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PERFORMANCE EFFECTIVENESS OF CASSAVA FLOUR PROCESSING MACHINE FOR SMALL-MEDIUM INDUSTRIES

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ABSTRACT

Cassava is one of the favorite foods in Indonesia. Tual and Southeast Maluku Province are the regions with cassava as their staple food since the ancient time, which in local language it is called "embal". The processing of cassava into traditional foods is still performed manually which in its process includes: peeling, cleaning, slice, and dried with squeezing step to release the water content, and then sieved by using a plaited bamboo sieve. Manual processing is far from economic because it requires plenty of time and energy. This research aims to find out the performance effectiveness of cassava processing machine for small and medium industries. This research used an engineering method by designing the cassava processing machine. This machine has three main parts: 1) Screw conveyor with a 1/2 HP motor with 1430 rpm torque, to reduce the gearbox torque (type 60) with the ratio of 1:50, 2) Grinder, FFC 23 mesh 0.5 type with 3 HP and 2300 rpm motor, 3) Sieve with 3/4 HP and 1430 rpm motor to reduce the gearbox (type 60) torque with a ratio of 1:30. The produced capacity by the cassava processing machine is 30 kg/hour.

KEYWORDS: Cassava, Flour Processing Machine Performance & Machine Built-up Design

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INTRODUCTION

Cassava is one of Indonesia's local carbohydrate sources which is the third-largest after rice and maize. This plant has the potential to be processed into flour [1]. In general, cassava fruit is white and cannot be directly consumed because fresh cassava contains cyanide which is very toxic to humans and animals. Therefore it needs to be processed to reduce the cyanide content to a safe level [2]. Currently, the processing of cassava in Southeast Maluku and Tual City is performed manually. The cassava is shredded manually by hands and slice using slicer equipment. Sliced cassava is then put into the sack, and on top, it is given a weight in the form of stone as a ballast material. After that, it is sieved into the flour with a sieve made of bamboo. For efficiency and economic reasons, better processing machine is required [3]. The research method used is the engineering method [4]. The research objective is implied by the manufacture of cassava flour processing machine that has a strong construction, adequate and efficient facilities to facilitate operation and produce quality flour. The type of conveyor can be selected based on the suitability of the fulfilment of the raw material requirements by the characteristics of a conveyor, the score calculation is carried out through the weighted evaluation method and the expected value criteria [5]. There are some researches related to cassava flour processing machines reported that the transfer process from one stage to another using material equipment is designed in such a way as to facilitate the loading process by human hands. For example, a conveyor system that can be used to facilitate the transportation of material [6]. Where the choice of a conveyor or other moving equipment is affected by the type of material being transferred. The capacity required in a

certain time, direction and length of transfer as well as economic value factors are also necessary for selecting material equipment [7]. The process of milling agricultural products is one of the oldest human cultural engineering processes. As a reduction in size, processing and storage the farmers are forced to develop technology to grind their products [8]. In the design of the sieving device, it was found that a tool to separate unused minerals was used a sand sieving machine with a motor power of 1.5 HP with a rotation of 1,400 rpm to reduce rotation, a gearbox reducer type 60 was used, the screen movement was transmitting back and forth connected to the crankshaft, the resulting capacity of 500 kg/hour sand sieving machine, [9]. In previous studies, the design of cassava flour making equipment greatly affects the level of comfort for operators when operating [10]. Because with the machine, the agricultural products of cassava flour, which are the staple food of the community can be processed quickly using machine power and in a short time. The remaining moisture content in the process of drying the chopped cassava with sunlight, the residual moisture content generally ranges from 12-15% to produce tapioca flour with a lower level of dryness than oven drying machines [11]. The degree of fineness of tapioca flour that is processed manually will usually be coarse due to the use of an unsuitable sieve and size. Mesh is the number of holes in 1 linear inch; the standard of flour fineness is 0.09 mm with the sieve material used is made of stainless steel. With the data and conditions in the field, we try to design and build a simple cassava flour processing machine so that it can streamline time and energy in processing cassava flour, which still uses manual processes.

RESEARCH METHOD

1. Tools and Materials

The tools used in the manufacture of cassava flour processing machine are cutting grinder machine, hand-handled grinder, and hand-handled drilling machine, 120-ampere welding machine, lathe, hand-handled saw, 30-cm meter, elbow tool 45°, plate scissor, hammer, wire brush, calliper, and ruler. The raw materials used in the testing of the cassava flour processing machine is cassava with harvesting age of 7-8 months. The used cassava fermentation preservative is stater Bimo CV.

