. Its purpose is to disintergrate the slivers and sticks coming from the grinder to avoid plugging risks in the process.

The pressure relief occurs before the cyclone in the control valve which keeps the level constant in the pipeline before the shredder. The flash steam escaping from the hot pulp will be separated in the cyclone.

After this, the pulp under atmospheric pressure is led to thickening where outgoing consistency will reach 10...15 %. Thus most of the hot water can be recovered and circulated directly back to grinder showers.

The thickener itself is of drum type but instead of vacuum it works with a small overpressure outside the drum achieved by means of a fan.

The outgoing pulp from the thickener will be diluted to a screening consistency with the mill white water and the same water will also be used as the make-up water for the showers.

Operation Experiences

The pressure grinders now in operation have proven to be reliable and they have been surprisingly easy in their operation.

When we started to design a new pressure grinder, we paid special attention to following points:

- sealing of the gates
- exhaust of pulp and slivers from the grinder
- log jams in the pocket

Continuos operation in the mills has shown that the anticipated points have created no problems whatsoever.

The pressure control of the grinder and the pulp exhaust have worked as expected. In no stage have we found any plugging in the machinery or pipelines. Neither have we found any gathering of slivers or sticks in the rginder pit.

Log jams have been rare and their elimination has succeeded as planned. Not even once has there been need to release the pressure from the grinder to clear a log jam in the pocket.

The pressurization of the grinder has been measured to consume 20 m^3 of air per pulp ton produced. If the compressed air is taken from the normal mill supply net of 6...7 bar, this will mean energy consumption of less than 20 kWh/ton.

The stone sharpening requires that pressure be released from the grinder, but practice has shown that this takes only some minutes more than with a conventional grinder. We have not observed any noticeable difference in stone sharpening intervals between pressure and atmosperic grinding.

Heat Balance

In grinding the major part of the electrical power of the motor is converted into heat which escapes with the hot pulp diluted with the shower water. In conventional grinding the heat content of the pulp is lost on open grinders and chests as steam flashing and radiation losses. Pressure grinding, however, offers a new alternative for heat recovery in the form of flash steam due to a short, close circulation.

Table No. 1 shows a theoretical calculation of the amount of electrical energy that can be recovered as heat energy.

CSF 100 ml
Specific energy 1200 kWh/t AD
Production 100 t/d AD
Motor load 5,2 MW

Shower water temperature (°C) (°F)	Pulp consistency (%)	Pulp temperature (°C)	Exhaust steam (kg/s)	Steam energy (MW)	Steam energy (%)
80 (176)	1,8	95	-	-	-
92 (198)	1,8	107	0,82	1,85	35
96 (205)	1,8	111	1,24	2,80	54
96 (205)	2,5	117	1,38	3,12	60

Table No. 1

For example, when producing Finnish news grade pulp, over 50 % of the energy consumed can be recovered when the shower water temperature is 96°C and the pit consistency 1,8 %.

PGW Results

The grinder pressurization and high shower water temperature clearly increase the long fiber content of the pulp (Fig. 3).

Consequently, pulp strengths are improved and, for example, the initial wet strength (Fig. 4) is increased 40...50 %.

Tear strength (Fig. 5) will be improved 40...60 % and tensile strength (Fig. 6) 10...30 % when going from conventional groundwood to pressure groundwood.

It is very interesting and also in greatest degree of economical importance to notice that the improved strength characteristics of PGW are not reached with the cost of higher power consumption. Test results (Fig. 7) show that no difference between atmospheric groundwood and PGW can be districted and the big gap of 50...100 % to disc refining remains.

One of the big advantages of groundwood has always been the good optical properties in the paper sheet and PGW can keep, for example, the high light scattering (Fig. 8).

Pulp brightness (Fig. 9) will slightly drop with rising pulp temperature as expected. However, if brightness would be a critical factor, it can be favourably affected by selecting proper process conditions.

In the connection og TMP we are used to think that high long fiber content would automatically mean poor surface smoothness. This is not the case with PGW. In spite of more long fibers PGW can still improve the smoothness of groundwood (Fig. 10).

The explanation must be in the better fibrillation of PGW and this fact has also been confirmed by photomicroscopy. Better fibrillation should also reduce the tendency, for example, for linting.

Different Wood Species

Major part of the Anjala trials is done with Finnish spruce but we have also made some trials with wood sent by customers.Table No. 2 shows some pine species in comparison to Anjala's normal spruce groundwood.

		SGW 1	PGW 1	PGW 2	SGW 2	PGW 3
CSF	ml	100	101	86	96	98
+ 28	%	22	35	33	36	48
+ 200	%	40	32	37	30	22
- 200	%	38	33	30	34	30
Wet strength	N/m	80	71		78	115
Wet stretch	%	4,8	4,4		4,3	4,6
Stretch	%	2,2	2,0		2,3	2,8
Tensile index	Nm/g	25	23,9	25,1	[illegible]	30,4
Tear index	mNm^2/g	3,3	3,9	4,08	4,1	5,4
Burst index	$kPam^2/g$	1,0	1,2	1,12	1,0	1,4
Light scattering	m^2/kg	69	63,6	66,7	62,7	60,9
Density	kg/m^2	370	337	331	329	310
Brightness	%	62	62,6	59,3	64,6	60

WOOD	SGW 1	Spruce from Anjala
	PGW 1	Finnish pine
	PGW 2	German pine
	SGW 2	Radiata pine
	PGW 3	Radiata pine
TESTING	Scan at Anjala	

Table No. 2

Some pine species compared to Anjala's spruce groundwood

Finnish pine is not normally used for grinding, at least not more than small amounts blended to spruce logs. The reason for this has simply been the fact that pine gives considerably lower strength properties.

However, the second column in this table shows that pressure groundwood clearly improves the properties of pine and tear strength is even better than with spruce groundwood.

The afore mentioned also applies to German pine in third column.

We have also had some Radiata pine and table gives the results when the grinder at Anjala has been run without and with pressure. Finnish spruce groundwood is normally considered very good pulp for paper making but according to test results, Radiata groundwood has clearly better tear strength.

