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Design and Development of Bread Slicer Machine

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Abstract

This study developed a compact front loading machine for slicing loaves of bread. The machine is fast, efficient, safe and easy to operate. It was designed to accommodate a normal loaf of bread per pass. It works on the principle of gravity loaf in-feed system and the up-and-down reciprocating motion of the blade frame that carries 22 parallel cutting blades spaced at a regular interval of 14.5 mm apart. It is driven by a 2 horsepower electric motor via a V-belt power transmission system. The moving components are born on self-lubricating bearings and specially designed vibration absorbers; it automatically stops to save running cost once the loaf is completely sliced. It also incorporates a crumb collection tray to enhance the hygiene of the process. Evaluation tests revealed that increasing the cutting speed above the standard commercial bakery speed of 420 r/min increased bread wastage and reduced uniformity of slice thickness.

Keywords: *Machine, Bread Slicer, Slicer, Electric motor*

INTRODUCTION

Bread is one of the most consumed staple food. It has been hitherto produced from wheat flour as a major component. There has been a lot of investment in technology within the baking industry. The process of slicing breads and rolls has remained unchanged since the first inclined slicers were introduced from the baking of bread to its actual storage, different tools and equipment that deals with bread had been invented and commercialized. One

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of the most important bread tool is the bread slicer, whose name alone states its function. However, slicing of bread may be an afterthought to most bakeries, but new bread type requires bakers to reexamine their slicing process and make necessary slicer modification. A growing trend in various type of bread such as premium, thick crust, raising and soft white bread, called for advancement in equipment flexibility.

The world's first mechanical sliced bread was produced in 1928, it was during that year that presliced bread were sold in bakeries. Nowadays, no bakery exists without some type of Bread slicing machine (BSM), some bread slicer are more conventional than Bread is one of the most consumed staple food. It has been hitherto produced from wheat flour as a major component. There has been a lot of investment in technology within the baking industry.

The process of slicing breads and rolls has remained unchanged since the first inclined slicers were introduced from the baking of bread to its actual storage, different tools and equipment that deals with bread had been invented and commercialized. One of the most important bread tool is the bread slicer, whose name alone states its function. However, slicing of bread may be an afterthought to most bakeries, but new bread type requires bakers to reexamine their slicing process and make necessary slicer modification. A growing trend in various type of bread such as premium, thick crust, raising and soft white bread, called for advancement in equipment flexibility.

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Considering the challenges and need for an effective method of slicing and the economic and commercial importance and nutritional values, the bread slicers will be of great importance, since the traditional method of slicing gives a non-uniform thickness of bread slices and for commercial purposes, this method will be tedious, laborious, time consuming and unhygienic with the risk

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of injury, thus, the need for an efficient and effective Bread Slicing Machine.

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METHODOLOGY

Work

It is proposed to carry out "Design and Development of wire cut Breads making machine." For this dissertation work, the proposed work is divided into the following phases.

Phase I

Survey about Types of Breads, their size and manufacturing process will be studied. Also input parameter like existing machine, their actual weight and actual working ofeach part will be analysed

Phase II:-

Market survey have been done on the structural members like c-sections, rectangular sections, and relative materials necessary for manufacturing and also parallel to that we have started concept design using 3D CAD software.

Phase III

Preparation of actual finished design product on 3D CAD with optimum design calculations.

Phase IV

Analysis of each designed part with proper material parameters and geometry using Analysis software. After successful results of validations we take further for manufacturing. We will procure B/O part.

Phase V

Preparation of Manufacturing and Assembly drawing with GD and T and started to for manufacturing and assembly simultaneously.

Phase VI

Testing and inspection will be done according to given drawing and we ensure about size of Breads will be make properly.

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Explanation of Block Diagram

1. Concept Phase

This is the initial phase where the idea for the new product is generated and documented. The idea here is to flush out the idea as much as possible and assess if it is worth pursuing. To some degree, this is always done by an inventor or client before coming to us, for why else would someone hire a product design and development company unless they already have an idea they want to pursue.

2. Discovery Phase

This is an added phase in our process where a customer shares their idea with us so we can bid on it. It's common practice to sign a non-disclosure agreement up front with the customer to keep what is discussed confidential (keeping a customer's information confidential is something we do even without the agreement in place, unless agreed to by the customer). We also work with the customer to flush out the idea, this usually stems naturally from our need to have a a good specification to create our quote and this process can range from a short phone call for a simple design to a couple of weeks of talks if the design is complicated or requires a lot of detail. We do not charge for this. At the end of this phase we usually deliver a proposal to the customer with a firm quote for the preliminary phase and estimates for the other phases beyond that.

