EJSIT

European Journal of Science, Innovation and Technology

ISSN: 2786-4936

www.ejsit-journal.com

Volume 3 | Number 2 | 2023

Development and Acceptance of Tomato Paste Processing Machine

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Abstract

Tomato products such as puree and tomato paste are used for the preparation of many food products which may include frozen food, pasta and pizza toppings, etc. Good quality tomato-based products are manufactured with good solid content, and the viscosity of the produce is derived from the combination of water with the fibrous strands in the tomato paste and the gelling effect of pectin found naturally in tomatoes. The developed prototype will be used in the preparation of the tomato paste as the final product used by different restaurants, wanders, cafeterias etc. The ketchup that is already used is costlier and full of preservatives which is not preferable for human health, whereas this machine produces 100% pure and hygienic ketchup without preservatives and it is also cheaper. This machine may be used for continuous ketchup production. Only one person can handle the machine.

The main objective of this study is to design and develop a "Tomato Paste Processing Machine". Specifically, it seeks to achieve the following objectives: (1) to identify the components needed to construct the "Tomato Paste Processing Machine" that can satisfy the standard requirements; (2) to determine the performance of the "Tomato Paste Processing Machine" in terms of extraction and machine efficiency; (3) to determine the acceptability of the machine in terms of evenness of cooking and mixing consistency as perceived by the machine user.

Keywords: Tomato Paste Processing Machine, extraction efficiency, belt and pulley, motor, torque

Introduction

Tomatoes are the major dietary source of the antioxidant lycopene, which has been linked to many health benefits, including reduced risk of heart disease and cancer. Tomato (*Solanum lycopersicum*), flowering plant of the nightshade family (*Solanaceae*), cultivated extensively for its edible fruits. Labelled as a vegetable for nutritional purposes, tomatoes are a good source of vitamin C, potassium, folate, Vitamin K and the phytochemical lycopene (Bjarnadottir, 2019). The fruits are commonly eaten raw in salads, served as a cooked vegetable, used as an ingredient of various prepared dishes, and pickled. Additionally, a large percentage of the world's tomato juice, ketchup, puree, paste, and sundried tomatoes. The amount of solid in Tomato Paste is covered by product standard, and the relevant standard for your area must be consulted. In the United States and according to Codex Alimentarius, tomato paste must contain at least 24% tomato solids on a salt-free basis. The use of artificial color is not permitted under any conditions. Only whole tomato paste may be called 'paste' without qualification. Commercially, this product nearly always contains salt and basils. Tomato Paste is common product which can be preserved by hot-filling at temperature of 90-92 Celcius without further pasteurization (Crawshaw, 2010).

In Laguna, it is found abundant in Municipality of Kalayaan. But most of the tomatoes are useless because of its oversupply. Last October 2018, there were breaking news of an oversupply of tomatoes which drove local farmers to discard more than ten tons of tomatoes that have begun to rot in Kalayaan town in Laguna province. The wastage prompted the provincial agriculture office to come up with measures like training vegetable growers on proper supply forecast. Unfortunately, the rejected tomatoes were of a different variety from those that could be processed into tomato paste or sauce.

The main reason of this project is to help the tomato farmers in Kalayaan, Laguna so that the excess tomatoes can be made use into tomato paste and earned profit out of it. It has a greater advantage than the traditional way of extracting which was by using a blender. Using blender is not suited for large scale production due to the time it would consume. The “Tomato Paste Processing Machine” would not consume a lot of time just by extracting and straining. The juice of tomatoes can be extracted and strained in just a second. When cooking, this machine has an on/off switch mixer that can help the tomato paste cooked evenly. Also, this machine may lessen the man power in cooking tomato paste.

Methodology

Data Gathering Procedure

Basically, the study is to design and development of Tomato Paste Processing Machine, which comprises of the whole cooking process and the separation of the tomatoes skin and seeds from its juice easier. AC motor, served as the heart and prime mover of the whole system, since it initializes the power needed to operate the machine. It provides rotary power which is essential for the actuator to perform its duty. Regarding the belts and pulley, and in terms of speed that used as guide to develop and construct the Design and Fabrication of the Tomato Paste Processing Machine.