2. Materials Used in the Construction of Flour Processing Machine

The making of the frame of cassava flour processing machine included: The making of conveyor frame, grinder frame, and sieve frame, which were made of C- grade steel sized 2cm x 2cm x 8 cm, with 3 mm thickness, using material S 45 C, the aluminium plate with 1 mm and 0.5 mm plate thickness. Stainless steel plate with a thickness of 0.5 mm and 1 mm. The collected data from the designing result were obtained using stopwatch and scale used to measure the water level in wet cassava, dried cassava, and flour.

3. Designing Method

The designing method used is the engineering method in the process of designing and building a cassava flour processing machine. With the design, the stage was covering dimensions, including length, width and height. Materials were iron, aluminium, plastic and others. Considered questions included how is the mechanical system of the machine so that cassava fruit can become flour, how are the series of electricity sources and construction used for the flour processing machine and the control method, in other words how the process runs and the process of flour production.

4. Construction of Cassava Flour Processing Machine Design

- The design of the cassava flour processing machine is shown in Figure 1 and divided into three main parts:
- Screw Conveyor which consists of a conveyor screw mounting tool frame, screw pipe, screw shaft, bearings,

electric motor, pulley, fanbelt, sprocket, chain, cassava filling funnel, cassava material outlet funnel and fastening bolt nuts.

- Cassava grinding equipment consists of a frame for a grinder holder, grinder, electric motor, pulley, fanbelt, cassava filling funnel, cassava material outlet funnel and fastening bolts.
- Cassava flour sieve consists of sieve holder frame, sieve, electric motor, pulley, fanbelt, spring, bearing funnel for filling cassava material, sieving frame body, storage tub for cassava flour, cassava material outlet, cassava sieve shaft and bolt nuts fastener

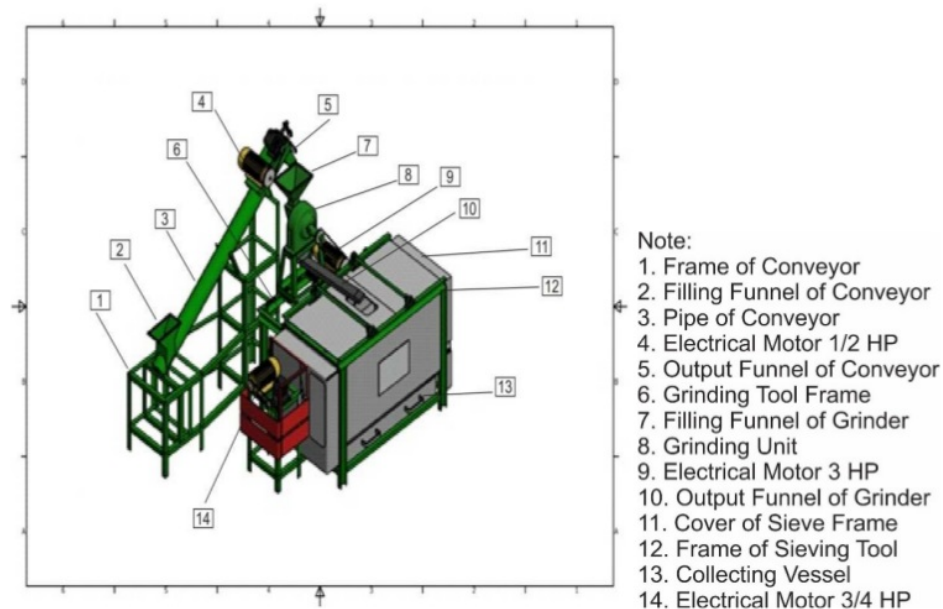


Figure 1: Build-up Design of Cassava Flour Processing Machine.

3. Trial Run Step

After all, the planning and design stages have been completed, and the next step is testing to evaluate whether the flour processing machine can work following the functions of each part, both from the mechanical and electrical side.

4. Design Calculation

Calculation mechanical components include pulley selection, belt length, and the distance between pulley centers, sprocket selection, chain length, and distance between sprocket centers. And calculate the rotational speed of the conveyor (Figure 2.A), the rotational speed of the grinder (figure 2.B), and the rotational speed of the sieve (figure 2.C).

