Pakistan J. Sci. Ind. Res., Vol. 27. No. 4, August 1984

OILSEED PROCESSING TECHNOLOGY IN PAKISTAN

Part II. Lahore Oil Expeller, Mechanical Aspects and Improvements

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(Received April 16, 1984)

The design of the existing Lahore Expeller (size 4″) has been modified by the addition of a reverse worm (1.5)″ at the end of the main screw assembly. Alternation in the adjascent iron bars of the drainage barrel for oil squeezing have also been affected. As a result of these modifications the residual oil in the cake has been reduced to 7.5% as against 11-12% obtained by the expeller now in use. The quality of the residual meal is not affected.

Working on rapeseeds alone, it has been estimated that an additional amount of 10,000 tons of oil worth about Rs. 100 million (@Rs. 10/- kg) can be additionally recovered.

INTRODUCTION

It has already been reported that a survey was conducted by the PCSIR to find out which of the available technologies for the expulsion of oil from oilseeds could be more usefully employed at the village level[1]. It was determined that the mechanical screw expeller using the 3″ and 4″ screws had a better promise of usefulness, and that such expellers could also be used to set up a cottage scale oil extraction industry. An expeller of this size can process upto 35 kg of oil seeds per hour and requires an approximate investment of Rs. 20000/- for its commercial operation. Such machines are already being manufactured locally by small engineering shops, but little attention is given to the quality control and other guiding principles on which the manufacturing process should rest.

This study, therefore, consideres the main design and fabrication aspects of the small size expeller, popularly known as the Lahore expeller, and suggests certain improvements that have been introduced and tried by the PCSIR to improve the oil output of the machine. Due thought has also been given to the fact that the resources of the small engineering shops happen to be limited and, therefore, they cannot afford any complicated processes of production.

The origin of a screw as a conveyer is attributed to Archimedes, but its application as an oil expeller is comparatively new and was probably first made by Anderson in 1900[2]. The basic feature of a screw press are simple: A screw or worm is rotated inside a cylinderical cage with a minimum of clearance, and the oil seeds are fed through a hopper at the starting end. At the discharge end, the cage opening is partially closed by an adjustable plug, usually known as the cone. As the screw rotates, the oil bearing materials is carried forward, but since the outlet is virtually blocked, a heavy back pressure is exerted on the material, which is thus made to squeeze its oil. It is usual to keep the pitch of the screw less than its diameter and the operation of the screw shaft below 100 rpm. The spacing between the cage bars is usually less than 1 mm and is so determined that it allows an efficient drainage of the oil and also provides a coarse filter for the solids. Theoretically, the processing capacity of the expeller depends on the rpm of the screw, its average pitch and the difference between the diameters of the cage and the screw hub, while the oil extraction proficiency is a function of the back pressure. However, some other factors are also involved and are briefly considered below:

1. Hopper. The hopper is placed at the starting end of the cage to store and feed the oil bearing material. Small expellers usually have a simple hopper but larger units are often equipped with a hopper which includes an elaborate feed mechanism. The main consideration in either case is that an unobstructed flow of the material into the cage should be maintained which thus becomes the first important factor to ensure the continuity of oil recovery from an expeller.

2. Screw. The screw, also called a worm or a scroll, is either made in a single piece or is an assembly on a single shaft of various screw sections. Usually a screw above 4 inches in diameter is fabricated in sections and a screw below 2 inches in diameter is made in a single piece. If the screw is made in sections, each section is provided with the same

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bore and is mounted and keyed on to a sturdy central shaft. The type of threads a screw has is a relative factor; usually the large diameter screws are given a square like thread, while the smaller ones a more conical thread. The choice of the right screw and its thread shape involve a complicated treatment, but a simple explanation can also be presented as given below:

A perfect square thread on a screw can only give an axial push and hence can cause only an axial pressure. Nevertheless, a radial pressure on the material is also needed and is obtained by providing a slope on the square thread. The radial pressure thus exerted by the screw is very important in order to drain out the oil through the cage and also to increase the friction of the cage bars against the material. This friction crushes or breaks the oil cells in the material, which again plays a very direct role in the recovery of the oil. It is generally recommeded that the pressure on the material should be built up gradually, which is achieved by so designing the screw as to give it a gradually decreasing pitch and an increasing hub-diameter. These recommendations are not always attended to by our local manufacturers and a brief reference to this is taken up again in the last section of this paper under discussion.