The researchers used various references in gathering data, information and procedures for the accomplishment of the study, it included books references, journals, other educating materials and basically from the internet. These ideas should be the basis in making and improving the preliminary idea on what would be the necessary requirements that can satisfy through the development of this research.

It is necessary to find and have a background research or information about different juicing and cooking equipment and procedures to fully satisfy our knowledge in creating and developing the Tomato Paste Processing Machine. The researchers used related facts and other related technical materials which were significant in the theory and principle were used in designing the study.

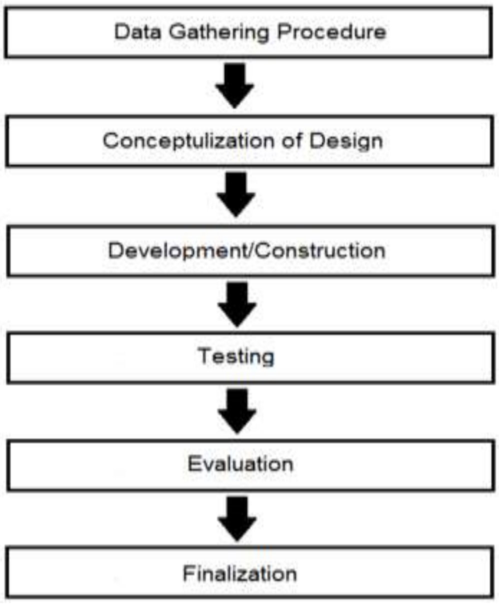


Figure 1: The Research Process Flow

Construction Procedure

The researchers used the following procedures in developing and constructing the project to meet the desired design and output.

1. Gathering of data needed in the conceptualization of designing the Tomato Paste Processing Machine.
2. Drawing and design calculations of the desired prototype including the heating and cooling elements.
3. Canvassing and purchasing of materials based on the standard specifications required of the designed prototype.
4. Cutting and welding of metals for prototype frame assembling.
5. Grinding and polishing of excess metal for the designed prototype.
6. Assembling and installing of the components that must be on the designed prototype.
7. Prototype finalization, test and revision if there is identified error or malfunction in the prototype.

Results and Discussion

Project Description

The research revolved through the theories and concepts gathered by the researchers from the fields and interest from related studies and literature with the Tomato Paste Processing Machine through the intended developed equipment design. This served as a more conventional way of making tomato paste that can produce more.

The machine contained a fan type blade that can crush the boiled tomatoes to get its juice. It also consisted of a layer of filter that can filter out the juice, the seed and the skin of the tomatoes. It also has a mixer that can mix while the tomato juice is cooking.

Physical Description

Below is the image and components of the Tomato Paste Processing Machine in terms of its height, weight, dimensions, structures, and color of the project.

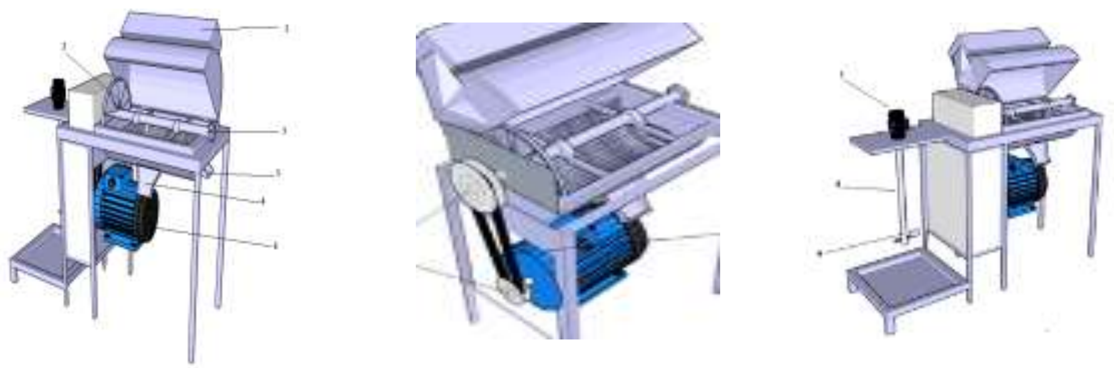


Figure 2: Tomato Paste Processing Machine

The prime mover of the prototype was the motor (6). The belt (10) and pulleys (11) were located at the middle of the machine and were connected to the shaft that rotated (3) the blade (2). Blade was the one that crushed the tomatoes from the feeder (1). The skin and seeds outlet (5) were located at the right side of the machine. The juice outlet (4) was located at the front of the machine where the tomato juice came out. Then, the juice would be transferred in the mixing area that rotated and powered by a low speed motor (7) where shaft (8) supports the spatula (9) in mixing and cooking the tomato juice.