3. Preliminary Design Phase

In this phase, we create a preliminary design based on the specifications agreed upon in the discovery phase. We create an engineering model and do any other engineering and design that is necessary to flush out the product so that there is a high level of confidence that the design will work before proceeding to detailing the parts and creating engineering drawings and documents.

This phase is really where the bulk of the product design & development is done. At the end of this phase the work is summarized and delivered to the customer at a Preliminary Design Review (PDR). A written report is also delivered detailing the work done in this phase. After this phase, it should be very clear to all parties what the final product will look like and what its features will be. If, after the review, the customer believes parts of the design need to be tweaked or they decide they want modification or new features added this will be incorporated into the next phase. Mechanical Engineering Professionals, will then update the original proposal and give a firm quote to our

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customers for the next phase before proceeding.

4. Critical Design Phase

Most of this phase is for detailing the design and creating engineering drawings and documents of the design presented at the Preliminary Design Review. Any changes or modifications to the design requested by the customer at the Preliminary Design Review are also incorporated before drawings are made. Once drawings and necessary documents are completed, these are sent out to manufacting houses for quote so that the customer will have a detailed price for the building of the product. We are happy to work with manufacturers specified by the customer if they have a particular vendor that they prefer. At the end of this phase the work is summarized and delivered to the customer at a Critical Design Review (CDR). A written report is also delivered detailing everything done in this phase. Again, at the end of this phase we will update the proposal and give firm costs for the next phase before proceeding.

5. Build Phase

In this phase, all the parts for the assembly are ordered, received and the product is assembled. Any kinks in the assembly process are ironed out and debugged. Bugs are sometimes surprising to many people who are new to product development because most people hear about software bugs but rarely do people hear about it being associated with mechanical or other types of projects. Most often, these are trivial and come from all sorts of areas such as a part just not being made correctly or a press fit being too tight etc. Overcoming bugs is large part of development and the reason why most major companies will do several revisions of a design before releasing a product to the public (alpha, beta, and release designs); especially those companies wishing to release high quality products. There should always be a buffer in an initial build of a product to allow for debugging during the build. Also in this phase, the initial manufacturing procedures are worked out and any necessary manufacturing documentation is created. Higher end or higher volume assemblies may also require specialty tools to do such things as fine alignments or to just speed up the assembly process. This would also be addressed here. At the end of this phase, fully built prototypes would be delivered to the customer.

6. Testing Phase

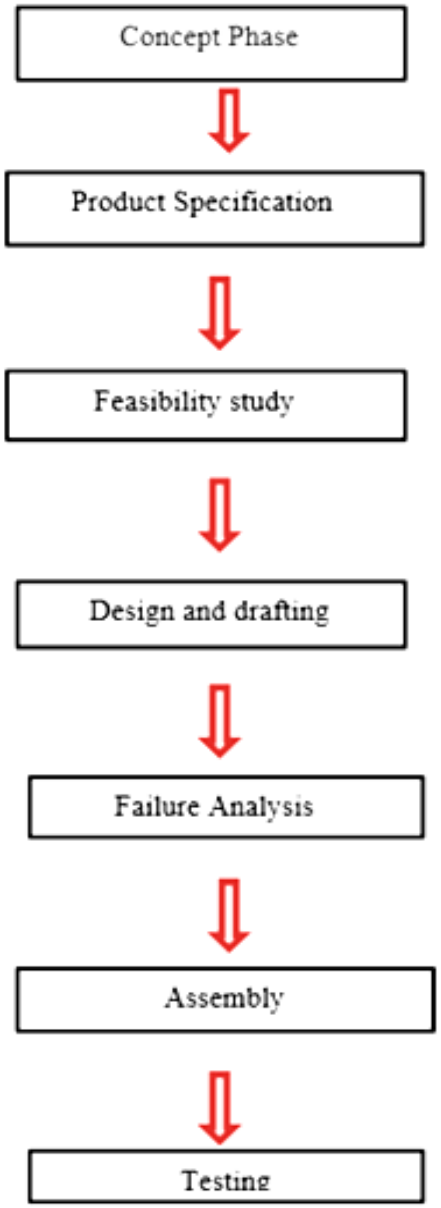
On simple projects this phase is often wrapped in with the build phase and we

