DESIGN OF AN IMPROVED SHORT ROLLERS SUGAR CANE JUICE EXTRACTOR MACHINE

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ABSTRACT
The Improved Sugar cane juice extractor has short stainless steel removable rollers. The juice extractor includes housing with three compartments, the first for extracting juice and contains the crushing rollers; the third contains the main drive, while the second serves as re-enforcement for the connecting shafts. The first compartment is a closure for accessing the compartment; the closure is preferably a clear plate which permits viewing the compartment during operation and, when removed, allows access to the compartment for removal of the crushing rollers and cleaning of the rollers and the compartment. A safety switch is provided to prevent rotation of the rollers when the closure is displaced. A guide into the compartment is provided to direct the sugar cane and any flavorings into the crushing rollers. A waste channel is provided for the exit of crushed cane pulp.

Keywords: Stainless, Rollers. Compartments, Pulp.

INTRODUCTION
The earliest sugar cane mills were probably malted and pestle arrangement operation press by human power, then by animals or water power, and screw press. These were widely used for juice extraction until it was taken over by roller mill, which was invented by a cane grower in sicily Italy in 1449. Wooden roller mills were not claded with iron until the mid 1600s animals; water wheel and wind mill steam drive were first used in sugar cane milling in 1768. (Deer, 1974)

Sugar cane juice extractors are often used commercially in a setting where juice is squeezed to order for individual consumers, such as at a fair or in a retail store. Sugar cane juice extractor generally have a plurality of powered crushing rollers, sugar cane stalks are pressed through adjacent pairs of the rollers, crushing the stalks and separating a fresh, drinkable juice from the remaining pulp. The crushing rollers are bulky and positioned closely to each other, making cleaning difficult. The housing is usually made of several assembled parts with many edges and
crevices where dirt may accumulate, further rendering cleaning difficult. Improper or incomplete cleaning can lead to unsanitary conditions. Presently available sugar cane juice extractors do not allow observation of the operation of the crushing rollers in the juice extracting compartment. Viewing this operation allows the operator to observe the condition of the rollers and the compartment, alerting the operator when there is a jam or when cleaning is necessary. Further, observation of the operation is an attraction for consumers, who can watch the operation of fresh juice.

It is sometimes desirable to enhance the flavor of sugar cane juice by adding fresh ginger, lemon, or some other flavoring. It is difficult, however, to introduce these ingredients to the crushing rollers due to the small relative size and a tendency of the flavoring to fall away from the rollers unless held in place. (Reeal, 1994)

**OBJECTIVES AND SCOPE OF THE DESIGN**

It is an object to provide sugar cane juice extractor which facilitates the cleaning of the extractor, and thus improves the sanitation of the device.
It is another object to provide sugar cane juice extractor which will permit viewing of the juice extraction operation.
It is yet another object to provide sugar cane juice extractor which will permit the introduction of added ingredients for inclusion into the sugar cane juice beverage.
It is still another object to provide sugar cane juice extractor which will be easy to operate.
It is another object to provide sugar cane juice extractor which will provide improved safety in operation.

These and other objects are accomplished by a sugar cane juice extractor having a plurality of crushing rollers that are substantially adjacent one another and counter-rotating so as to pull the sugar cane stalk between the rollers. The stalk will be crushed and the juice separated from the sugar cane pulp. The crushing rollers are preferably provided in a compartment within housing. Entry and exit ports are provided for the sugar cane stalk, and an outlet is provided for the juice. A guide is preferably provided to direct the sugar cane stalk from the entry port to the crushing rollers.

The crushing rollers are removable to permit cleaning of the rollers and the juicing compartment. An access opening is provided in the housing to permit removal of the crushing rollers from the compartment, preferably by hand. A suitable closure is provided, such as a hinged door or a removable cover shield. The closure can be clear to permit viewing of the operation of the juice extractor by the operator and by the customer.
A safety switch is preferably provided to discontinue operation of the crushing rollers when the closure has been removed to the open position, to prevent injury.

**DESCRIPTION OF THE MODIFIED EXTRACTOR**
Fig. 1 Front left assembled view (1-Stalk guide, 2-Pulp exit port, 3-Top housing cover, 4-Closure cover, 5-Juice outlet, 6-Side housing cover, 7-Juice collector, 22-Compartment, 26-Guide block).

Fig. 2 Rear left assembled view (8-Side right housing cover, 9-Electric cord, 10-Rear panel, 11-Ventilation openings)

The frame shall be able to hold the rollers in position and keep the crusher stable.

Fig 3 Front left exploded view (12-Front cover, 13(a-c)-Crushing rollers, 14(a-c)-Drive shafts, 15-Base collector, 16-Compartment plates, 19-Base, 23-Opening, 24-Key, 25-Slot)

WORKING PARTS
CRUSHING ROLLERS
In a most preferred embodiment, three crushing rollers namely king, crushing and extracting shall be used. The king and the extracting rollers may be of the same diameter, the face length of all rollers shall be the same irrespective of their diameter. (Nehru, 2010)\textbf{13a-c} are provided in a substantially triangular arrangement within the compartment \textbf{22}.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig4}
\caption{Crushing rollers}
\end{figure}

\textbf{DRIVING SHAFTS}

The operation of the crushing rollers \textbf{13} is provided by suitable drive apparatus. The shafts \textbf{14a-c} preferably extends through the rear face of the compartment \textbf{22} to a rear drive compartment \textbf{28}.

\begin{figure}[h]
\centering
\includegraphics[width=0.2\textwidth]{fig5}
\caption{Driving shaft}
\end{figure}

A motor is provided and can be powered electrically, as through a chord \textbf{9}. The manner by which power from the motor is transferred to the rollers \textbf{13} can vary. Chain sprocket arrangement can be use to link the motor with the spur driving gears.