Specification:
Material: Stainless Steel Bar
Length: 46 inches
Width: 17 inches
Height: 53 inches
Motor
Specification: 2Hp, 220V, 60Hz, 1740rpm
Shafting
Material: Stainless Steel Shafting
Length and Diameters:
3ft of 5/8 inches diameter shaft
2ft of $2\frac{1}{2}$ inches diameter shaft
Overall Physical Property
Length: 46 inches
Width: 17 inches
Height: 53 inches
Color
Stainless Color

Design Calculations

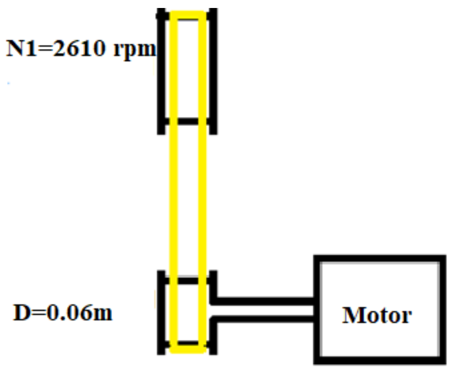
This was the process of designing the immediate lay out of the proposed project. Also in this stage, the dimensions of the component of the project were identified through computations. Principles of Machine Design, Machine Elements were used in this stage such as;

Sizing of Motor

Sources of Formulas: Machine Design 1 & Machine Design 2 Books by Jose R. Francisco, PME, Machine Design by R.S. Khurmi and J.K. Gupta, Design of Machine Elements by V.M. Faires.

Sources of Tables: Design of Machine Elements by Virgil Moring Faires.

****Solving for tangential force***



Given:

$N1^2 = 2610\ rpm$ = Speed of the motor based on Peeling and Juicing machine of the Shanghai Triowin (en.triowin.com)

$m = 12$kg = Capacity of tomatoes to be extracted

$D^2 = 0.06\ m$ = Size of the smaller pulley on the machine

Solution:

Formula of the Tangential Force by R.S. Khurmi and J.K. Gupta, Machine Design:

$$F_t = N1^2 m D^2$$

$$F_t = (\frac{2610rpm}{60})^2(12kg)(0.06m)^2$$

$$F_t = 81.7452N \times \frac{1KN}{1000N}$$

$$F_t = 0.0817KN$$

***Solving for the torque of shaft**

Given:

$F_t = 0.0817\ KN$ = Tangential Force

D = 0.12 m = Diameter of the bigger pulley on the machine

Solution:

$$T_q = F_t(\frac{D}{2})$$

$$T_q = 0.0817KN(\frac{0.12m}{2})$$

$$T_q = 4.902 \times 10^{-3}\ KN \cdot m$$

***Solving for Motor Hp,**

Given:

$T_q = 4.902 \times 10^{-3}\ KN \cdot m$ = Torque of the Shaft

$N = 2610\ rpm$ = Speed of the motor

Solution:

$$P = \frac{\pi TN}{30}$$

$$P = \frac{\pi(4.902 \times 10^{-3} KN \cdot m)(2610rpm)}{30}$$

$$P = 1.3398KW \times \frac{1Hp}{0.746KW}$$

$$P = 1.8Hp$$

Therefore, use Motor Hp = 1.5 Hp

Belt and Pulley

Determination of the appropriate belt section,

From Table 17.7 (Design of Machine Elements by V. M. Faires)