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always do some testing of a product in the build phase before shipping a prototype to a customer. The testing can be as simple as "does it work or not?" but with more intricate assemblies this can become much more complicated as you are not just testing if it works but how well or how long it works. Tests vary tremendously on the type of product and level of quality the customer wants to achieve. These can also involve market research testing to see how well the product would be received. We work hand in hand with many customers on this phase as they usually want to be intimately involved in the testing to see for themselves how well the product works. Many times the customer takes over this phase completely. The amount of testing is most often limited by time and budget constraints.

Release Build Phase

Often the product development cycle listed above is repeated several times mainly to iron out bugs or fix problems that were discovered in testing. The beta and release phases aren't really phases so much as a shortened iteration of the entire product development cycle. Of course, in the beta and release, the design and build phases are much cheaper and quicker to complete since one is building on a design already created instead of starting from scratch. The goal of the beta phase is usually to create a short run of prototypes that are as close to release as possible and get them into the hands of key testers, select customers or others to do some final testing before a full product launch. The release build phase is usually just to get the final bugs out of the design as production is ramped up for the initial product launch.



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Design and Calculation

It will start with the design criteria for individual system component. This includes design of position of roller, bearing selection, motor selection and other system components. Also it includes selection of proper elements for easy and fast response. We are designing 3D model with the help of 2D and 3D software like AutoCAD, SolidWorks and CATIA.

Guideline used for design:

a) Compared the cost of production of work with present tools with the expected cost of production, using the tool to be made and see that the cost of buildings is not in excess of expected gain.
b) Decide upon locating points and outline clamping arrangement.
c) Made all clamping and binding devices as quick acting as possible.
d) Made the machine full proof.
e) Made some locating points adjustable.
f) Avoided complicated clamping arrangements.
g) Rounded all corners.
h) Provide handles wherever these will make handling easy.
i) Placed all clamps as nearly as possible opposite some bearing point of the work to avoid springing action.