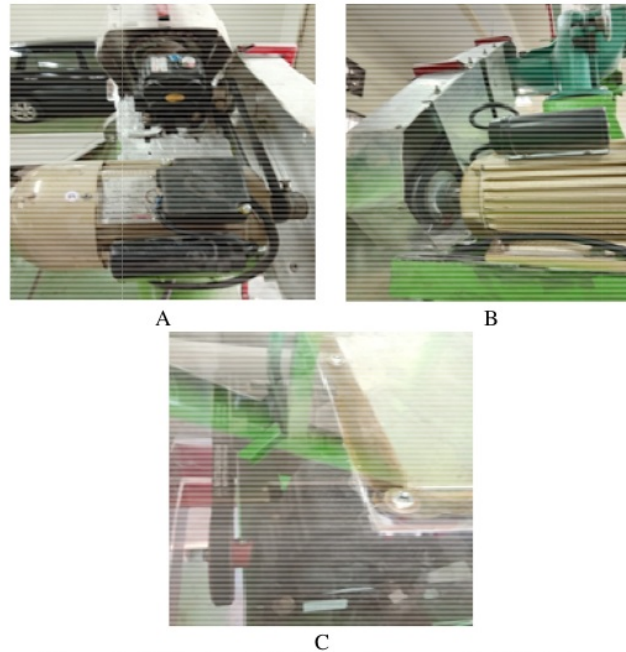


Figure 2. (A) Design of the Screw Conveyor Tool Rotation. (B) The Design of the Grinder Rotation (C) the Design of the Sieve Rotation.

5. Used Formulas

- Main components of the designed screw conveyor
- Calculation of machine speed (N2) generated on the conveyor. The speed of the motor that drives the conveyor tool is known (N1) 1430 rpm [12].
- $N2 = (N1 \times 2) : 3$ (1)
- Calculation of the gear box ratio (N3). The gear box ratio used is: (1:50) data:
- since type gear box = WP A 40 [12].
- $N3 = (N2 \times 1) : 50$ (2)
- Calculating gear box ratio (N4) [12].
- $N4 = (N3 \times 3) : 1,5$ (3)
- Figure 3 is the schematic of belt transmission for screw conveyor, grinder and sieve

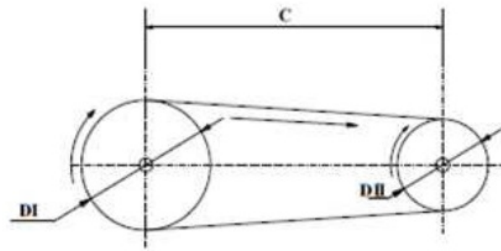


Figure 3: Schematic of Belt Transmission in Screw Conveyor.

- Selection of the appropriate belt.

Selection of the belt type according to the carpet diagram shown in the figure 4 .

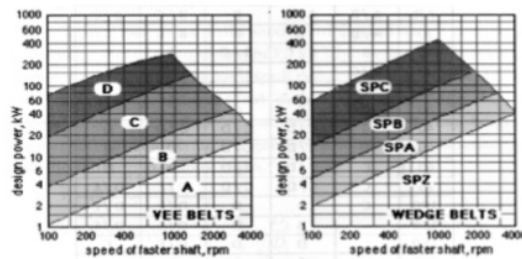


Figure 4: Carpet Diagram [13].

- Calculation of the distance between the pulley centers

So that based on the equation, it can be obtained the distance between the centers of the pulley (c) with the following equation [13].

$$C = 3 (D1 + D2) \quad (4)$$

- Calculating the circumference of the belt.

To obtain the circumference of the belt, the following equation is used [13].

$$L = 2C + (D1 + D2) \quad (5)$$

- Schematic planning of transmission of sprocket, chain on conveyor.
- Determining the size of the sprocket with the following equation. [13].

$$D = \frac{\text{Pitch}}{\sin \left[\frac{180^\circ}{\text{Gear Number}} \right]} \quad (6)$$

- Determining the length of the chain and sprocket with the following equation [13].

$$L = 2c + \frac{N_2 + N_1}{2} + \frac{(N_2 + N_1)^2}{4\pi^2 \cdot c} \quad (7)$$

- Determining the distance between the centers of the sprocket

Distance between the centers of the Cs sprocket is questioned. So based on the following equation [13]:

$$C_s = \frac{1}{4} \left[L - \frac{N_2 + N_1}{2} + \sqrt{\left(L - \frac{N_2 + N_1}{2} \right)^2 - \frac{8(N_2 + N_1)^2}{4\pi^2}} \right] \quad (8)$$

- Determining the diameter of the conveyor screw shaft, with the following equation [14].

$$T = \frac{\pi}{16} T d_0^3 \left(1 - \frac{d_1}{d_0} \right)^4$$

- Main components of designed grinding tool
- Calculating the machine speed (N2) generated on the grinder. Electric motor rotation (N1) 2890 rpm, with the following equation. [12].

$$N_2 = (N_1 \times 4): 3 \quad (9)$$

- Schematic drawing of the belt transmission on the grinder can be seen in Figure 3
- Selection of appropriate belts.