\textbf{AXLES}

The axles shall be finished to close tolerance at the bearing and shall be properly aligned. Allowable shearing stress shall be 30% of the elastic limit, but not more than 10% of the ultimate strength in tension for axle without keyway. The value shall be reduced by 25%, if keyway present.

\begin{equation}
d^3 = \frac{16}{\pi S_s \sqrt{(K_b M_b)^2 + (K_t M_t)^2}}
\end{equation}

Where:
- \(d\) = axle diameter in cm
- \(S_s\) = allowable Shear Stress in N/cm\(^2\)
- \(K_b\) = combine shock and fatigue factor applied to bending moment (1.5 to 2)
- \(M_b\) = bending moment in Ncm
K_i = combine shock and fatigue factor applied to torsional moment (1.0 to 1.5) and
M_i = torsional moment in Ncm

**BEARINGS**
Provision shall be made for lubrication of bearings, except where pre-lubricated bearings are used. Lubricating nipples shall be easily accessible. Provision for protection of bearings from entry of juice shall be provided. (J.Nehru, 1999)

![Fig. 6 Bearing Housing](image)

**SPUR DRIVING GEARS**
The gears shall be properly mashed, ensuring noiseless and smooth running and shall be tightly fastened with axles. Keys shall be so fitted and secured that they cannot work loose. All gears shall be provided with means for lubrication. (J.Nehru, 1999)
The spur gears shown in Figure 6 below are coupled to shaft 14 a, b and c.

![Fig. 7 Spur Driving Gears](image)

**DESIGN CONSIDERATIONS FOR A GEAR DRIVE**
In the design of a gear drive, the following data is usually given:
1. The power to be transmitted
2. The speed of the driving gear
3. The speed of the driven gear or the velocity ratio, and
4. The centre distance

The following requirements must be met in the design of a gear drive:

a. The gear teeth should have sufficient strength so that they will not fail under static loading or dynamic loading during normal running conditions
b. The gear teeth should have wear characteristics so that their life is satisfactory
c. The use of space and material should be economical
d. The alignment of the gears and deflections of the shafts must considered because they effect on the performance of the gears
e. The lubrication of the gears must be satisfactory. (Gupta, 2006)

**Gear Parameters**

Gear cutter to be used for cutting = 10DP (diametral pitch)
Module = $M = 1/DP = 25.4/10 = 2.54\text{mm}$
Addendum = Module = 2.54mm
Dedendum = $1.25M = 1.25 \times 2.54 = 3.75\text{mm}$
Working depth = $2M = 2 \times 2.54 = 5.08\text{mm}$
Minimum total depth = $2.25M = 2.25 \times 2.54 = 5.72\text{mm}$
Tooth thickness = $1.5708M = 1.5708 \times 2.54 = 3.99\text{mm}$
Minimum clearance = $0.25M = 0.25 \times 2.54 = 0.64\text{mm}$
Fillet radius = $0.4M = 0.4 \times 2.54 = 1.02\text{mm}$
Pitch circle diameter = 102mm
Number of teeth = $PCD \times DP = PCD/M = 102/2.54 = 20.08 = 20T$
Root diameter = $PCD-2DED = 102-2(3.175) = 95.65\text{mm}$
Base circle diameter = $PCD \cos 20^\circ = 102 \cos 20^\circ = 95.85\text{mm}$
Outside diameter = $PCD + 2Add = 102 + 2(3.175) = 95.65\text{mm}$
Circular pitch = $\pi PCD/N = \pi M = 8.01\text{mm}$
Circular tooth thickness = $\Pi pcd/2N = 1.57M = 1.57 \times 2.54 = 3.99\text{mm}$
Chordal thickness = $PCD \sin (90-20) = PCD \sin 70^\circ = 102 \sin 70^\circ$. (Hensel, 2003)

It is desired that the shafts rotate at substantially the same rate so that movement of the sugar cane stalk through the extractor will be smooth. The use of spur gears of the same diameter and gearing is therefore desirable.

**Stalk Block**

For ensuring proper and safe feeding of sugarcane stalk and guiding or directing the stalk towards the crushing rollers, a stalk block is fitted and attached fixed to the vertical left frame plate 8.
CONCLUSION
From the design, the following conclusions may be drawn:-
1. The sanitation of the device can be improved by providing easier access to clean the first and the extraction compartment.
2. Viewing of the extraction process is easy, simply by lifting the closure cover 4.
3. Additional ingredients can be added to the extracted juice with help of guide block 26.
4. The modified juice extractor is safe and can easily be operated.
5. Three dimensional design shows the true picture of all component parts and their assembly, as such tendencies of having scrap is minimal.

Recommendation
If fabricated using recommended materials and specifications, the machine can be used for research purposes, commercial and even for small and medium scale enterprises.

References