Table No. 3 contains some results gathered from Southern Pine.

		SGW1	SGW2	SGW3	PGW	TMP
CSF	ml	100	43	[illegible]	[illegible]	91
r 28	%	22	12,8	16	26,2	40,6
r 200	%	40	42,8	46,7	38,2	29,1
-200	%	38	44,3	38,3	36,6	30,1
Wet strenght	N/m	80	41,8	42	68,4	106,8
Wet stretch	%	4,8	5,1	3,3	8,1	6,6
Stretch	%	2,2	1,9	2,3	2,6	2,8
Tensile index	Nm/g	26	16,4	18,5	20,6	21,6
Tear index	mNm²/g	3,3	2,1	1,9	3,3	5,0
Burst index	kPam²/g	1,0	0,42	0,5	0,96	0,89
Light scattering	m²/kg	69	64,7	66,7	66,9	44,2
Density	kg/m³	370	380	348	327	311
Brightness	%	62		54,8	56,1	
Bond	J/m²	170	193	171	186	102

WOOD	SGW 1	Spruce at Anjala
	SGW 2	Southern pine in USA
	SGW 3	Southern pine at Anjala
	PGW	Southern pine at Anjala
	TMP	Southern pine at Anjala USA
TESTING	Scan at Anjala	

Table No. 3
Different Southern Pine pulps

As known Southern or Loblolly pine make rather poor groundwood but pressurized grinding seems to improve its properties considerably and according to the trials, it is possible to reach the same strength as with Finnish spruce.

Paper Machine Trials

The good strength and optical properties of the pulp are, of course, as such interesting and give an indication as to what quality of final paper can be obtained with the pulp. However, the quality and potential of a pulp will be finally determined on a paper machine in production circumstances.

For example, we have delivered 90 tons of pine pressure groundwood to a paper maker in Finland. The trial lasted 5 hrs and it started when the machine was running 880 m/min and making 48,8 g/m^2 newsprint paper. The normal spruce groundwood was changed to pine pressure groundwood and broke dosage was stopped.

During the trial the basis weight was lowered to 45 g/m^2 and the chemical pulp content was reduced from the original 20 % to 16...17 %.

The purpose of the trila was to study the suitability of Finnish pine for paper making. Table No. 4 proves that high quality paper can be made with pine and additionally the chemical content can be reduced.

SCANDINAVIAN NEWSPRINT

			48,8 g/m^2		45 g/m^2	
			PGW Trial	Standard	PGW Trial	Standard
Bulk		cm^3/g	1,55	1,5...1,6	1,60	1,5...1,6
Tear		mNm^2/g	5,05	4,4	4,63	4,6
Tensile		Nm/g	35,6	30...35	35,1	30...35
Smoothness	ts	ml/min	75	85...105	95	85...105
	ws	ml/min	88	95...115	104	95...115
Porosity		ml/min	373	400...500	395	400...500
Water abs.	ts	s	3,6	5...10	3,8	5...10
	ws	s	3,0	5...10	3,5	5...10
Oil abs.	ts	g/m^2	21,0	18...22	17,8	18...22
	ws	g/m^2	23,3	22...26	22,3	22...26
Opacity		%	92,9	93...94	92,0	92...93
Luminance	ts	%	66,8	64...65	67,3	64...65
	ws		66,7	63...64	67,4	63...64

WOOD — PGW: Finnish pine; Standard: Finnish spruce

TESTING — Scan

Table No. 4

Results of a pine PGW trial

Here again we can note that even if pressure groundwood contains more long fibers and gives somewhat bulkier sheet, paper is, however, somewhat less porous and has better smoothness than reference paper containing normal groundwood.

The printing of the trial paper was done normally without difficulties in 4 different offset printing houses.

Economics

As PGW has now entered the field of competition it is certainly interesting to compare PGW to SGW and TMP in manufacturing costs.
It is fully understood that each particular mill case shall be studied and calculated on the basis of its own specific conditions.

Nevertheless, to get a general idea, models of new mechanical pulping plants for newsprint are compared. The assumed mill capacity is 160000 tons/year. The location is in the Nordic countries and raw material is spruce.

The summary of the calculations corresponding to the situation in mid 1980 is shown in Table No. 5

Table No. 5

		PGW		GW		TMP	
A. Mechanical pulping			US $/t		US $/t		US $/t
Energy consumption	MWh/ton	1450		1400		2265	
Energy cost $ 40	US $/MWh		58		56		90
Energy recovery,	ton steam/ton pulp	1.0		-		2.3	
Energy recovery, $ 5	US $/ton steam		- 5		-		- 11
Wood cost	US $/ton pulp		100		100		100
Operation costs	US $/ton pulp		51		51		53
Capital costs (18 % annuity)	US $/ton		24		20		21
Total	US $/ton pulp		228		227		253
B. Paper blend							
Share of chemical pulp	%	10		18		7	
Chem. pulp cost $ 530	US $/ton		53		95		37
Mechanical pulp cost							
PGW	0.9 x 228		205				
GW	0.82 x 227				186		
TMP	0.93 x 253						235
Total	US $/ton paper		258		281		272

Comparison of economy of PGW, SGW and TMP in newsprint paper

PGW gives clearly the cheapest paper furnish and groundwood paper is most expensive with assumed chemical pulp contents.

Unfortunately the relative price of electricity is expected only to rise in the future. If we assume an increase of 30 % for power, Fig. No. 11 shows the change in furnish costs.