Driving Machines: AC Repulsion Induction

Driven Machines: line shaft

Nsf = 1.1

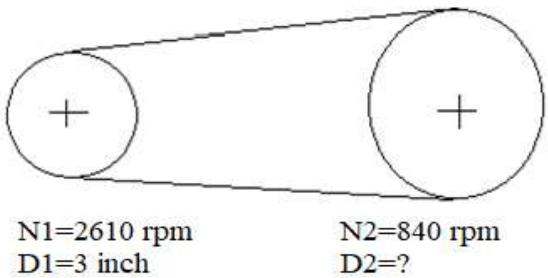
***Solving for the design Hp**
Design Hp = Nsf(Hp)
Design Hp = (1.1) (1.5)
Design Hp = 1.7Hp
Selecting the belt section, from Figure 17.14 (Design of Machine Elements by V. M. Faires)

@2610 rpm and 1.7 design Hp: Use, A-section V-belt
Determination of Rated Hp per belt
From Table 17.3 (Design of Machine Elements by V. M. Faires), Use $D_1 = 3"$ (minimum diameter)

**Solving for Vm*
Given:
$$D_1 = 3" = \text{ Minimum Diameter found in table } 17.3$$
Solution:
$$Vm = \pi\left(\frac{3}{12}\right)(2610)$$
$$Vm = 2049.89\, fpm$$

For the diameter of the Driven sheave,

Where:



$$D_1 = 3" = \text{ Minimum Diameter}$$

N1= 2610 rpm = Speed on the smaller pulley based on Peeling and Juicing machine of the Shanghai Triowin (en.triowin.com)
N2=840 rpm= Speed on the bigger pulley based on Peeling and Juicing machine of the Shanghai Triowin (en.triowin.com)
Solution:
$$D_2 = D_1\left(\frac{N_1}{N_2}\right)$$
$$D_2 = (3)\left(\frac{2610}{840}\right)$$
$$D_2 = 9.32 inch$$

$$\frac{D_2}{D_1} = \frac{9.32}{3} = 3.1, Kd = 1.14$$

***Solving for the rated Hp,**

$$Rated\ Hp = \frac{\left[a\left(\frac{10^3}{Vm}\right)^{.09} - \frac{c}{KdD_1} - e\left(\frac{Vm^2}{10^6}\right)\right]Vm}{10^3}$$

a = 2.684
c = 5.326
e = 0.0136

$$Rated\ Hp = \frac{\left[2.684\left(\frac{10^3}{2049.89}\right)^{.09} - \frac{5.326}{(1.14)(3)} - 0.0136\left(\frac{2049.89^{\ 2}}{10^6}\right)\right](2049.89\ )}{10^3}$$
$$Rated\ Hp = 1.8\ Hp/Belt$$

Determining of Adjusted Hp

***Solving for the center distance**

$$C = \frac{D_1 + D_2}{2} + D_1$$
$$C = \frac{9.32 + 3}{2} + 3$$
$$C = 9.16\ inches$$

***Solving for belt length**

$$L = \frac{\pi}{2}(D_1 + D_2) + 2C + \frac{(D_2 - D_1)^2}{4C}$$
$$L = \frac{\pi}{2}(3 + 9.32) + 2(9.16) + \frac{(9.32 - 3)^2}{4(9.32)}$$
$$L = 38.74\ inches$$

A38, L = 39.3 inch.

Computation for the actual Center Distance,

$$C = \frac{B + \sqrt{B^2 - 32(D_2 - D_1)^2}}{16}$$

Where:

$$B = 4L - 6.28(D_2 + D_1)$$
$$B = 4(39.3) - 6.28(9.32 + 3)$$
$$B = 79.83$$

Then,

$$C = \frac{79.83 + \sqrt{79.83 - 32(9.32 - 3)^2}}{16}$$
$$C = 9.45\ inch$$

$$\frac{D_{2+}D_1}{C} = \frac{9.32+3}{9.45} = 1.3$$
$$K_\theta = .73$$

For the belt length correction factor, from Table 17.6 (Design of Machine Elements by V. M. Faires), V-belt A38$K_l = 1.2$