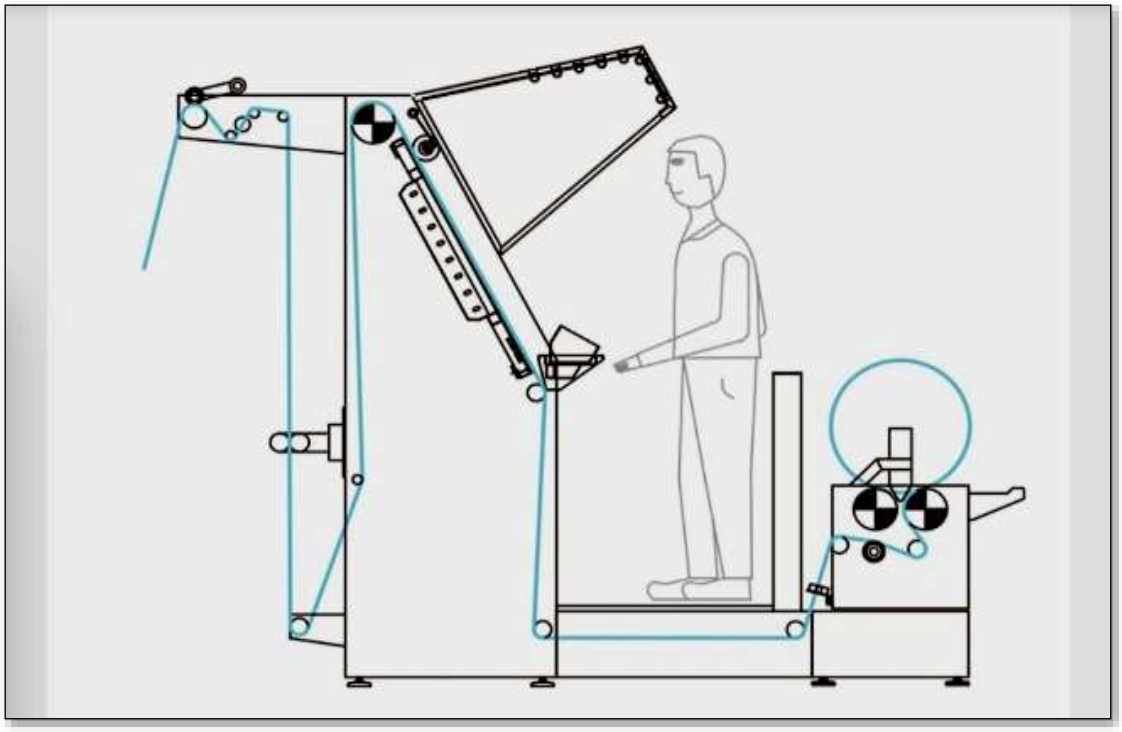


Figure:-1 Layout of Fabric Rolling Cum Fabric Inspection Machine

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CALCULATION

a) Selection of the drive motor

A single phase, 2 horsepower electric motor was used to power the blade frame. The motor runs at 1500 r/min (angular velocity (N1), according to manufacturer's specifications). The selection involved the determination of the power required to drive the blade frame and the blade. It is desired to have 14 up and down (reciprocating) motions per second (r/sec), thus the required angular velocity, N2, of the crank driving the connecting rod plus blade assembly was calculated

b) Selection of V-Belt

Belts are employed to transmit power from one shaft to another where it is not necessary to maintain an exact speed ratio between two shafts. Power losses due to slip and creep amount to from 3% to 5% for most belt drives Selection of V-belt and pulleys in the design of the bread slicer was accomplished with the use of a Catalogue). The basic variables required for the selection are transmission power, P, motor speed, centre distance and pulley diameter.

c) Shaft design

This primarily consists of the determination of the correct shaft diameter in order to ensure satisfactory strength and rigidity when the shaft is transmitting power under various operating and load conditions The shaft is made of ductile iron material.

d) Keys design

Keys are employed to prevent relative motion between the shaft and the connected member (sprocket, pulley) through which torque was transmitted. A rectangular sunk key with head at one end (Gib-head key) was used because of the easy of removal (Bayo, 2006; Oladejo and Oriolowo, 2015).

For shaft:

Material used for shaft =40C8

Yield strength =380syt

According to ASME Shaft without key-way =0.30syt

Ultimate Tensile strength =0.18sut

Required speed of shaft 40RPM

For hollow shaft consider ratio of inner diameter to outer diameter c=0.9

We are considering worst case scenario,

Where whole load is on only one shaft

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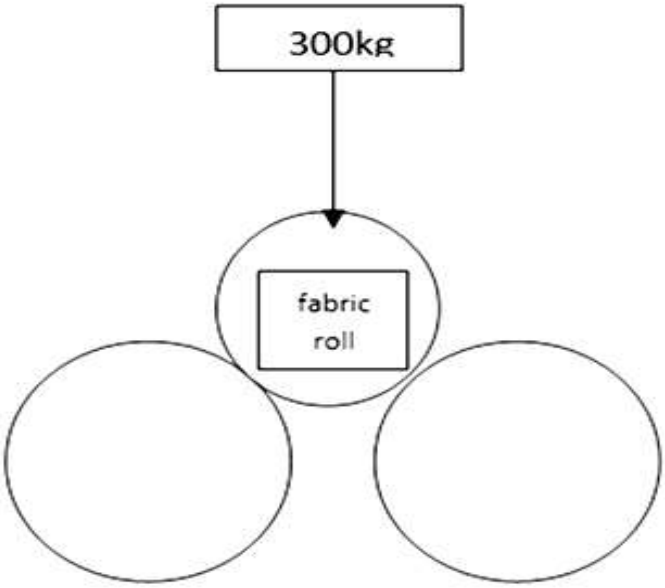


Figure:-2 Load Distribution

Then loading condition will be as follows

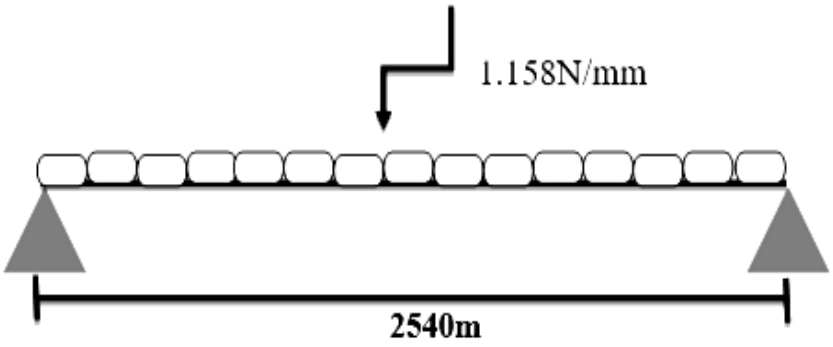


Figure:-3 UDL distribution

In this case our total weight of cloth=300kg

=2943N

Which is uniformly distributed over 2540 length

w=$\frac{2943}{2540}$=1.158 N/mm

let's draw the FBD for above case

Maximum bending moment=934.4 NM

Hence we have to design the shaft

We must calculate twisting moment

Torque=?

