Predesolventizing of Soybean Meal

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ABSTRACT

Predesolventizing of meal provides opportunities for potential savings in the extraction operation. The reduction of the moisture level in meal can save considerable energy during the meal drying operation. Ways to reduce the hexane content before drying include: (a) changing seed preparation; (b) increasing drainage time; (c) mechanical pressing; (d) evaporating by indirect heating; (e) circulating metallic heat transferring units; and (f) using new technology. These options are evaluated in terms of economics and operating efficiencies.

PREDESOLVENTIZING OF SOYBEAN MEAL

Predesolventizing means removal of solvent from the extracted meal by means other than direct steam condensation, and it is regarded as a potential source for energy conservation. Of course, such a procedure will have different impacts on the energy involved, depending on the type of seed being treated.

This paper only deals with predesolventizing of soybean meal and its aim is to analyze the technical and economical advantages which can be offered by a predesolventizing system incorporated into a conventional soybean plant and to demonstrate the limits for predesolventizing defined by other parameters to be respected in a normal soybean extraction operation.

For comparison purposes, all the following technical and economical considerations are related to a 600 ton/day continuous soybean plant running 300 days per year and having a multistage desolventizer/toaster (DT) with a relatively meager heat exchange surface followed by a meal drying step using hot air and a meal cooler to achieve 12% moisture and 30 C in the finished meal.

Technical and Economic Considerations

The steam requirement (Fig. 1) to accomplish the whole operation of desolventizing/toasting and drying shows an increase in steam consumption as a function of the soybean flake moisture and the solvent retention in the extracted meal.

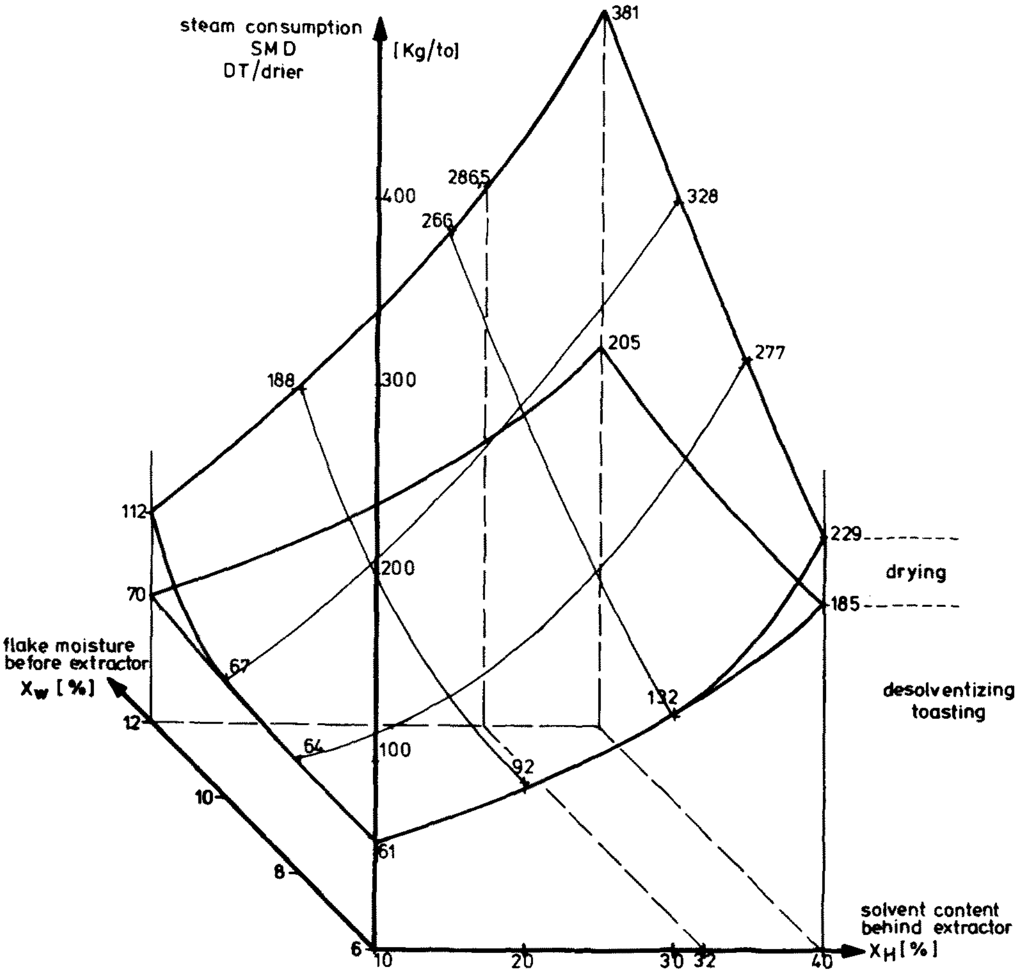


FIG. 1. Steam consumption DT/meal drier.