***Solving for the number of belts**

$$Number\ of\ belts = \frac{Design\ Hp}{Adjusted\ Rated\ Hp}$$

$$Number\ of\ belts = \frac{1.65Hp}{1.6206Hp/Belt}$$

$$Number\ of\ belts = 1\ belt$$

Break Even Analysis

Formula for breakeven analysis,

$$Breakeven\ Point = \frac{Fixed\ cost}{Sales\ price\ per\ unit - Variable\ cost\ per\ unit}$$

Break Even point – Amount of Tomatoes per process
Fixed cost – Total cost of the Tomato Paste Processing Machine.
Sales price per unit – The selling price of Tomato Paste per process.
Fixed cost = Php 42,000.00
Sales price per unit = Php 700.00 per process

Solving for Variable cost per unit

Expenses:
Laborer salary per day = Php 250.00
Number of laborer per unit = 1
Cost = (Laborer Salary) (Number of laborer)
Cost = (250 pesos)(1) = Php 250.00

Solving for the power consumption of the machine:

Motor power = 2 Hp = 1.491 KW
Maximum Usage Time per day = 8 hours
Cost per kWh (Residential Rate) = Php 11.00
Cost = (Power) (Time) (Cost per kWh)
Cost = (1.491 kW) (8 hours) (Php 11.00 per kWh)
Cost per day =Php131.21 (at Maximum Load)
Total expenses = 250 + 131.21 = Php 381.21

Variable cost per 12 kilos of Tomatoes = Php 381.21

$$Breakeven\ point = \frac{Fixed\ cost}{Sales\ price\ per\ unit - Variable\ cost\ per\ unit}$$

$$Breakeven\ point = \frac{Php\ 42{,}000.00}{(Php\ 700\ process - Php\ 381.21\ process)}$$

$$Breakeven\ point = 132\ process$$

***In** every 1 process of tomato paste processing machine it is equivalent to 12 kilos of tomatoes, if the tomatoes we're extracted and cooked it became 7 kilos tomato paste.

Break Even Point = 132 Process of Tomato Paste

Therefore, given the fixed cost, variable cost per unit, and the selling price of the tomatoes, the machine need to process at least 132 to break even.

Trials and Revision

To be able to achieve a consistent and operational result of the prototype, consecutive trials and enhancements were made by the proponents. The table below shows the desired output. The try-out and revision was also used to gather the data about the operation and production of the machine and a come up with a product.

Table 1: Trials and Remarks

Trials	Tomatoes (kg)	Juicing Rate	Kilos of Juice extracted (kg)	Tomato Juice Extraction Efficiency (%)	Remarks
1st	10	7 mins	6	60%	Effective
2nd	10	8 mins	7	70%	Effective
3rd	12	10 mins	9	75%	Success
4th	12	10 mins	9	75%	Success

During the fabrication period of the design project, the researchers made some adjustments of their design for a more reliable and better outcome. Table 1 shows different testing and outcomes conducted by the researchers. With the testing and revisions made by the researchers in their project they came up using 2 Hp electric motor as the prime mover and rotating element where the components and linked. The researchers used a rotating fan type blade to crush the tomatoes and they also put a sieve to gain the right juice extraction efficiency. In terms of cooking the tomato juice, they used an automated rotating mixer to have an evenly cooked tomato paste.

Table 2: Efficiency of Tomato Paste Processing Machine

Trial	Input (kg)	Output (kg)	Efficiency (%)
1	12 kg	7 kg	58.33 %
2	12 kg	8.3 kg	69.17%
3	12 kg	9 kg	75%
AVERAGE	**12 kg**	**8.1 kg**	**67.50%**

Table 2 shows the efficiency of the project Tomato Paste Processing Machine. On the 1st trial, 12 kg of tomatoes was extracted with the efficiency of 58.33%. On the 2nd trial, 12 kg of tomatoes was extracted with the efficiency of 69.17%. On the 3rd trial, 12 kg of tomatoes was extracted with the efficiency of 75%. The average efficiency of extracting the 12 kg of tomatoes was 67.50%.

Evaluation Results

The result of the evaluation for the effectiveness of the mechanize process of Extracting, Mixing and Cooking of Tomato Paste and the Acceptability of the product Tomato Paste was presented. The data were gathered from (15) respondents of Kalayaan, Laguna.