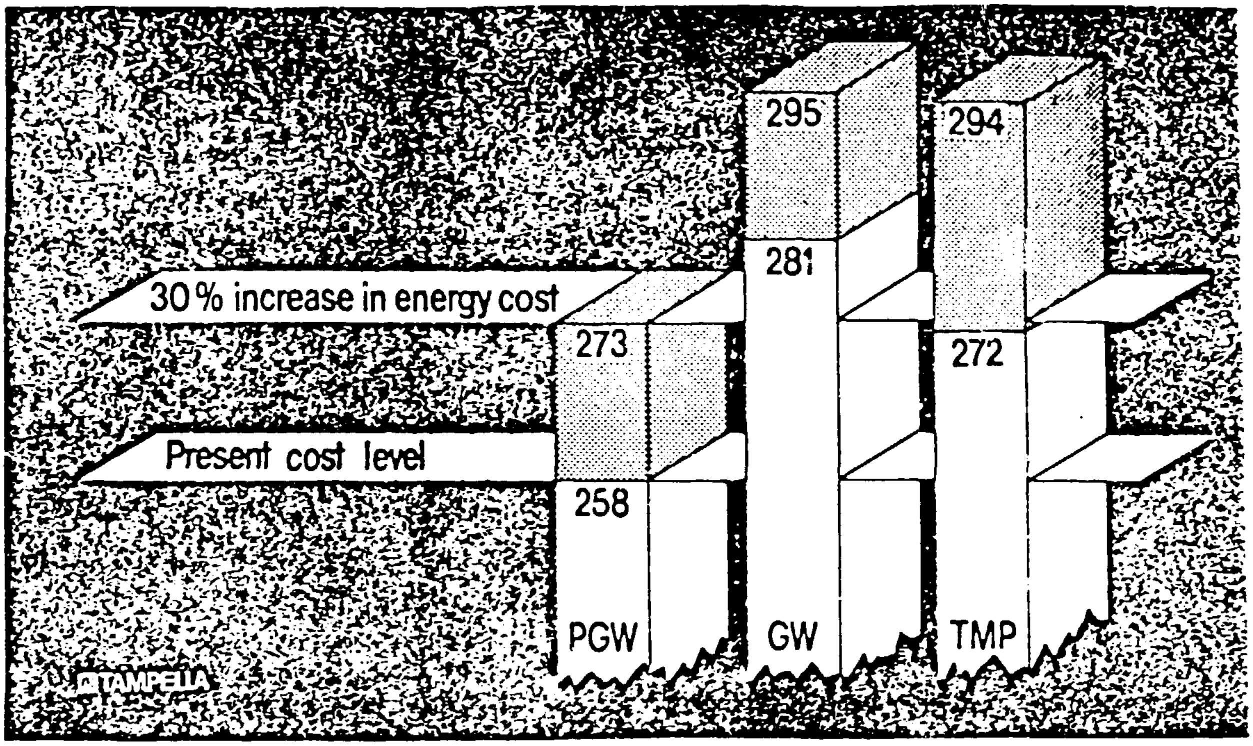

Fig. No. 11
Total paper furnish costs with increased energy prices

The figure confirms that PGW stays very competitive indeed but the difference between groundwood and TMP will diminish with increased energy prices.

References

Pressure groundwood has really expanded very rapidly and today following mills have ordered PGW installations:

Company	No. of grinders	Capacity TPD	Grade
MoDoCell Bure	1	50	Market pulp
Tampella Anjala	1	50	Pilot plant
Myllykoski	2	100	SC-magazine
Holtzmann Maxau	6	320	Newsprint
Kaukas	2	150	LWC
Madison	4	280	SC-magazine
Kajaani	4	360	Newsprint
Tampella Anjala	10	1100	Newsprint
Tampella Anjala	2	230	Folding box board

Totally the grinders listed here represent a yearly production of almost 1 million tons.

The first three plants mentioned are already in operation. Anjala and Bure grinders were started-up in summer 1979. Myllykoski was the first real commercial installation and it has been in operation since end of June 1980.

Summary

As a summary we can say that Pressure Groundwood gives totally new possibilities for paper making. PGW has good optical and printing properties of stone groundwood and it can thus be used for high grade printing papers.

On the other hand, its improved pulp strength enables a reduction in the chemical pulp content and we can use cheaper paper furnish and save in overall costs.

Lower power consumption in comparison to disc refining process means that PGW is less sensitive for likely rises in the electricity price and that it is better adjusted for the modern energy conscious world.

PGW seems to combine successfully the good sides of conventional stone groundwood and TMP.

Full scale trials on paper machines have confirmed that expected chemical pulp savings can be realized and that the produced paper is of high quality.

The units in operation have shown that the machinery works reliably and that the governing and controlling of the process is not essentially more difficult than a normal stone groundwood process.

The disc refining process was readily accepted and the installed capacity grew rapidly during the 70's. Now the response for PGW from paper makers all around the world and received orders hint that PGW could even have a faster pace of expansion. The future for PGW looks very bright indeed.