Figure 2 shows the variation in the meal moisture when leaving the DT as a function of flake moisture and solvent retention in the meal. It also shows the lower limit of 18% for the meal moisture after DT dictated by the necessity of reducing urease activity and antithrypsin factor to acceptable levels, in accordance with the industrial practice.

Besides the limit prescribed by the urease activity and antithrypsin factor, the heat recovery of DT vapors practised in the first miscella distillation step of a normal extraction plant also limits the application of predesolventizing systems.

Starting from a rich miscella concentration of 30% after extraction, a concentration of ca. 75% is normally expected after the first column of the distillation plant.

As DT vapors of ca. 72C have a higher enthalpy, due to entrained steam, than pure solvent vapors generated in a meal predesolventizing system, a certain limit must be defined for predesolventizing. Otherwise, additional steam would be required for the distillation plant.

These two pertinent limits are shown in Figure 3. From the view of sufficient moisture level in the meal, the area on the right side of the line (a) is available for predesolventizing procedures. Down to line (b), theoretically a mechanical predesolventizing would be feasible without influencing

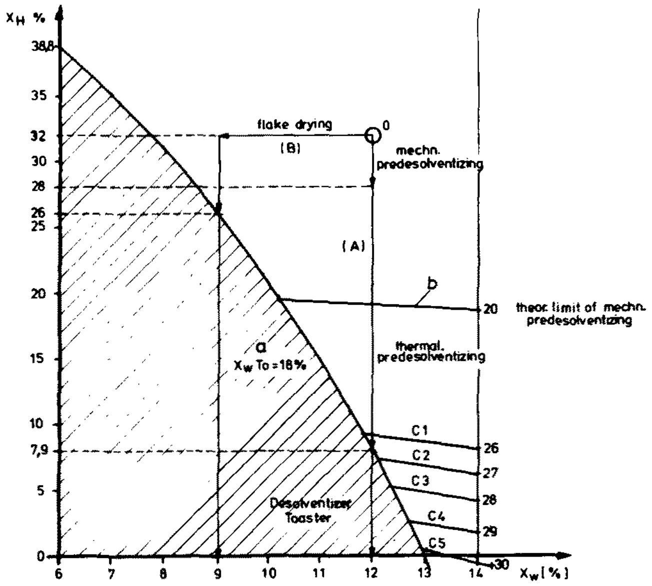


FIG. 3. The area of predesolventizing.

