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**FORECASTING OF PERFORMANCE  
PARAMETERS OF THE SUGAR HOUSE IN THE  
SUGAR FACTORY**

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# FORECASTING OF PERFORMANCE PARAMETERS OF SUGAR HOUSE IN THE SUGAR FACTORY

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The analysis of the available models of the multistage crystallization has shown that they are based on the balance equations of the products calculations and could be classified generally as follows [1]: model for calculations as to circuits, model with the mathematical coefficients and model at the steady state. These models have the the same disadvantage: they take into account the process dynamics partially, the relative recirculate flows being included into the principal crystallization system in the stageless way, and do not correspond to the real process dynamics of the multistage crystallization.

Therefore, it is impossible to describe the real way of the process development, beginning with the net thick juice up to the end of the crystallization, and to follow the individual recirculation influence on the crystallizing product parameters change in the system at the stage of their setting at the steady state. The calculations made on the base of these models do not allow to simulate the process with the sufficient degree of detail and have the substantial discrepancies with the real process.

The universal model of the multistage sugar crystallization has been developed (Fig.1) which permits to avoid the above-mentioned disadvantages, to simulate the multistage crystallization process with the help of the computer with the sufficient degree of detail and sequence sharply corresponding to the real industrial process. The program realizing this universal model has been made on the language Borland C and operates in Windows 95.

The calculation experiments carried out with the help of the universal model have shown that with the precision, when the error does not exceed 1%, the multistage crystallization process is stabilizing at the 6-8th circuit. The movement of the sugar purity is shown in the Fig2. The process starts to be steady at the 4th circuit when the recirculate flows are included in it.

The calculation experiments has been carried out according to the folowing schemes: c2-3 — without recirculation of the 2nd syrups of the 1st and the 2nd crystallizations; c1-3 — with recirculation of the 2nd syrup of the

1st crystallization; c2-2 — with recirculation of the 2nd syrup of the 2nd crystallization ; c1-2 — with recirculation of the 2nd syrups of the 1st and 2nd crystallizations.