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LONG FIBRE FRACTION VS. CSF THROUGH A SHARPENING CYCLE

BASIC SERIES 2

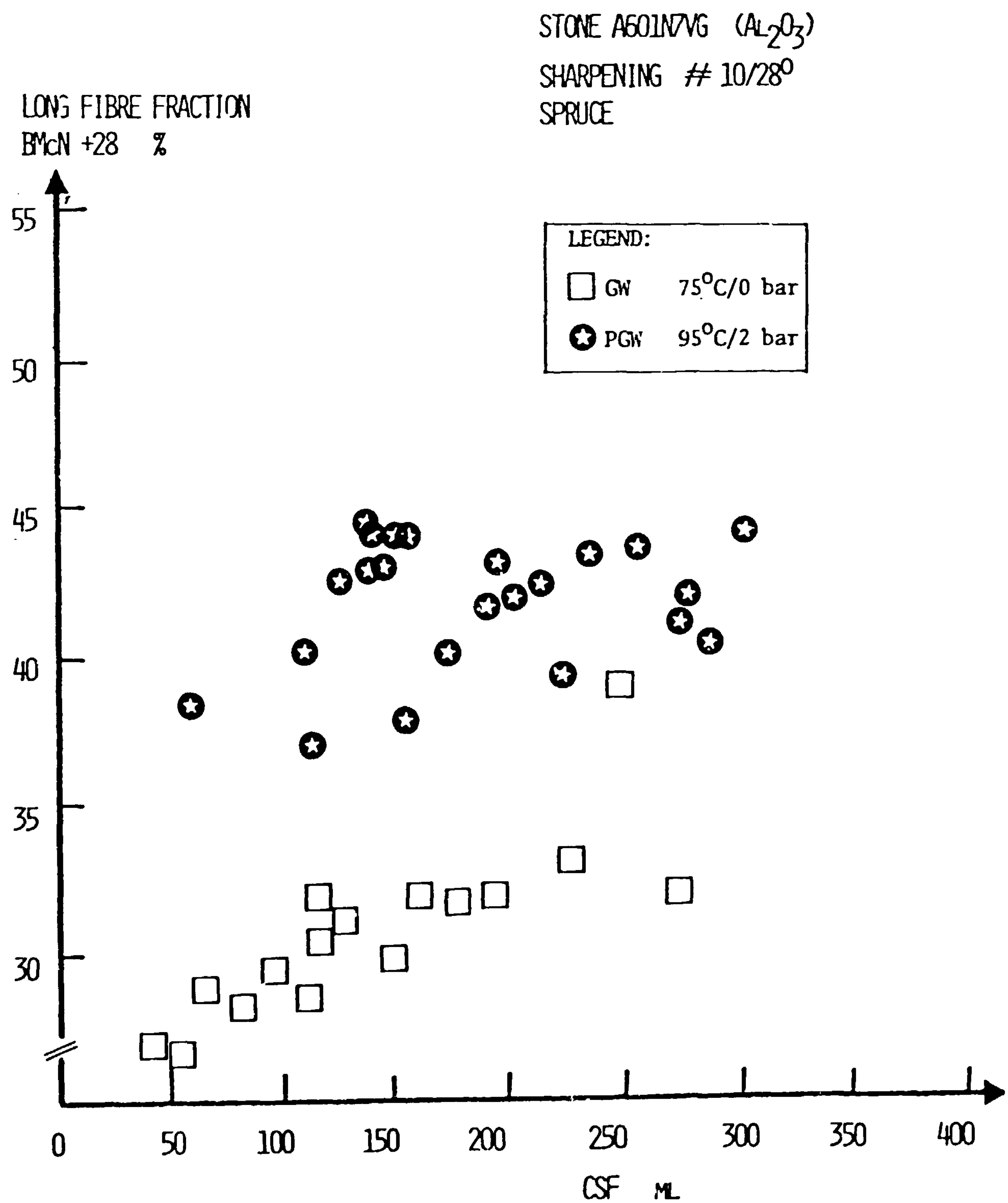

Figure 3

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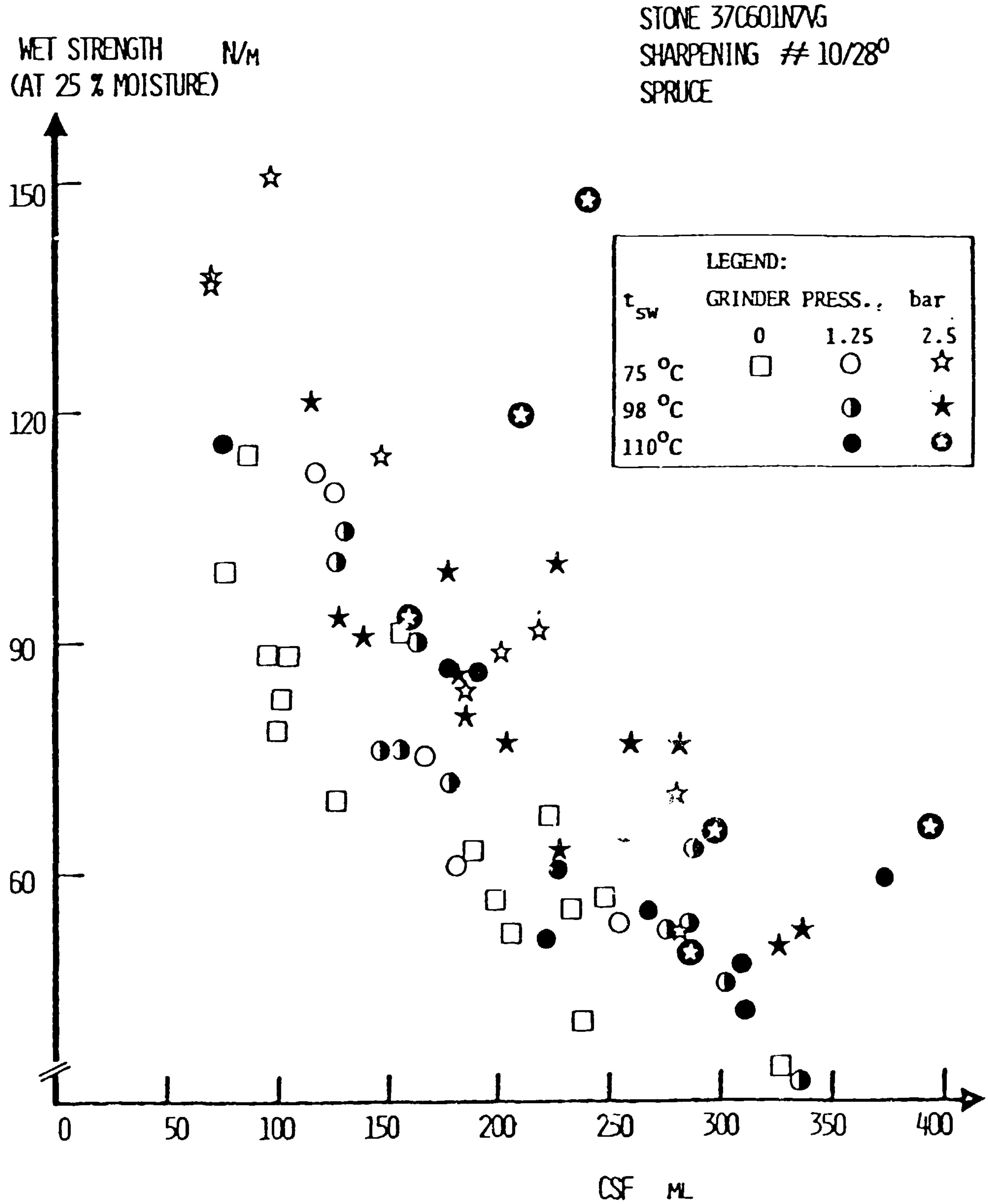