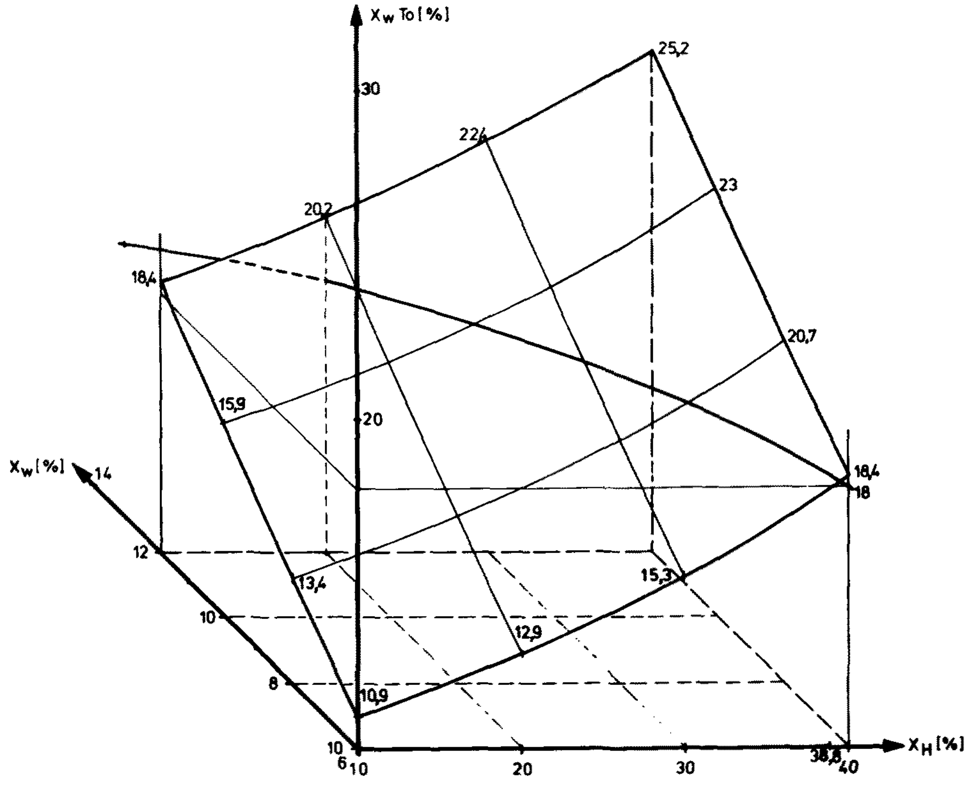


FIG. 2. Meal moisture after DT.

the heat requirements of the distillation. And down to line (c_1 - c_5), a thermal predesolventizing can be envisaged without disturbing the miscella distillation.

Figure 3 demonstrates that at point O, defined by 12% flake moisture and 32% solvent retention, there are 2 possible extreme paths (A) and (B). These involve either reducing the flake moisture to ca. 9% and improving drainage to 26% residual solvent, or using additional drainage to 28% thermal predesolventizing to ca. 8% solvent residue, before going into the DT system dictated by line (a). As a result, three possible locations for predesolventizing system can be considered, as shown in Figure 4.

The following systems for predesolventizing are actually available or are results of recent developments.

Mechanical predesolventizing. This involves increase of gravity drainage time in the extractor or additional drainer, and forced drainage by a differential pressure drainer.

Thermal predesolventizing. This involves fluidbed flake dryer, Schnecken-type desolventizer, rotary pipebundle dryer, flash desolventizing system, and circulating heat transfer bodies.

Systems which provide a certain predesolventizing effect. These include the Alcon process, extruding of solvent wet meal, flake shaking/conditioning, and flake extruding/expanding.

The systems which provide a certain desolventizing effect will not be discussed here, because their main purposes are not the predesolventizing; this is only a positive side-effect of these systems.

The Schnecken-type desolventizer is also excluded, because of the enormous heat exchange surface and geometry to comply with the requirements defined in Figure 3 which make it impractical to incorporate into existing extraction plants.

In Figure 5, in confirmation of figures already in the literature, the effect of increased drainage time is shown and the additional reduction of the solvent retention by forcing a solvent gas flow through the meal bed.

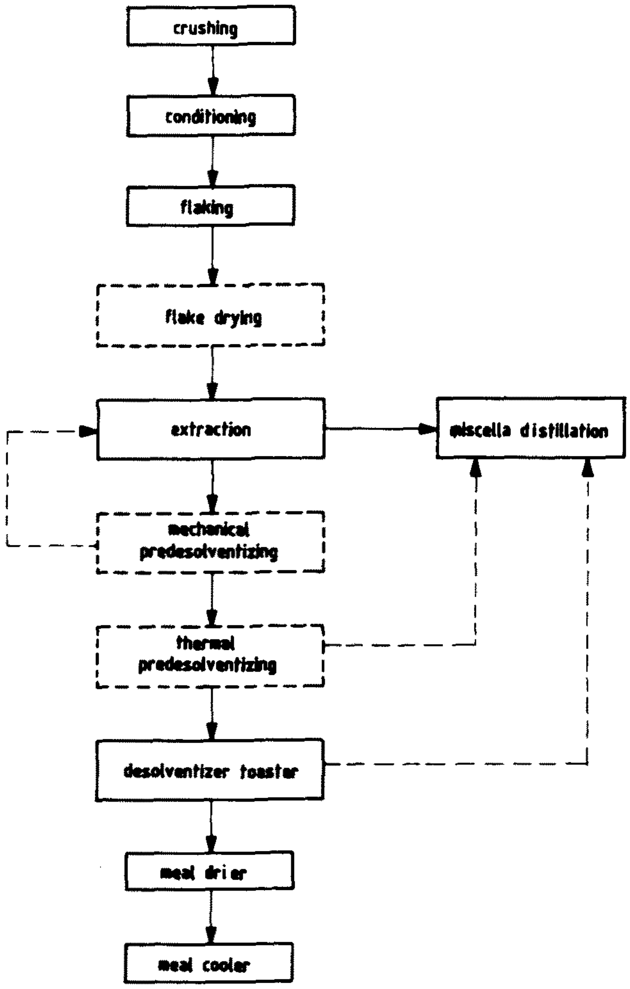


FIG. 4. Possible location of predesolventizing systems.