The type of belt is selected based on the power and rotation of the initial drive used and can be obtained from the carpet diagram in Figure 4.

- Calculating distance between the centers of the pulleys, with the following equation [13].

$$3(D_1 + D_2) \quad (10)$$

- Calculating the circumference of the belt, with the following equation [13].

$$L = 2C + (D_1 + D_2) \quad (11)$$

- The main component of the designed sieve
- Calculating the machine speed (N2) generated on the sieve unit. The rotation of the motor driving the sieve (N1) is known as 1430 rpm. [12].

$$N_2 = (N_1 \times 3): 2 \quad (12)$$

- Calculating gear box ratio. [12].

$$N_3 = (N_2 \times 1): 30 \quad (13)$$

- Calculating gear box ratio (N4). [12].

$$N_4 = (N_3 \times 4): \frac{1}{2} \quad (14)$$

- The schematic image of the belt transmission on the sieving device can be seen in Figure 3
- Selection of appropriate belts.

The type of belt is selected based on the initial power and rotation used and can be obtained from the carpet diagram in figure 4.

- Calculating distance between pulley centers with the following equation.

$$3(D1+D2) \quad (15)$$

- Calculating the circumference of the belt using the following equation [13].

$$L = 2C + (D1+D2) \quad (16)$$

RESULTS AND DISCUSSIONS

1. Design of Flour Processing Machine

This design is more focused on what is stated in general objectives: the effectiveness of the performance of the cassava flour processing machine which includes screw conveyor, grinder and sieve with a capacity of 30 kg/hour with excellent results shown in Figure 5. Related researches. The design of cassava tapioca flour producing machine with three steps is implemented in one process series with shorter duration and higher production. The three phases, including grating, squeezing, and sieving, require high energy in one run of processing averagely 5 kg cassava, which needs 11 minutes processing time. The resulted tapioca flour is minimal, an average of 5 kg of cassava produce 300-350 grams because the processed cassava is not fresh or dried so that the cassava starch produced is minimal. [15].



Figure 5: The Result of Designed Cassava Flour Processing Machine.

2. The Results of the Trial Run of the Cassava Flour Processing Machine with the Measurement of each Tool Dimensions are

- Screw conveyor with Ø 5 inch pipe and 2 meters in length, 1 inch screw conveyor shaft diameter with a 35° slope of the screw conveyor
- Grinder with FFC 23 size, dimensions 687x429x115 with 0.5 mm mesh size
- Cassava flour sieve with a length of 1400 cm x width 7.76 cm x height 1080 cm with mesh sieve size 60.

3. Calculation Data of Cassava Flour Processing Machine Components

- Screw conveyor holder. Electric motor = ½ hp, rotation N1 = 1430 rpm, N2 = 953.33 rpm, N3 = 19.06, N4 = 47.65 rpm, fan belt type A, distance between pulley centers = 15 inch, length of belt circumference = 24.47 inch,

gear box ratio = 47.65 rpm, sprocket size \varnothing D 5 inch, \varnothing d 2 inch, chain length 26 inch, distance between sprocket center 20 pitch. Screw conveyor rotating speed = 47.65 rpm, \varnothing screw conveyor shaft = 25 mm

- Grinder holder. Electric motor = 3 hp, rotation N1 = 2890 rpm, N2 = 3853.3 rpm, fanbelt type A / B, distance between pulley centers = 21 inch, length of belt circumference = 56.57 inch \varnothing . the result of the rotating speed of the grinding tool = 3853.33 rpm
- Flour sieve. Electric motor = 3/4 hp, N1 rotation = 1430 rpm, N2 = 2145rpm, N3 = 71.5 rpm, N4 = 143 rpm, fan belt type A, distance between pulley centers = 7 inch, belt circumference length = 20.57 inch, ratio gear box = 143 rpm, the result of the sieving tool rotational speed = 143 rpm

4. Trial Processing Data

In the process of testing the production of cassava flour, the following results were obtained:

Table 4.1: Trial Process Data

Trial	Cassava Raw Material	Cassava Weight	Production Time
1	Wet Cassava	100 kg	1 jam
2	Dried Cassava	50 kg	40 jam
3	Cassava Flour	30 kg	1 jam

CONCLUSIONS

The results of the designed cassava flour processing machine are considered adequate and able to facilitate human power in the processing of cassava flour which is still performed traditionally and takes a long duration of time. This traditional flour processing produces 40 kg of flour/day by the processes of peeling, grating, squeezing and sieving with a bamboo sieve.