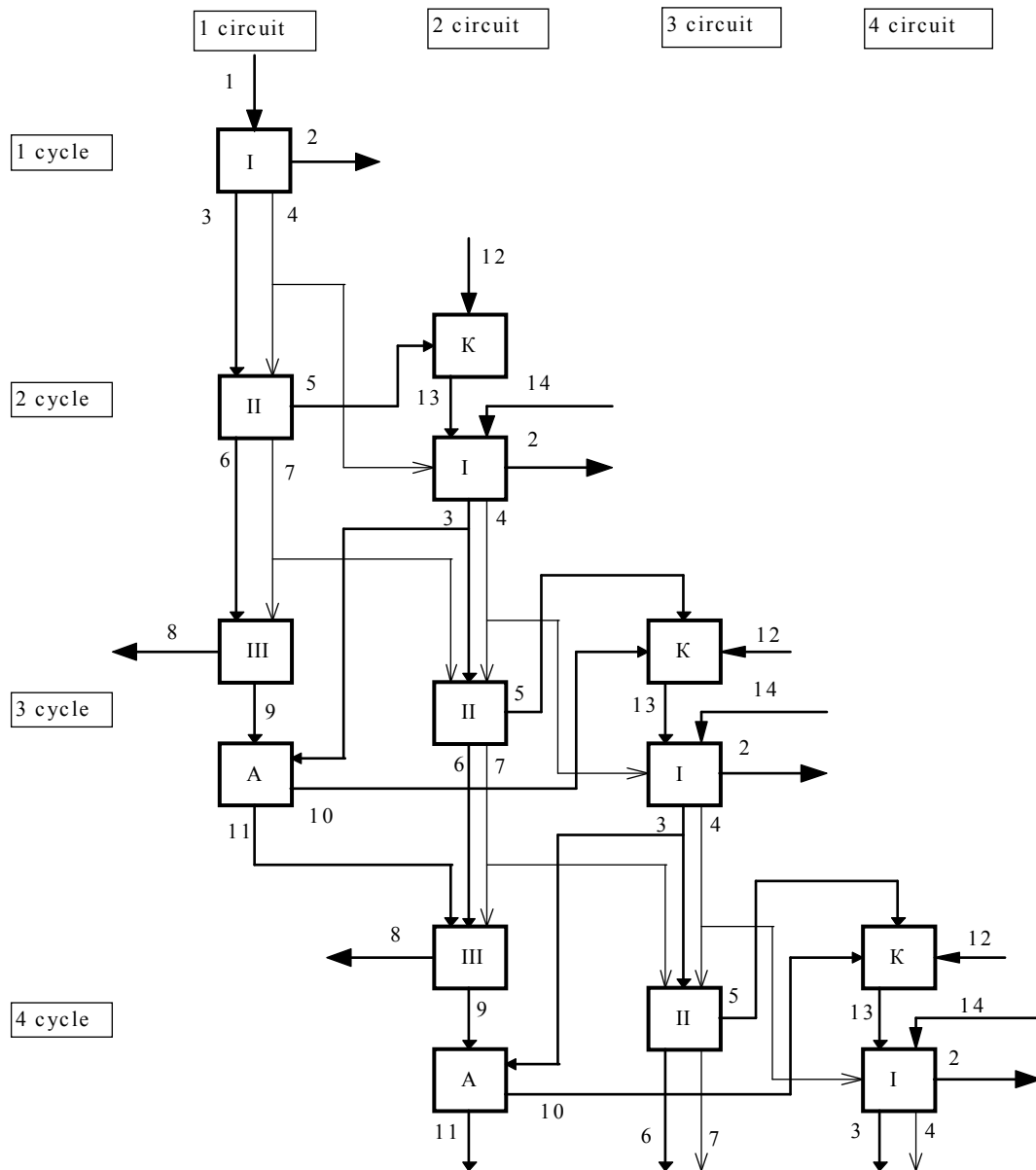


Fig.1. The universal crystallization model:

*I, II, III —the first, second, third stages of crystallization ; K — melting; 1 — net standart liquor; 2 — sugar of 2nd crystallization; 3 — 1st syrup of the 1st crystallization; 4 — 2nd syrup of the 1st crystallization; 5- sugar of the 2nd crystallization; 6 — 1st syrup of the 2nd crystallization; 7 — 2nd syrup of the 2nd crystallization; 8 —molasses; 9 — sugar of the 3rd crystallization ; A — affination; 10 — affined sugar; 11— affination syrup; 12 —thin juice to melting; 13 — melting; 14 —thick juice.*