3. Cone. The cone is essentially an adjustable plug placed at the discharge end of the cage on the axis of the screw shaft. Its main purpose is to maintain the back pressure on the oil bearing material at high level. It also provides a variable orifice in order to allow the cake to be extruded in such adequate thickness that it is neither burnt nor charred. These functions, namely the high back pressure and the adequate cake thickness, are at variance with each other, and hence the cone design requires a careful compromise. The design is also dependent to some extent on the type of the screw.

4. Cage. Two types of cages are available in 3 inch and 4 inch expeller. In one type the cage is formed in two halves cylinders which are then assembled on the expeller frame by heavy clamps, and in the other, the cage is made an integral part of the exepller frame. Spacing between the bars is provided by inserting steel strips of the required thickness between each two bars and the average width of spacing is about 0.7 mm. The usual sizes of cage bar are: 12 mm width 20-25 mm height x 280 mm length. When these bars are assembled they produce, strictly speaking, a hollow prism and not a hollow cylinder, each side of the prism being 12 mm in width. Now a serious trouble experienced during the operation of most expellers is that the oil bearing materials, as it coagulates, tends to set as a solid mass around the screw and then starts rotating in the cage. Such a happening ultimately jams the whole operation. Since only a cylinder can rotate inside a hollow cylinder, but not a prism inside a prism, an obvious check to the rotation of the material could be obtained if the cage were given the more distinctive configuration of a prism, say by increasing the width of the cage bars. However, the 12 mm width has almost been universally adopted and the main reason for this practice appears to be that if the cage is made to approach the shape of a hollow cylinder it would allow the screw to be rotated with a minimum of clearance.

5. Driving Gears and Bearings: In order to rotate the screw shaft below 100 rpm with an electric motor, say of 950 rpm a reduction gear train of about 10:1 ratio would be necessary. This reduction cannot be achieved by a simple belt system, for the reason that the back pressure in a 3 or 4 inch expeller usually goes as high as 5 tons and hence the torque needed for the screw becomes so great that the belt system looses its effectiveness due to slippage. Hence the gear reduction at the last stage must be employed. Both spur and helical gears are used for this prupose, but the later has the advantage that it shares a part of the screw thrust and hence the load on the thrust bearings is reduced.

IMPROVEMENTS AND DISCUSSIONS

The Lahore Expeller. The name Lahore expeller is applied to the locally produced expellers of 3″ and 4″ screw. These expellers are produced with the screw assembled in sections of decreasing pitch. The cage form is available mostly in a single unit but cages in two halves are also fabricated. These locally produced units were closely studied and it was found that without making much changes in the current design, some improvements in the screw and some specific widths of spacing between the cage bars can have a marked effect on the oil recovery and the processing of rape seed was, therefore, especially studied in the 4 inch Lahore expellers and the following improvements were made to achieve a more satisfactory oil recovery.

Cage Improvements. It has already been mentioned that the cage shell is made of rectangular steel bars with an average spacing of less than 1 mm between each two bars. The spacing is slightly larger at the feed-end and more close at the discharge-end. This is understandable, because the pressure on the material goes on increasing towards the discharge-end and hence closer spacing is necessary to check the escape of the solid, known as foots, through the spacing. Exact spacing also depends upon the nature of the material, but the main considerations are that it should act as an efficient drain and at the same time as an adequate filter. Observations were taken with various thickness of the strips used as the spacers and it was observed that the best results were obtained with 21 gauges (0.8 mm) strips inserted between the cage bars at the feed end, and 30 guage (0.31 mm) strips at the discharge end. It is not simple and easy to open and re-assemble the cage bars each time with a different set of spacer, but various observations were taken in order to get an in-sight as to what sort of results were obtained with various width of spacings. These observations are summarised in Table 1. It is to be emphasised that other factors on which optimum spacing depends are the maximum attainable pressure in the cage and the nature of preparatory treatment given to the oil bearing material. In the present expriments, however, no special preparatory treatment was given except a simple cleaning of the seeds and adjusting the moisture contents to about 5%.

Table 1. Combination of strips to produce spaces between iron bars of drainage barrel.

Combination number	Feed end clip	Discharge end clip	Remark
Ist	26 guage	26 guage	Clogging problems
2nd	24 guage	14 guage	Uncontrolable foots
3rd	24 guage	28 guage	Uncontrolable foots
4th	24 guage	30 guage	Frequent clogging
5th	22 guage	30 guage	Smooth operation
6th	21 guage	30 guage	Smooth operation
7th	20 guage	30 guage	Excessive foots
8th	18 guage	30 guage	Uncontrobale foots

It is also important to realise that the cage friction generates a large amount of heat and considerable abrasion occurs if even a small quantity of grit is present in the material. The abrasion tends to wear the edges of the cage bars quickly. Use of suitable heat treated bars of steel is, therefore, a pre-requisite and the bar's edges should be slightly rounded off from the very beginning. These important aspects in the production of cage bars are paid only casual attention in the locally produced expellers.