Figure 4 Initial wet strength vs. CSF

TEAR INDEX VS. CSF THROUGH A SHARPENING CYCLE

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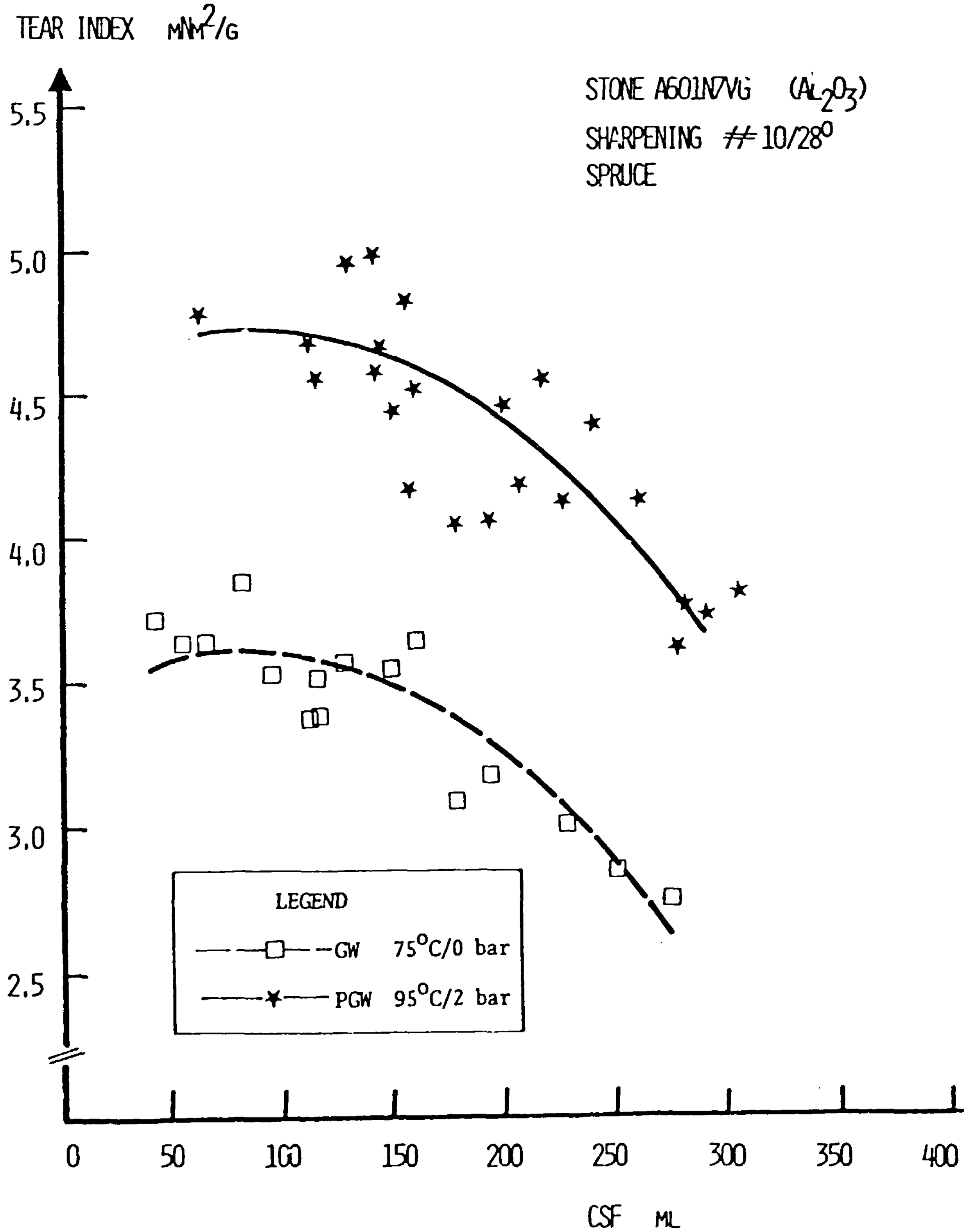