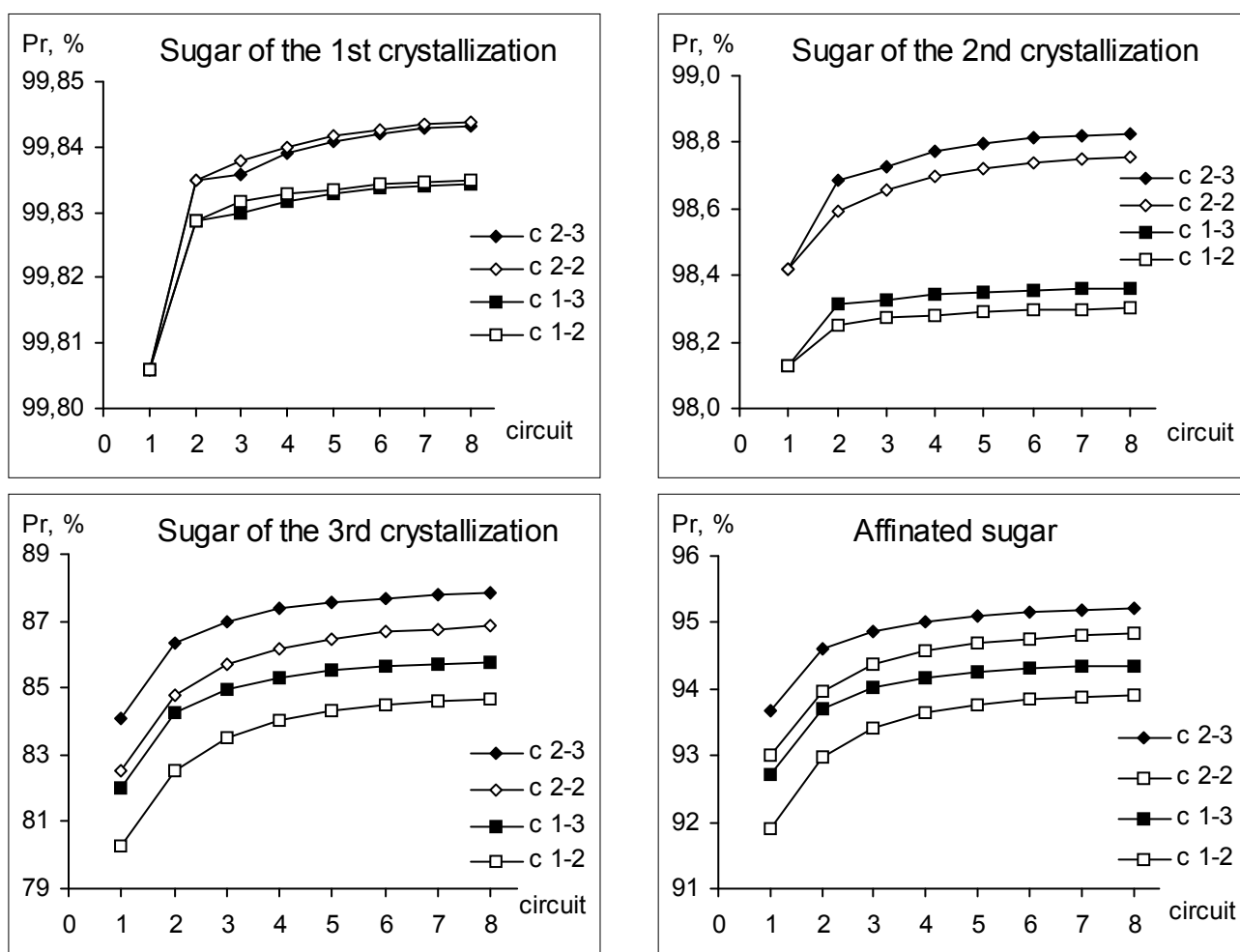


Fig.2. Behaviour of sugar purity according to the circuits

The investigations have shown that recirculation of the 2nd syrups of the 1st and 2nd crystallizations influences substantially on the qualitative and quantitative product parameters. Yield of the final product is going up and molasses quantity and its purity are going down with the higher quantity of the recirculates.

Recirculation of the 2nd syrups of the 1st and 2nd crystallizations influences on the product parameters in the different way, namely: recirculation of the 2nd syrup of the 1st crystallization causes the decrease of the sugar purities more significantly than the recirculation of the 2nd syrup of the 2nd crystallization. This influence is more pronounced with the purity of the sugars of the 2nd and 3rd crystallizations. In the first case the purity drop is about 0,5% and in the second case — 1,2...4,0%. At the same time purity of the 1st crystallization sugar goes down by 0,008%.

The diagrams of the E-specific value (kg evaporated water/kg commercial sugar) - recirculate mass relation are given in the Fig.3. These