Screw Improvements. The screw of the locally fabricated 4 inch Lahore expeller is usually made in 4 separate sections which are mounted and keyed on to a central shaft. It is now accepted that the best screw-sections should have a flight that wraps something less than 350°; this allows some back flow of the cake and oil which is a useful factor in pressing[3]. The practice, however, is not always adhered to in the locally produced expellers. In some expellers, which were examined, it was found that lengths of the sections were in the order of 6.5, 3.0, 2.75 and 1.75 inches, while the respective pitches were 4.0, 3.0, 2.75 and 1.75. Evidently the wrap was full 360° in the last 3 section and more than 360° in the first section.

The above described screw assembly was modified by shortening the length of each section so as to have a wrap of about 350° in the last three sections, but since the length of the first section functions mainly as a feeder, its wrap was allowed to have a value greater than 360°. The shortened length of the full screw which thus resulted was made up

Table 2. Screw evolution rpm 60.

Screw Forms		Ist worm	Spacer width	2nd worm	Spacer width	3rd worm	Spacer width	4th worm	Spacer width	5th worm	Spacer width	Remarks
Original	Length	6.5"	–	3.0"	–	2.25"	-	1.75"	–	–	–	Oil contents in
screw	pitch	4.0"	–	3.0"	–	2.25"	–	1.75"	–	–	–	cake = 12.5%
Ist modified	length	6.5"	–	3.0"	0.5"	2.25"	–	1.5"	–	–	–	Oil content in
screw	pitch	4.0"	-	3.0"	–	2.25"	–	3.0"	Rev.)	–	–	cake = 6-7% screw jaming.
2nd modi-	length	6.5"	–	3.0"	–	2.25"	–	1.5"	0.5"	1.75"	–	Oil content in
fied screw	pitch	4.0"	–	3.0"	–	2.25"	–	3.0"	(Rev.)	1.75"	–	cake = 7.5%, frequent screw jaming.
3rd modi-	length	6.5"	–	3.0"	–	2.25"	-	1.75"	–	1.5"	–	Oil content in
fied screw.	pitch	4.0"	–	3.0"	–	2.25"	–	1.75"	–	3.0"	Rev.	Oil content in cake = 7% smooth operation.