Figure 5

TENSILE INDEX VS. CSF THROUGH A SHARPENING CYCLE

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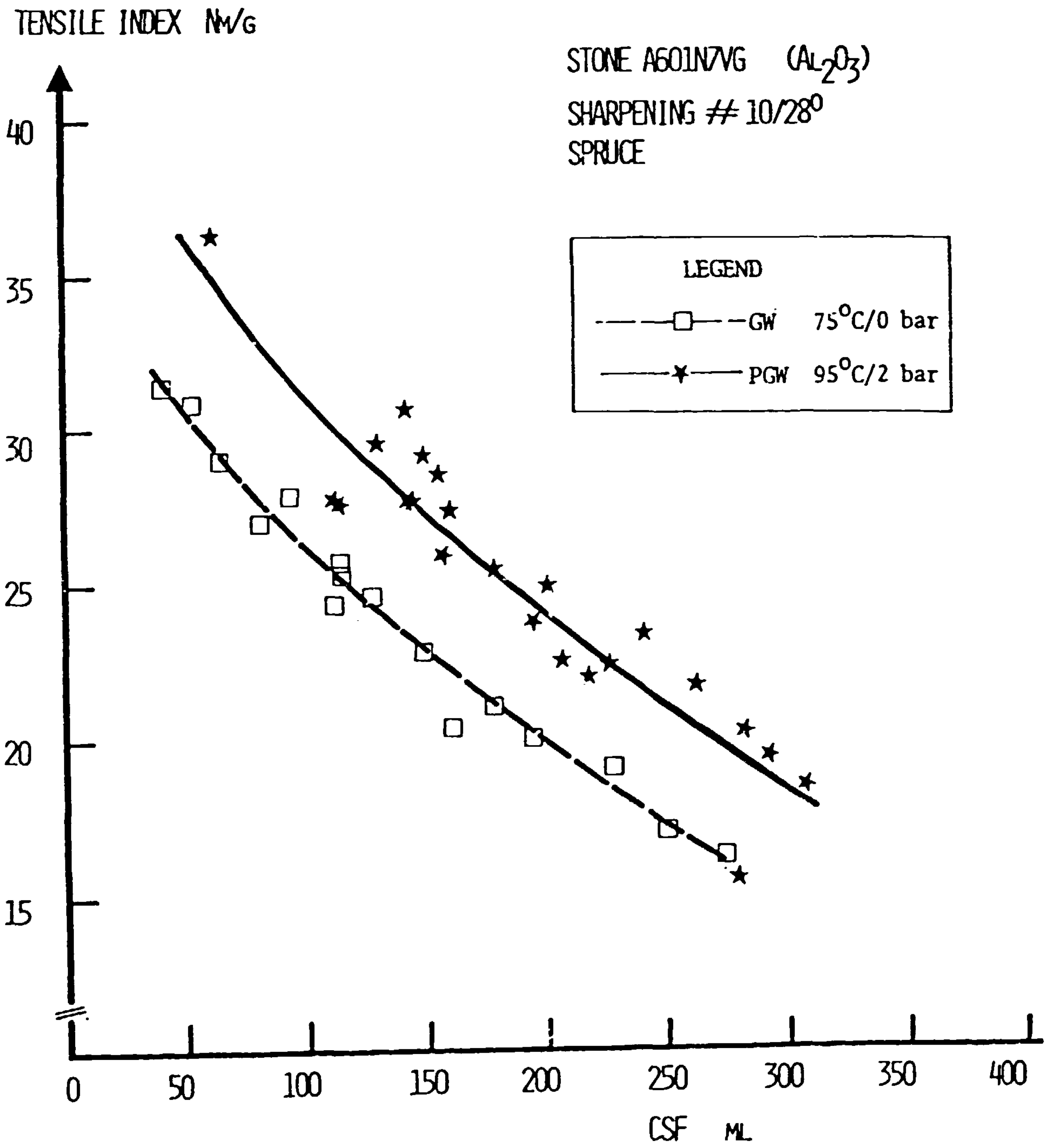

Figure 6

CSF VS. POWER CONSUMPTION THROUGH A SHARPENING CYCLE

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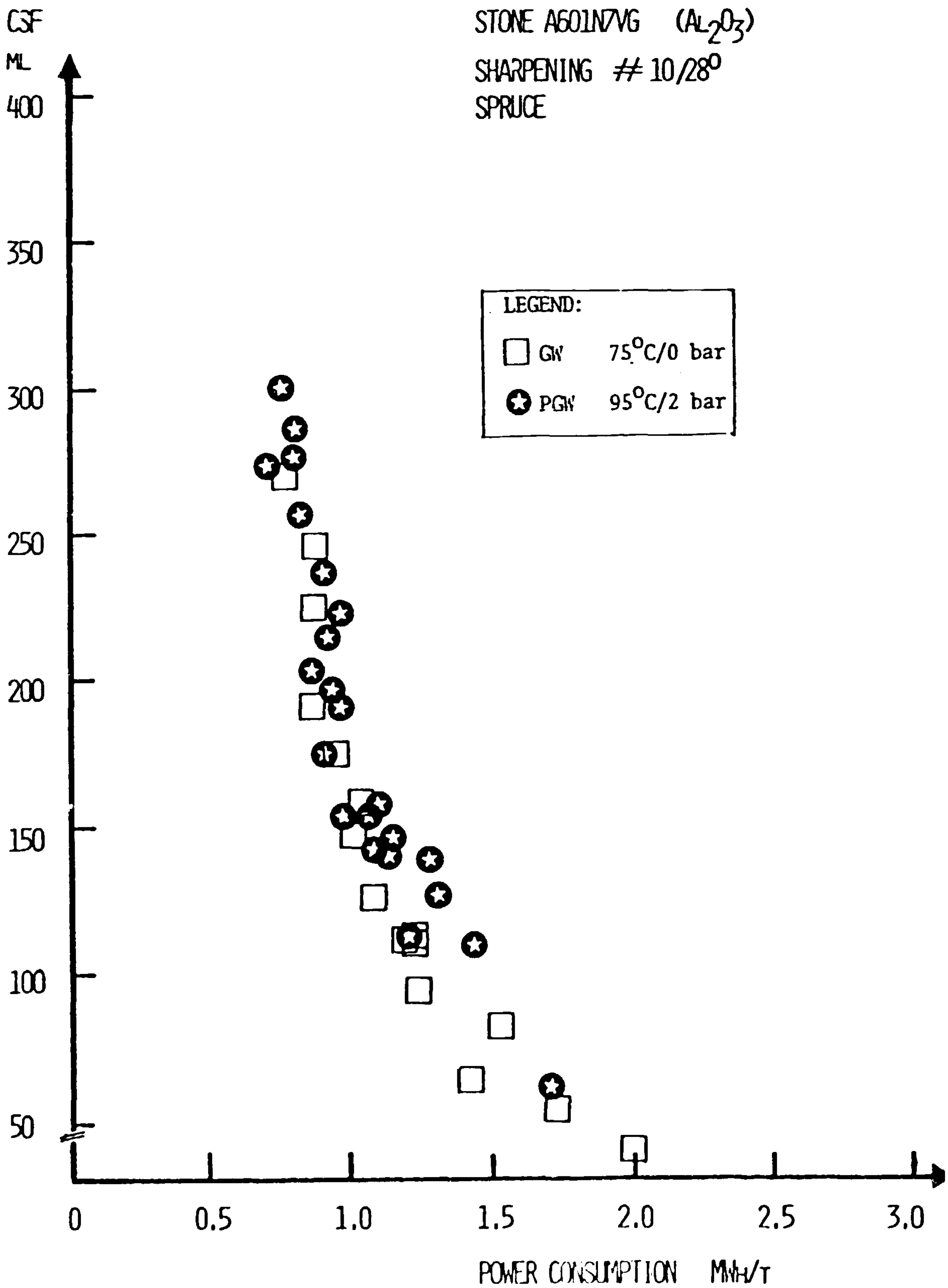