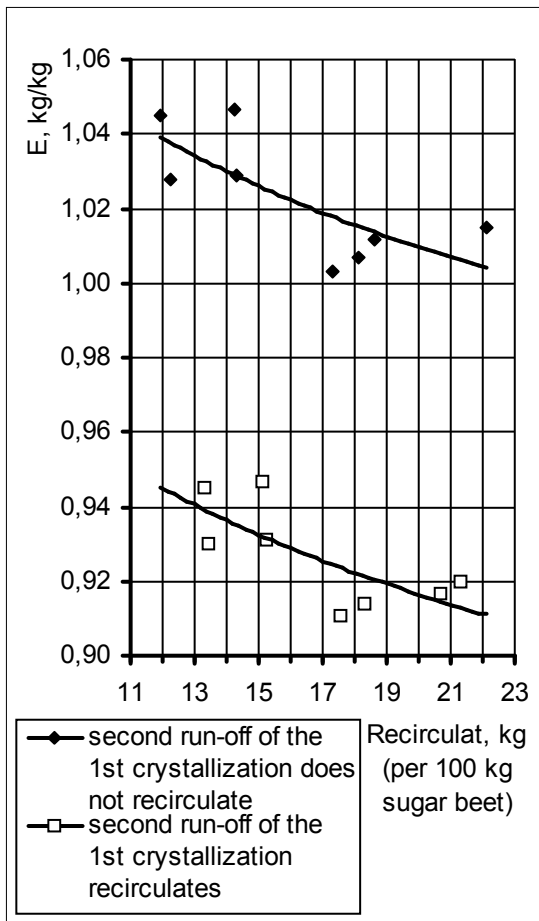


Fig. 3. Influence of the recirculate mass on the E-specific value

crystallization sugar: without treatment (iî), with water washing (ið), with affination (ac) and use of the affined massecuite (àó) as a crystalline base for the 2nd crystallization. So, the rise of the commercial sugar output does not exceed 1% when the 3rd crystallization sugar is not treated or is washed with water. If the affinated massecuite is used as a crystalline base for the 2nd crystallization or with affination of the 3rd crystallization sugar the growth of the commercial sugar output is more than 2%. It is necessary to note that the purity of the 1st

diagrams show that E-specific value goes down with the rise of the total recirculating product mass that confirms the results of our previous investigations [2]. The quantity of the evaporated water is considerably lower with the recirculation of the 2nd syrup of the 1st crystallization than without its recirculation. Difference between the E-specific values for these groups constitutes on the average 9%. At the same time with the recirculate mass increase the output of the commercial sugar rises (Fig. 4).

Besides that, the above-mentioned schemes have been considered for the different ways of treatment of the 3rd

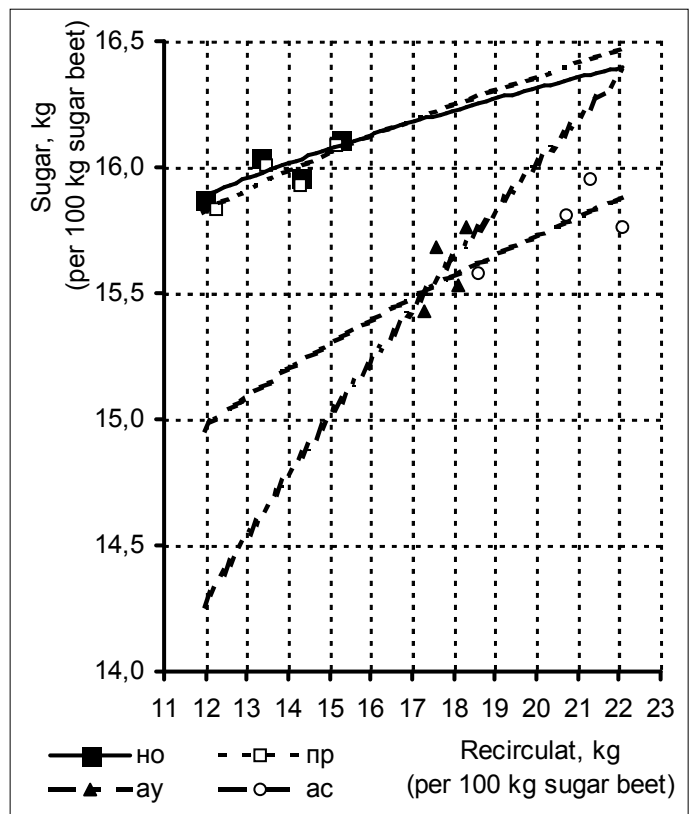


Fig. 4. Yield of the commercial sugar in relation to the recirculate mass and treatment of 3rd crystallization sugar