Table 3: Effectiveness of the mechanize process of Extracting, Mixing and Cooking of Tomato Paste

Criteria	Mean	Standard Deviation	Verbal Interpretation	Remarks
1. The machine can mix the ingredients evenly.	3.67	0.47	Highly Acceptable	Highly Acceptable
2. The machine can extract 12kgs of tomato for 9mins.	3.73	0.44	Highly Acceptable	Highly Acceptable

3. The machine can cook 9kg of tomato paste for 2hrs.	4.00	0	Highly Acceptable	Highly Acceptable
4. The machine can cook tomato paste well.	3.8	0.4	Highly Acceptable	Highly Acceptable
AVERAGE WEIGHTED MEAN	3.8			Highly Acceptable

Table 3 shows the effectiveness of the mechanize process of extracting, mixing and cooking Tomato Paste in the machine. Criteria 1 has a computed mean of 3.67, a standard deviation of 0.47 and a remark of "Highly Acceptable". Criteria 2 has a computed mean of 3.73, a standard deviation of 0.44 that has also a remark of "Highly Acceptable". Criteria 3 has a computed mean of 4.00, a standard deviation of 0 with a remark of "Highly Acceptable" and Criteria 4 has a computed mean of 3.38, a standard deviation of 0.4 with "Highly Acceptable" remark. Over all, the average weighted mean was 3.8 which remark as "Highly Acceptable" based on the respondents.

Table 4: Acceptability of Product Tomato Paste

Criteria	Mean	Standard Deviation	Verbal Interpretation	Remarks
1. Tomato Paste has a good quality.	4.00	0	Highly Acceptable	Highly Acceptable
2. Tomato paste does not taste like burnt when cooked at the machine.	3.87	0.35	Highly Acceptable	Highly Acceptable
3. Taste of the Tomato Paste was achieved.	3.73	0.44	Highly Acceptable	Highly Acceptable
4. Stickiness of the Tomato Paste was achieved.	3.87	0.35	Highly Acceptable	Highly Acceptable
AVERAGE WEIGHTED MEAN	3.9			Highly Acceptable

Table 4 shows the acceptability of the Product Tomato Paste. The Criteria 1 has a computed mean of 4.00, a standard deviation of 0 and a remark of "Highly Acceptable". Criteria 2 has a computed mean of 3.87, a standard deviation of 0.35 that has also a remark of "Highly Acceptable". Criteria 3 has a computed mean of 3.73, a standard deviation of 0.44 with a remark of "Highly Acceptable" and Criteria 4 has a computed mean of 3.87, a standard deviation of 0.35 with "Highly Acceptable" remark. Over all, the average weighted mean is 3.9 which remark as "Highly Acceptable" based on the respondents.

Conclusion

The researchers were able to determine the important ideas and principle upon the development of the study, it was determined that:

The component to design and construct Tomato Paste Processing Machine was developed with specifications of components like: Blades, Sieve, a Rotating Shafts and a Mixer.

Based on the trials performed by the researchers:

The juice extraction ranges from 6-9 minutes of juicing process and the efficiency of the juice from the 12 kilos of tomatoes ranges from 60%-75% so therefore using the machine the production was much faster than the traditional way of making tomato paste.

Based on the survey that was conducted, the tomato paste resulted as a good quality product. It does not burn the tomato juice and it the ingredients mix evenly. In terms of consistency of mixing it has a computed mean of 3.67, a standard deviation of 0.47 and a remark of 'Highly Acceptable'.

The researchers operating approximately for 8hrs/day, it would take 1 month and 3 days for all the investment to be returned. For determined that with the prototype every 2 hours there one processed, in 8 hours per day, the total processed tomato paste are 4 processes. To meet the 132 process, the machine should run for at least 1 month and 3 days to break even.

Recommendation

Improvement in the project can be made by applying recommendations from the researchers. The Tomato Paste Processing Machine has rooms for improvement which are expressed in the following recommendation:

1. The future researchers may attach a blower for the continuous flow of skin and seeds.
2. The future researchers may develop a machine for the study of biomass procedure for the skin and seeds of the tomato.

References

Amiss, J. M., Jones, F. D., Ryffel, H. H., & McCauley, C. J. (2016). *Machinery's Handbook*. Industrial Press.