Figure 7

SCATTERING COEFFICIENT VS. CSF
THROUGH A SHARPENING CYCLE

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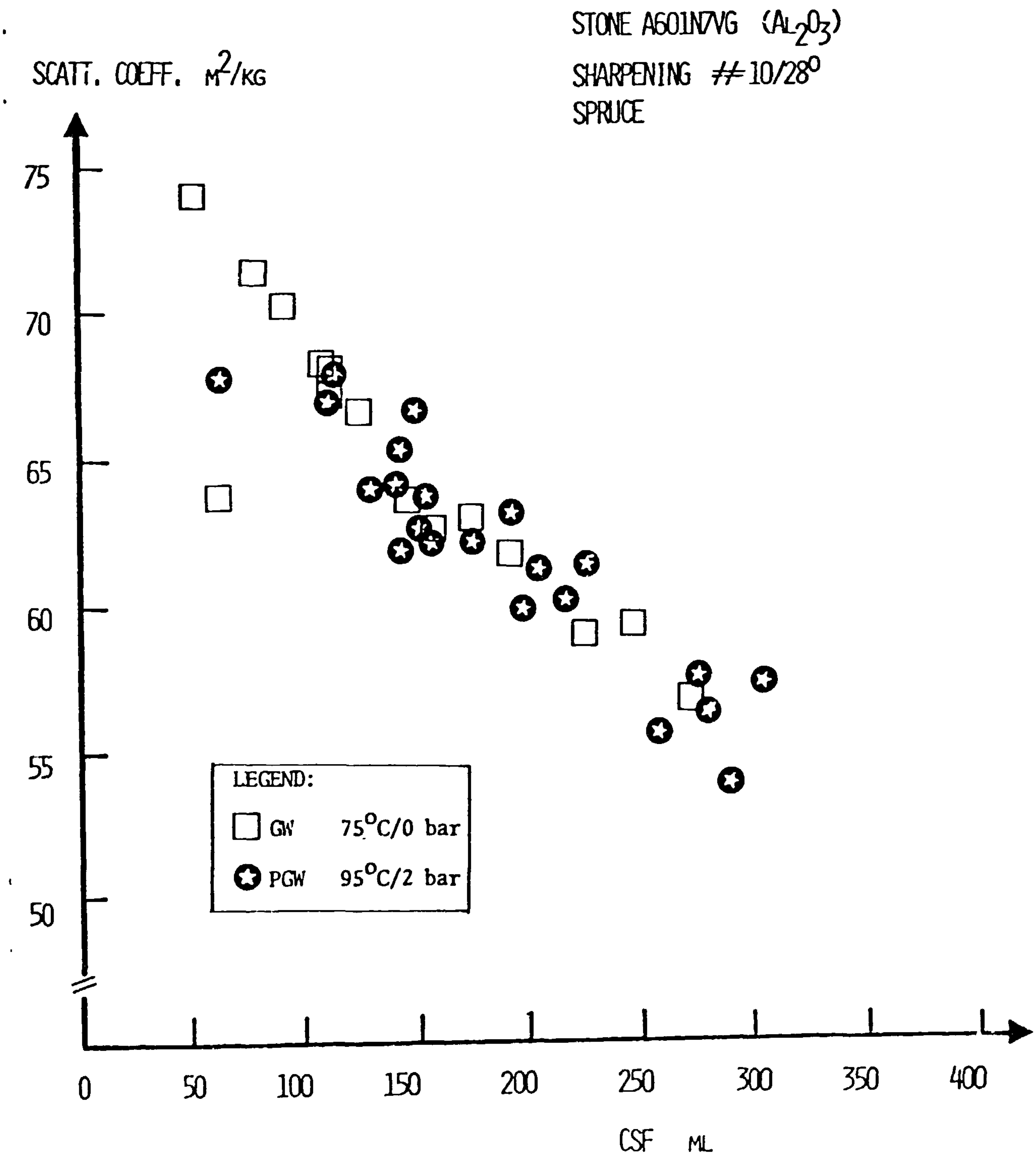