T=frictional force X radius

Frictional force=μ X N =0.78 X 1471.5

μ =0.78=for hard steel =1147.77 N

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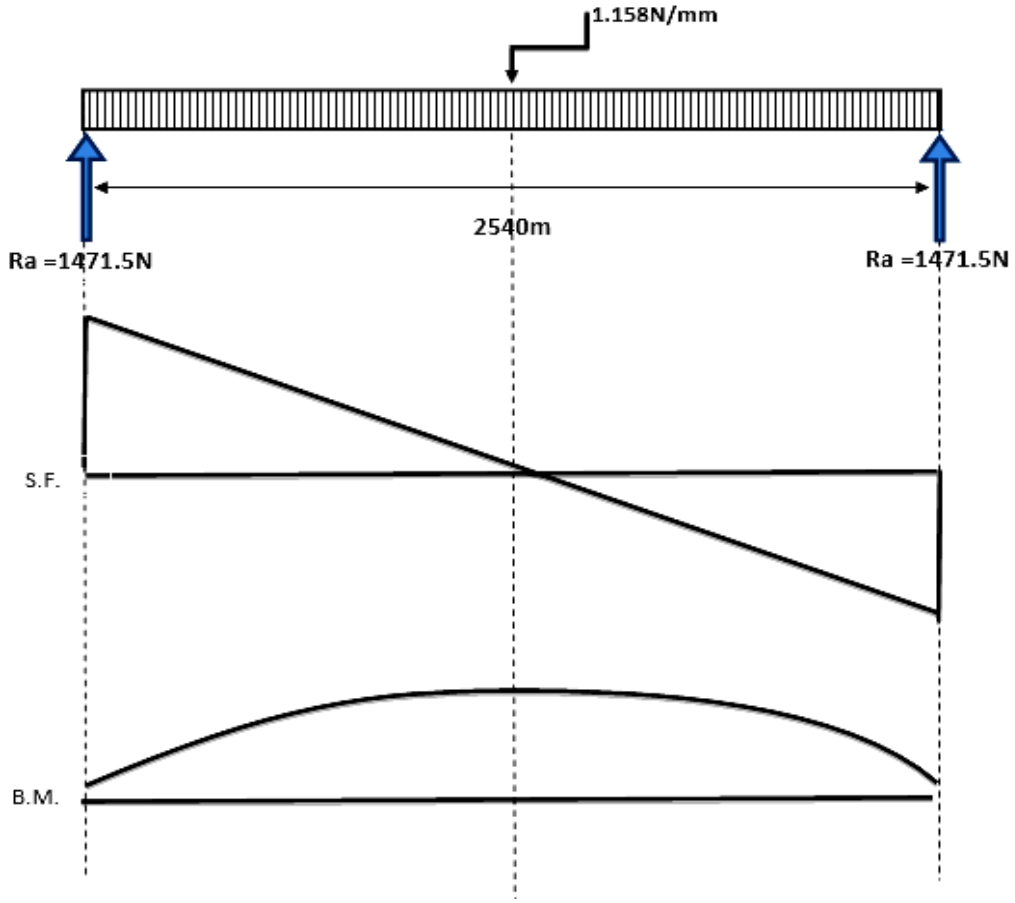


Figure: - 4 shear force and bending moment diagram

By thumb rule let's assume diameter of shaft goes in bearing is 20mm

By considering factor of safety =2

Outer diameter of bearing OD =60mm

T=frictional force X radius

=1147.77 X $60x10^{-3}$

=68.86 NM

This friction is on both sides

Total friction (torsional)=2 X 68.86=137.73 NM

The RPM with which we are supposed to drive=40rpm

Power = $\frac{137.73\ X\ 2\ X 3.14\ X 40}{60}$

= 576.63 Watt

= 0.7729 hp

And by assume factor of safety=1.3

Rated power ≅1 Hp

Motor selected= 1Hp

Hence maximum torque offered by 1hp motor at 40 rpm

$=\frac{746X60}{2\ X\ 3.14\ X40}$

=178.18 N.mm

Maximum twisting moment=178.18 NM

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Shaft design as per ASME code