Ashby, M. F. (2017). *Materials Selection in Mechanical Design* (5th ed.). Elsevier.

Berk, Z. (2018). *Food Process Engineering and Technology* (3rd ed., Ch. 7). Academic press. Retrieved from https://www.sciencedirect.com/science/article/

Bhandari, V. B. (2010). *Design of Machine Elements*. Tata McGraw Hill Education Private Limited.

Bjarnadottir, A. (2019). *A Medical Review* – written on March 25, 2019.

Boblenz, J. N. (2015). *Belts (mechanical).* Retrieved from https://en.wikipedia.org/wiki/Belt_(mechanical)

Bolton, W. C. (2013). *Mechanical science*. John Wiley & Sons.

Budynas, R. G. & Nisbett, J. K. (2011). *Mechanical Engineering Design* (4th ed.). New York: McGraw – Hill Companies.

Budynas, R. G., & Nisbett, J. K. (2015). *Shigley's mechanical engineering design* (10th ed.). New York: McGraw-Hill.

Capote, R. S. (2009). *Complete mechanical engineering formula and principles*. Jam Publishing.

Chalmers, B. J. (2013). *Electric motor handbook*. Elsevier.

Crawshaw, R. (2010). *Handbook of Waste Management and Co-Product Recovery in Food Processing* (Vol. 2). Retrieved from https://www.sciencedirect.com

Daniells, S. (2010). *Lycopene-Rich Tomato Paste Helps Skin From Within: Study*. Retrieved from https://www.nutraingredients-usa.com/Article

Del Rincon, A. F., Viadero, F., Iglesias, M., García, P., De-Juan, A., & Sancibrian, R. (2013). A model for the study of meshing stiffness in spur gear transmissions. *Mechanism and Machine Theory*, *61*, 30-58.

Delany, A. (2018). *What Is Tomato Paste? And How Do You Unlock Its Full Potential?* Retrieved from https://www.bonappetit.com/story/what-is-tomato-paste?

Eliseev, V., & Vetyukov, Y. (2012). Effects of deformation in the dynamics of belt drive. *Acta Mechanica*, *223*, 1657-1667.

Elliot, B. (2016). *Electro Mechanical Device and Components: Illustrated Sourcebook*. The McGraw-Hill Companies.

Faires, V. M. (1965). *Design of machine elements* (4th ed.). Macmillan Coll Div

Francisco, J. R. (2014). *Design of Machine Elements* (Vol. 1). C & E Publishing. Incorporated.

Glavatskih, S. (2018). *Machine Elements*. Retrieved from https://www.kth.se/profile/sergeig

Hao, A. P., & Jia, Y. H. (2013). Research on the characteristics of bearing behavior of the profiled throttling cavity air bearing. *Procedia Engineering*, *67*, 367-377.

Herman, S. (2013). *Electrical Studies for Traders*. Boston, Massachusetts: Cengage Learning.

Jensen, C. (2011). *Engineering Drawing and Design* (7th ed.). McGraw Hill.

Juvinall, R. C., & Marshek, K. M. (2013). *Machine component design*. Wiley.

Khabou, M. T., Bouchaala, N., Chaari, F., Fakhfakh, T., & Haddar, M. (2011). Study of a spur gear dynamic behavior in transient regime. *Mechanical Systems and Signal Processing*, *25*(8), 3089-3101.

Khurmi, R. S., & Gupta, J. K. (2005). *A textbook of machine design*. S. Chand Publishing.

Pop, C. A., Simut, R., Pintea, S., Saldien, J., Rusu, A., David, D., ... & Vanderborght, B. (2013). Can the social robot Probo help children with autism to identify situation-based emotions? A series of single case experiments. *International Journal of Humanoid Robotics*, *10*(3), 1350025.

Shercliff, H. R. & Ashby, M. F. (2017). Elastic Structures in Design. Retrieved from https://www.sciencedirect.com/topics/materials-science/material-selection-chart

Srivastava, N., & Haque, I. (2009). A review on belt and chain continuously variable transmissions (CVT): Dynamics and control. *Mechanism and Machine Theory*, *44*(1), 19-41.