Figure 8

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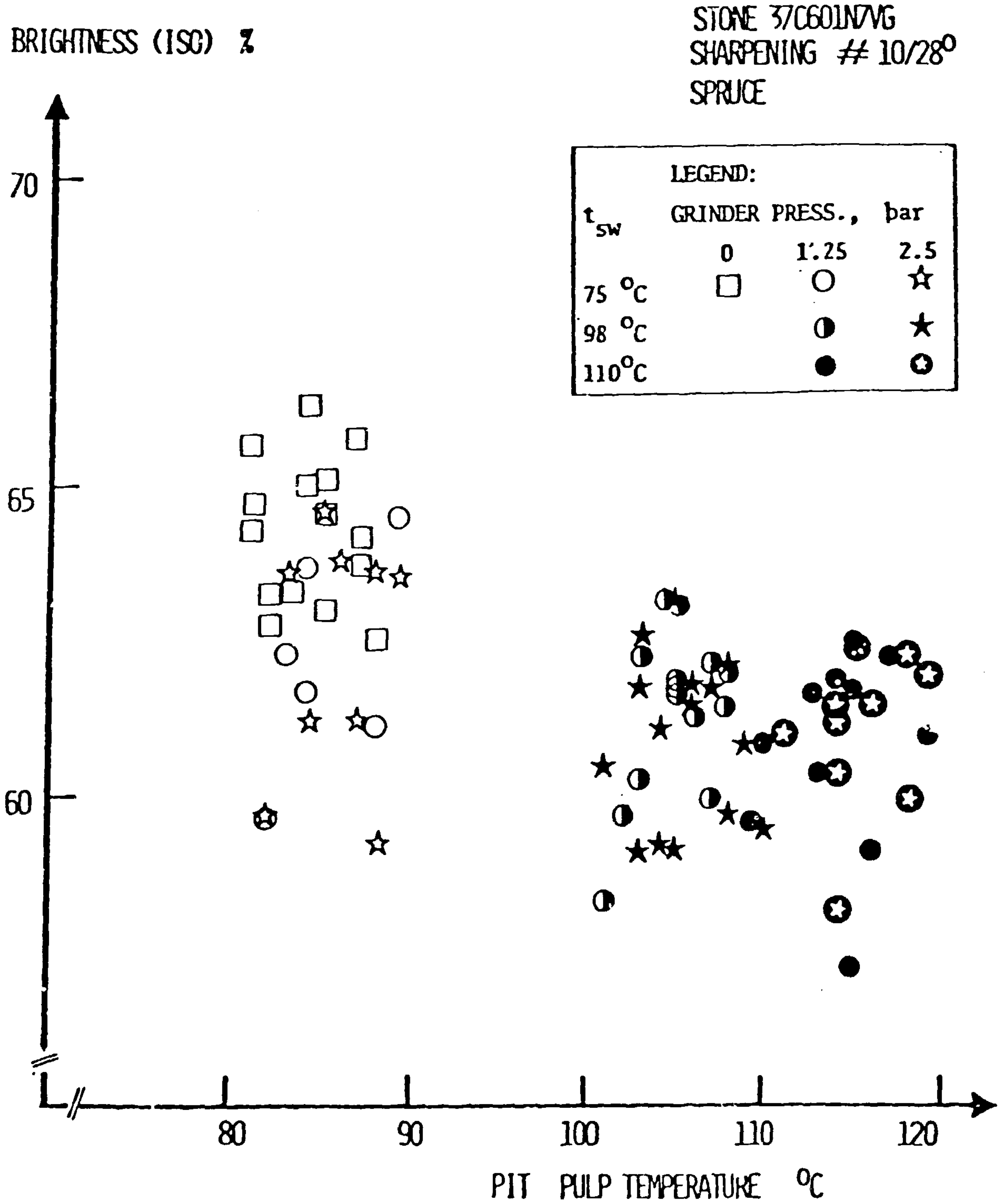

Figure 9 : Brightness vs. pit pulp temperature

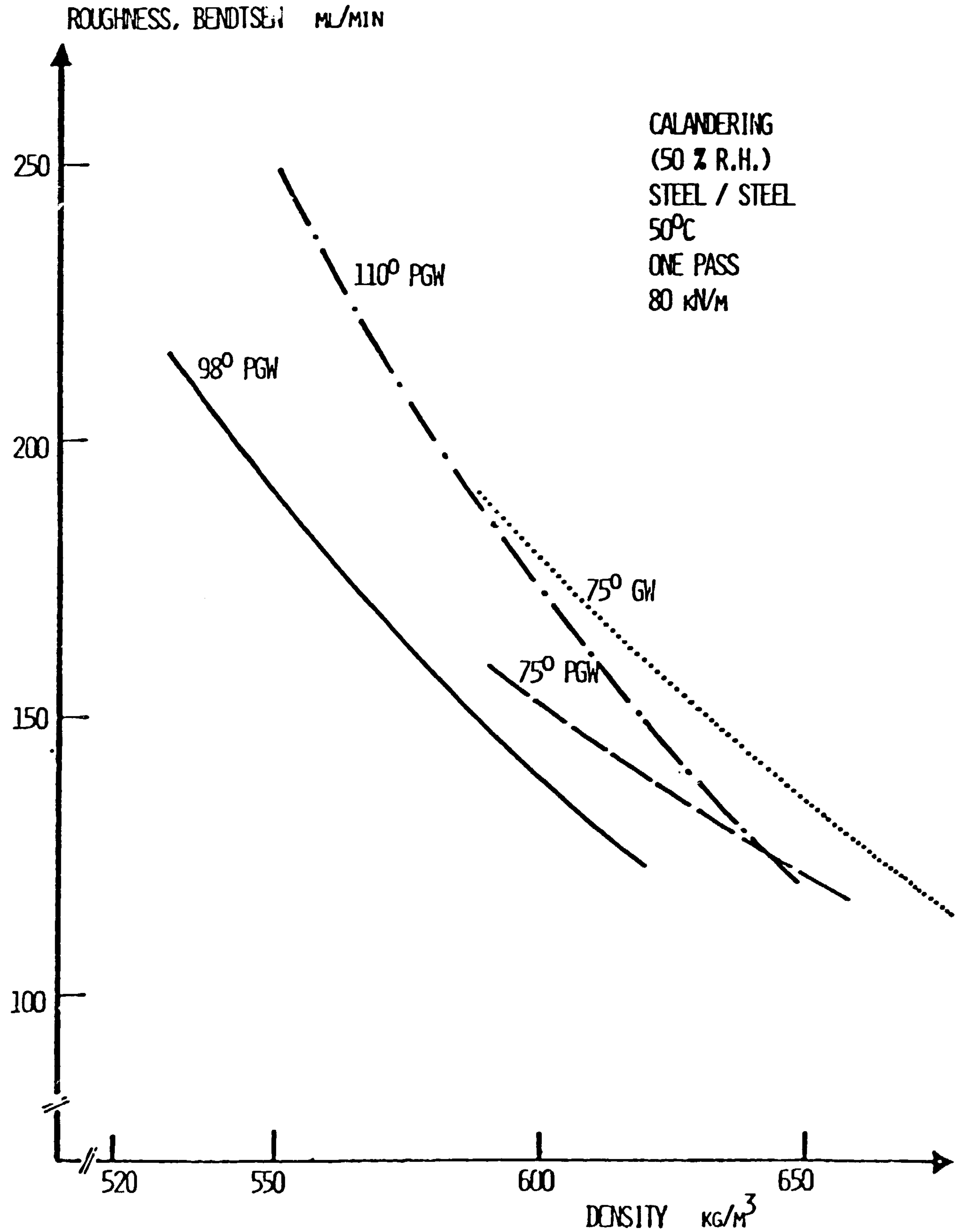

Figure 10: Roughness vs. density of calandered sheets