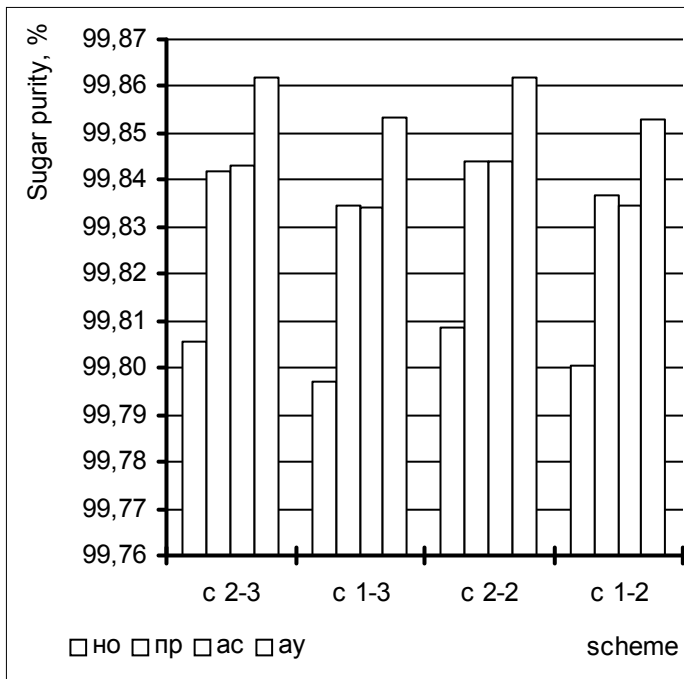


Fig.5. Commercial sugar purity at the different treatment of the 3rd crystallization sugar

function for selection of the optimum scheme where the 1st crystallization sugar quantity and its purity should be maximized and the molasses quantity of the preset purity and the evaporated water quantity — should be minimized.

Taking into account the standards requirements to the sugar and molasses purity the optimization model could be described as follows:

$$f(s, w, m) = -\rho_s \cdot s + \rho_w \cdot w + \rho_m \cdot m \rightarrow \min,$$

$$D_s > D_{s\ st},$$

$$D_m < D_{m\ st},$$

where  $s$  — sugar quantity, kg;  $w$  — evaporated water quantity, kg;  $m$  — molasses quantity, kg;  $\rho_s, \rho_w, \rho_m$  — the corresponding weight coefficients; where  $D_s$  — sugar purity;  $D_{s\ st}$  — sugar purity per standard;  $D_m$  — molasses purity;  $D_{m\ st}$  — molasses purity per standard.

The results of optimization demonstrated in the Fig.6 show that the target function value is lower than its mathematical expectation in the schemes with recirculation of the 2nd syrup of the 1st crystallization, and higher in the schemes without recirculation. It indicates on the evident advantage of the schemes with the recirculation of the 2nd syrup of the 1st crystallization. The schemes with the recirculation of the 2nd syrup of the 2nd crystallization and

crystallization sugar grows with the treatment of the 3rd crystallization sugar (Fig.5): with washing or affination — by 0,035%, with use of the affinated massecuite as a crystalline base for the 2nd crystallization — by 0,056%.

So, one can conclude that the schemes with the recirculation have the evident advantage to compare with the schemes without recirculation.

The described universal model of crystallization allows to select the optimum crystallization scheme with the known starting products. Let us use the target

function for selection of the optimum scheme where the 1st crystallization sugar quantity and its purity should be maximized and the molasses quantity of the preset purity and the evaporated water quantity — should be minimized.

Taking into account the standards requirements to the sugar and molasses purity the optimization model could be described as follows:

$$f(s, w, m) = -\rho_s \cdot s + \rho_w \cdot w + \rho_m \cdot m \rightarrow \min,$$