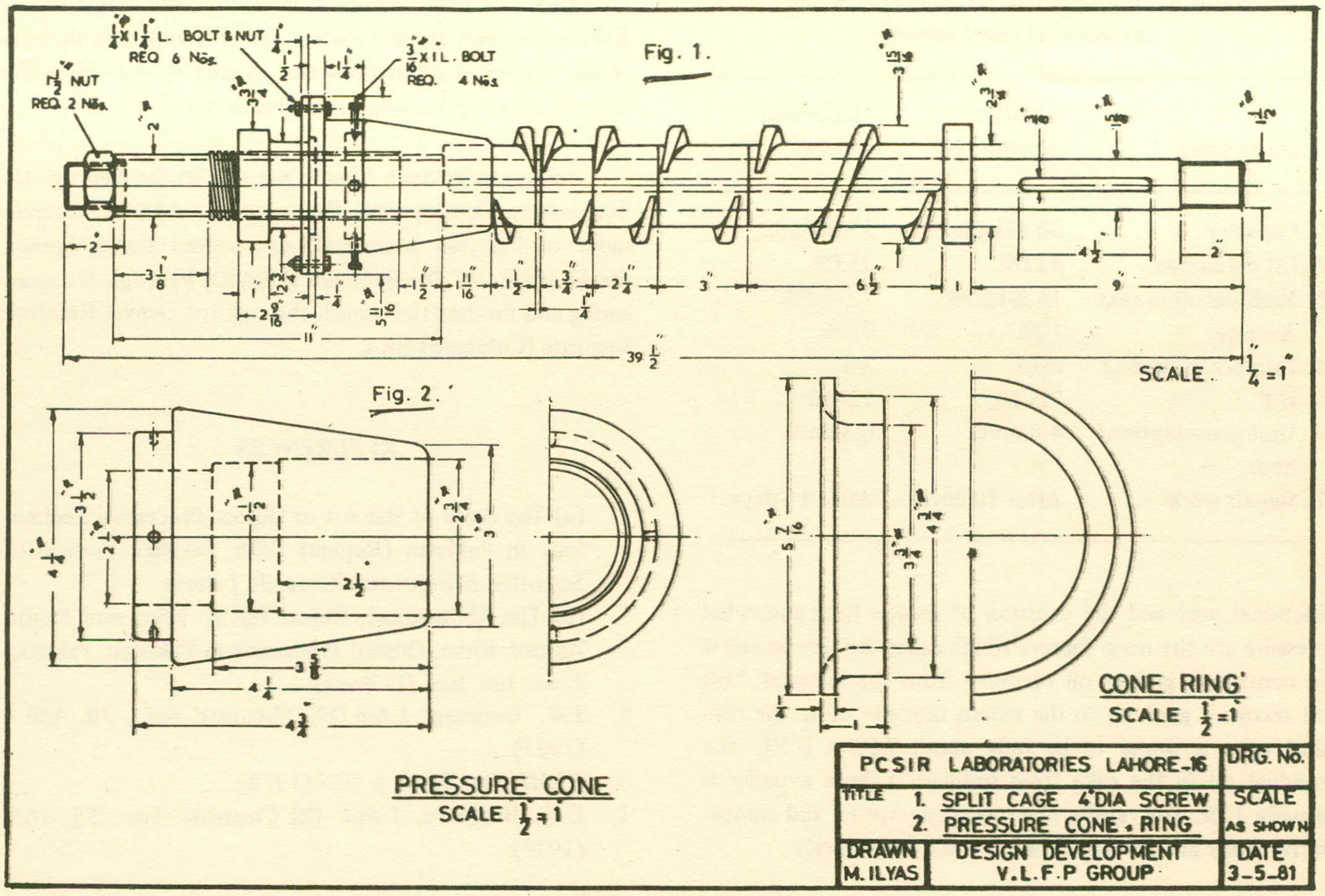

Fig. 1. (above) Fig. 2. (below).

in the first trials by the insertion of a spacer or collar in between each two sections in conformity with the general recommendations given in the literature [4] .

In larger size expellers, the free spaces around the collars are usually utilised to introduce fixed blades projecting downwards from the cage shell and help preventing the rotation of the material. This device was found complicated for use in 3 and 4 inch expellers and, therefore, the use of collars was rejected and instead a reverse screw was introduced at various positions between the screw sections. The pitch and the length of this reverse screw were 3.0 inch and 1.5 inch respectively but the outer diamter was only 3.75 inches instead of 4 inches, which allowed a free pass of the material through the small space between the cage and the reverse screw. Also a greater slope angle was provided on the thread of the reverse screw to increase its radial thrust. Since the use of the reverse screw was initially introduced to replace the collars, its right place was tried by introducing it at various places in between the sections. The observations made in these experiments are given in Table 2. It was finally found that the best place for the reverse screw was at the end and this position was decided to be the final. The final form of the whole screw with the reverse screw at the end position is shown in Fig. 1 and a suitable cone which matches this screw is shown in Fig. 2.

It is considered that a sort of wringing action, extra

Table 3. Results of modified expeller-4"

1. Capacity (range)	= 35-60kg/hr.
(average)	= 46kg/hr.
2. Oil extraction (range)	= 30-40%
(average)	= 35%
3. Residual oil (range)	= 7.0-8.5%
in cake (average)	= 7.5%
4. Number of passing through expeller	= 3-4 times
5. H.P. to drive the expeller	= 7.5=10
6. Power unit consumption	= 6.3 units/hr.
7. Repair work	= After 15 days.

Table 4. Comparison of normal expeller and improved expeller size- 4″

Characteristics	Normal expeller – 4″	Improved expeller – 4″
1. Capacity	30-38kg/hr.	35-60kg/hr
2. Oil extraction	32.0%	35.0%
3. Residual oil in cake	11.3-12.7%	7.0-8.5%
Average	12%	7.5%
4. Number of passing	6-15	3-4
5. H.P.	7.5-10	7.5-10
6. Unit consumption/ hour.	4.8 units	6.3 units.
7. Repair work	After 30 days	After 15 days

frictional heat and the exertion of greater back and radial pressure are the main factors which cause the reverse screw to contribute greater oil recovery from the material. This oil recovery goes up to the extent that the oil in the residual cake is found to be only about 7.5% ± 0.5%. The residual oil in the cake from ordinary Lahore expeller is usually 12%. The results of a modified expeller and comparative study are given in Tables 3 and 4 respectively.

Further studies, aimed at modifying the design of the Lahore expeller, are in progress and it is expected that because of these modifications the residual oil content in the oil seed cake will be reduced to almost 3%.

Acknowledgement. Thanks are due to the Appropriate Technology Development Organization (ATDO), Government of Pakistan Islamabad, and United States Agency for International Development (USAID) Pakistan for sponsoring and funding the project through the Denver Research Institute (Colorado) USA.

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