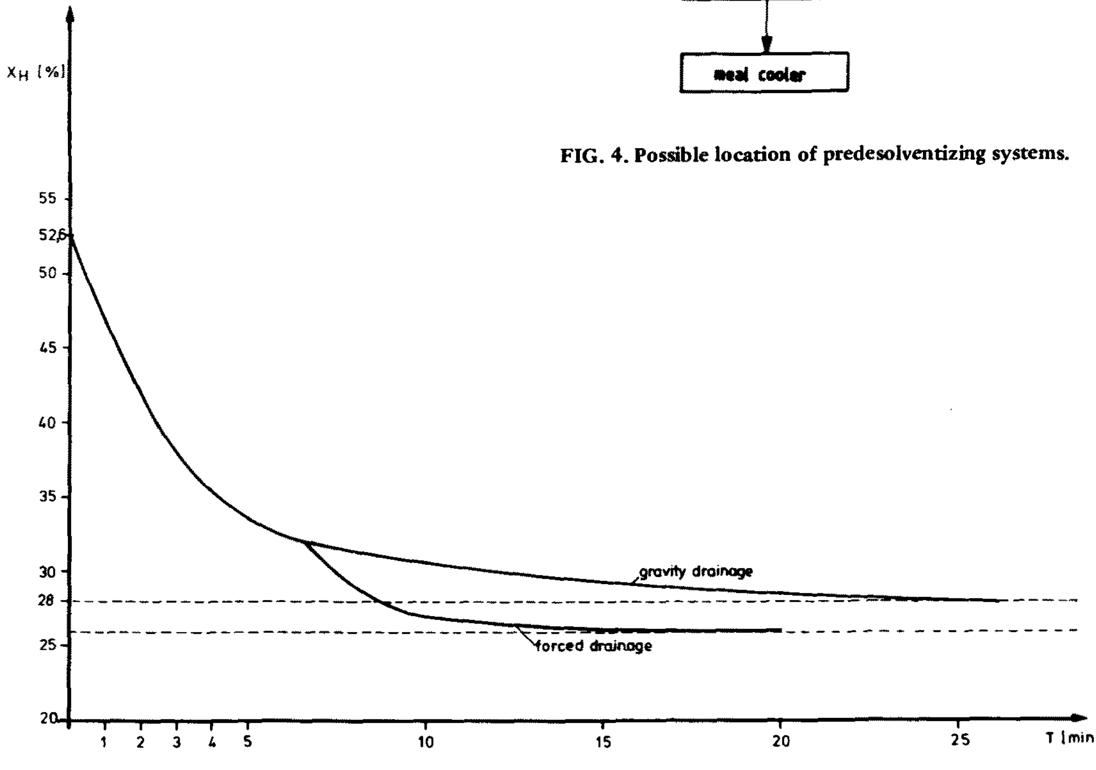


FIG. 5. Solvent retention as a function of the drainage time.

In Figure 6, the selected predesolventizing systems for comparative purposes are listed with the indication of their location in an extraction plant and their basic features. Table I compares the predesolventizing performances and efficiencies of the different systems on the basis of utility consumption and investment.

Figure 7 gives the cumulative savings vs the investment costs over a 10-year operation period.