The results of the processing of cassava with a harvesting age of 7 months, with the cassava in fresh, wet, peeled, washed conditions and chopped with a machine with a thickness of 2-3mm, the weight of cassava is 100kg. Cassava is dried under the sun for 4 - 5 days with 12-13% remaining moisture content, making the weight of cassava reduced to 50kg. When dried cassava is processed into the flour with a machine of 5kg filling capacity, the time required to produce powder is 10 minutes with a mesh size of 60 on the machine sieve. If the flour processing process is developed, the yield of cassava flour for 1 hour is 30 kg.

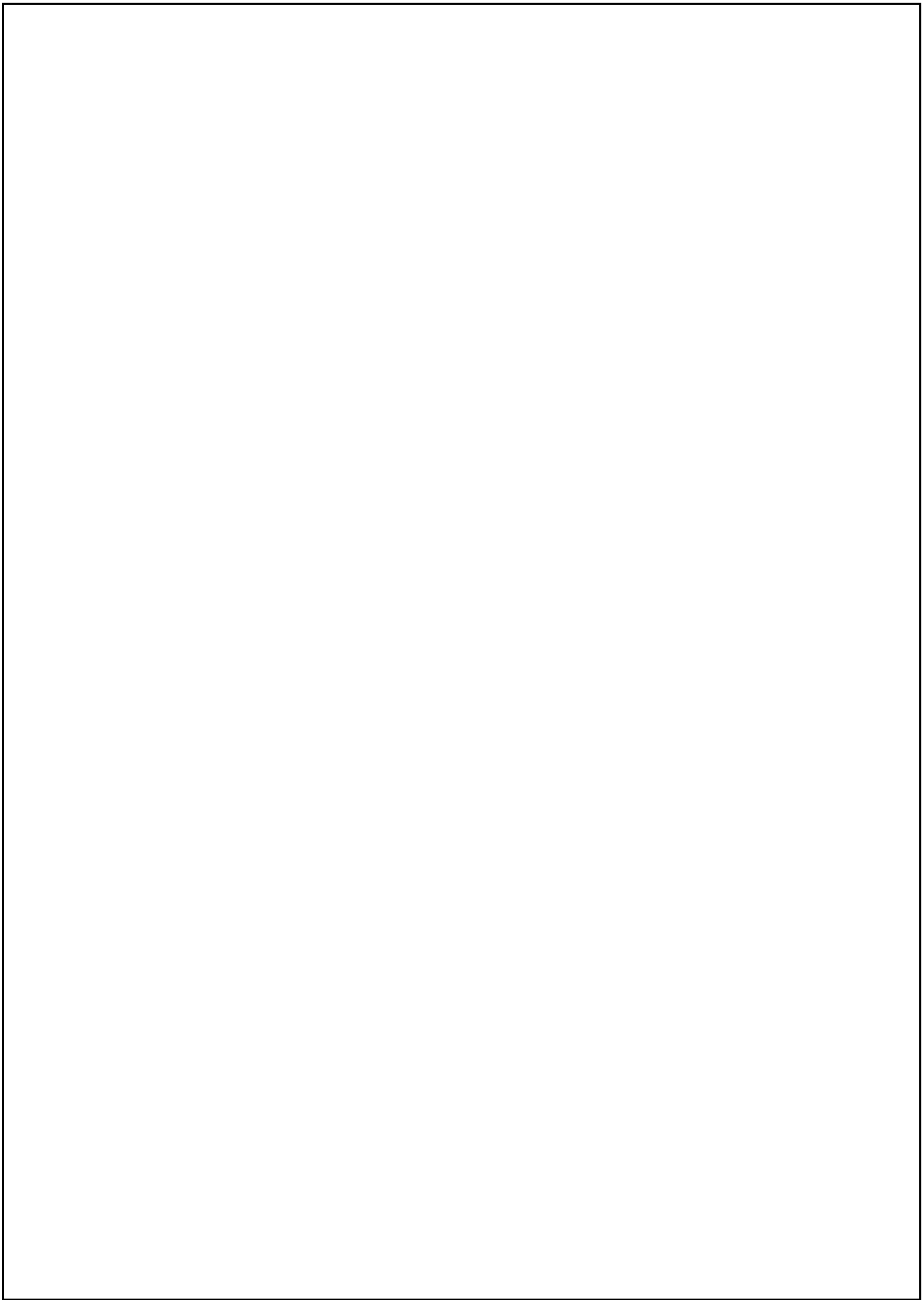
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