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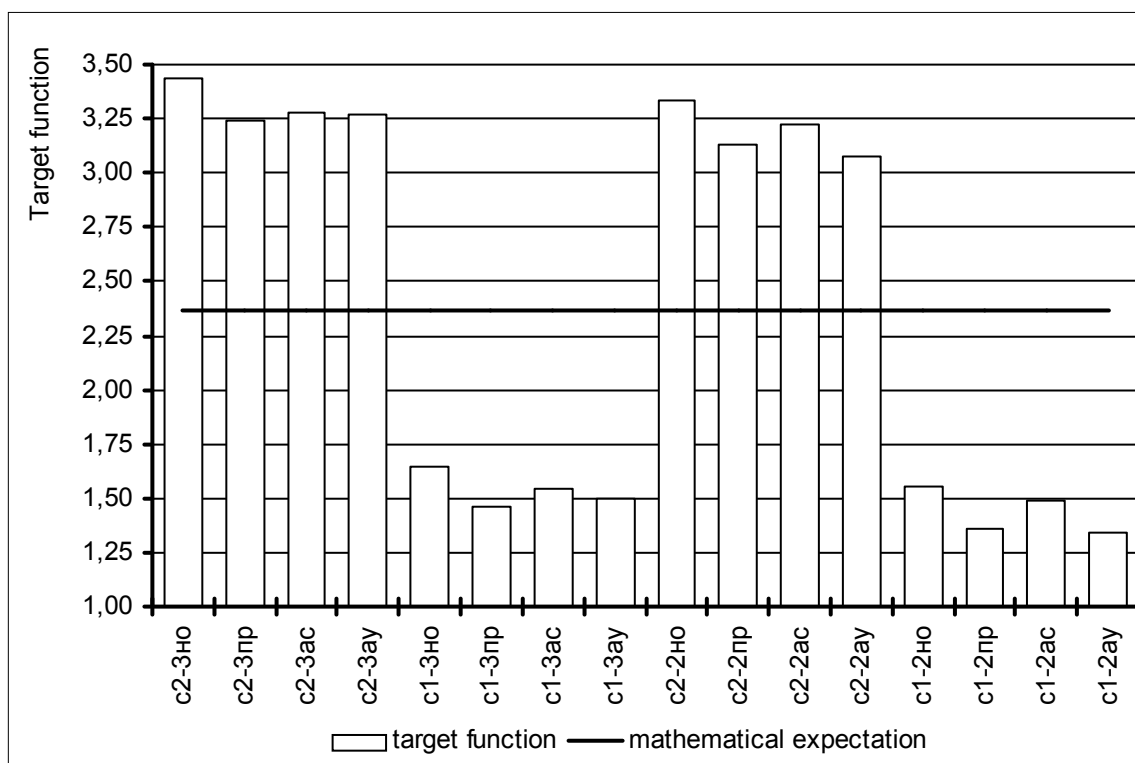


Fig.6. The target function values at  $\rho_s=\rho_w=\rho_m=1$

use of the affinated massecuite as a crystalline base for the 2nd crystallization have the obvious advantage among them. The schemes without treatment of the 3rd crystallization sugar take the last place. The analogous distribution could be noted also among the schemes without recirculation of the 2nd syrup of the 1st crystallization. They, however, do not meet the optimization conditions.

### Conclusions:

1. The proposed universal model of the sugar crystallization process allows to forecast the parameters of the performance of the sugar house in the sugar factory.
2. The investigations carried out have demonstrated the advantage of the sugar crystallization schemes with the recirculation.

### References

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## **Summary**

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On the basis of the component mixing theory the model has been updated and the computerized program for calculation and forecasting of the quantitative and qualitative parameters of the sugar house performance in the sugar factory has been developed.

The proposed model and program allow to predict and currently correct the regime of the whole sugar house performance and its separate sections with the help of the personal computer according to change of the parameters of the starting and intermediate products. It ensures the rational; performance of the technological process with the aim to produce the standard commercial sugar with the minimum energy consumption.

## **Resumé**

### PRONOSTIC DES INDICE DU TRAVAIL DE SECTION DE PRODUIT DE SUCRERIE

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On précise le modèle et on élabore le programme de ccomputeur du compte et du pronostic des indices qualitatifs et quantitatifs du travail de section de produit de sucrerie.

Le modèle et le programme qui sont proposés permetions faire le pronostic et cossiger expéditivement le règlement du travail de tout la section cristallique et ses secteurs détachés à l'aide du ordinateur personell dépendre du changement des caractéristiques des produit de départ et intermédiaire.



Cela assure la direction rationnelle du processus technologique dans le but de la réception de sucre de marchandise de qualité standardisé avec les dépenses de plus petites énergétiques.