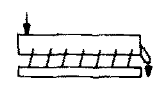
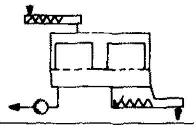
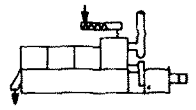
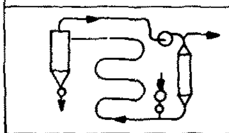
TABLE I

Comparison of the Different Predesolventizing Systems

Definitions

FDR	flake drier
AD	additional drainer
FD	forced drainage
RD	rotary pipebundle drier
FDS	flash desolventizing system
CHTB	circulating heat transfer bodies
x_w	flake moisture before extractor
x_h	solvent content before desolventizer toaster
SMD_0	steam consumption DT/meal drier (x_w=12 % x_h= 32%)
PDMD	steam consumption for predesolventizing
SMD	steam consumption DT/meal drier after predesolventizing
ΔMD	steam saving compared to SMDo
ΔE	power consumption for predesolventizing
Inv	estimated investment costs for predesolventizing equipment

		flake drying	mech. predesolventizing		thermal predesolventizing			mech./therm. predesolvent.
		FDR	AD	FD	RD	FDS	CHTB	FD/CHTB
x_w	%	9	12	12	12	12	12	12
x_h	%	32	28	26	8	8	8	8
SMD_0	kg/to	286,5	286,5	286,5	286,5	286,5	286,5	286,5
PDMD	kg/to	60	-	-	75	60	55	40
SMD	kg/to	211,5	247	229	101	101	101	101
Δ MD	kg/to	15,5	39,5	57,5	110,5	125,5	130,5	145,5
	DM/a	83.700	213.300	310.500	596.700	677.700	704.700	785.700
Δ E	* kwh/to	1,0	0,5	0,6	2,0	3,0	1,0	1,6
	DM/a	18.000	9.000	10.800	36.000	54.000	18.000	28.800
Δ MD+ΔE	DM/a	65.700	204.300	299.700	560.700	623.700	702.900	757.000
Inv.	DM	500.000	300.000	320.000	350.000	600.000	400.000	700.000

	Flake drier FDR	Fluid/shaked bed drier behind flaker
	Additional drainer AD	Carrousel drainer between extractor and DT (alternatively increasing drainage time in the extractor)
	Rotary predesolventizer RD	Gastight rotary pipe bundle drier between extractor and DT
	Flash Desolventizer FDS	Superheated hexangas recirculation with simoultaneous solvent wet meal transport between extractor and DT

recent developments

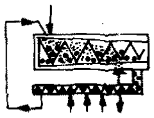
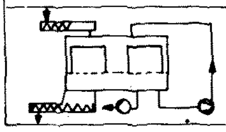
	Circulating heat transfer bodies CHTB	All spherical bodies heated by direct steam contacted with solvent wet meal separated and recycled again through heating zone to be installed between extractor and DT
	Forced drainer FD	Carrousel drainer in which a differential pressure is maintained between the upper and lower zone

FIG. 6. Comparison of the predesolventizing systems.

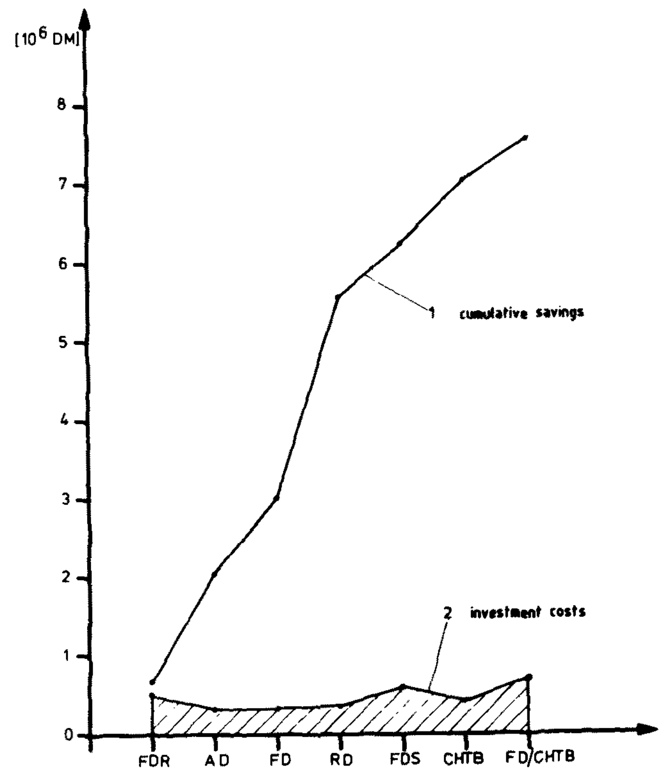


FIG. 7. Cumulative savings for 10-year operation vs. investment costs for predesolventizing equipment.