Let's consider shaft material as 40C8

Syt=380 N/mm^2

Sut=650 N/mm^2

Permissible shear stress=0.38 Syt=0.38 X 380=114 N/mm^2

=0.18 Sut = 0.18 X 650 = 117 N/mm^2

Minimum =114 N/mm^2

Permissible shear stress=114 N/mm^2

τ_{all} = $\frac{16}{3.14*do^3(1-K^4)}\sqrt{(Cbm.M)^2+(Ct.T)^2}$

Cbm=1.5

Ct=1.5

Assume, do=80mm

114= $\frac{16}{3.14*80^3(1-K^4)}\sqrt{((1.5X178.18)^2+(1.5X934.4)^2)X10^6}$

k≅0.9

di=do X K

=80 X 0.9

di=72mm ≅di=70mm

So, inner diameter of shaft=70mm and outer diameter is=80mm

The step we are using at the end is 20mm solid shaft which is having twisting moment

$\tau=\frac{16T}{3.14.d^3}$

$\tau=\frac{16X178.18X10^3}{3.14.(20)^3}$

=113.49 MPa

Which is less than 380 N/mm^2 with FOS=3.33

Hence that step also safe

Our consideration also safe

Bearing selection

Total load =2943N

Total no of bearings =4

Radial load on each bearing = 735.75N

Outer dia. of shaft = 80mm

In our case, inner race rotates and outer is fixed

Race rotation factor = v = 1

equivalent dynamic load = $P = xvFr + yFa$

Only Radial load is there

P=Fr

P=735.75N

As per, load life relationship ex,

From SKF catalogue we have selected bearing with 80mm inner diameter having, C=71.5KN

let's check the life for same

$$L_{10} = \frac{c^n}{p}$$

n =3 ---------- for ball bearing

$L_{10} = \frac{71.5\times10^3{}^3}{735.70}$

=920568 million Rev.

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$$life = 920568 \times 10^6 rev$$

and if we consider 40 rpm speed of shaft and runs for 16 hours then revolution/day = 38400

$$life\ in\ days = \frac{920568 \times 10^6}{38400}$$

= 23973125 days = infinite life selected bearing is appropriate

As life coming for the 80mm bearing is infinite to reduce the cost we and have decided to use step at the ends of shaft and that step diameter would be 20mm.

Then the bearing available as per catalogue is having C= 12.7KN
Let's check life for this.

$$L_{10} = \frac{12.7 \times 10^{3^3}}{735.75}$$

$$life = 5143 \times 10^6 rev$$

$$life\ in\ days = \frac{5143 \times 10^6}{38400}$$

= 133933 days = 366 years

Which is sufficient?

We have selected bearing of SKF which is UCF20Q

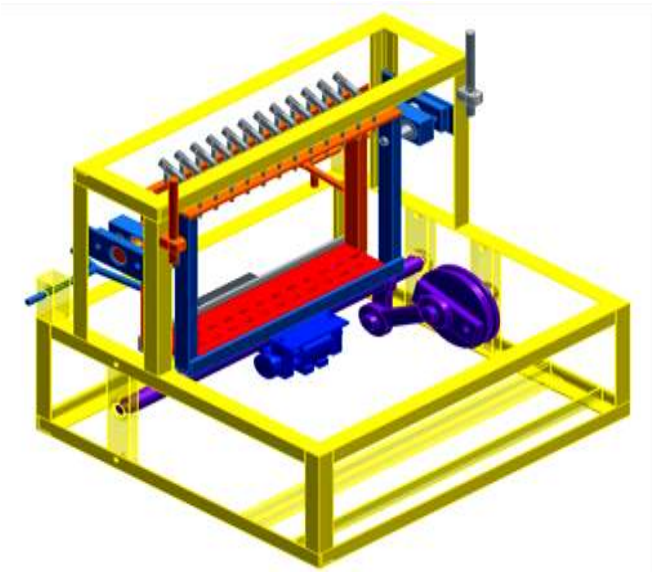
Bill of Material

Total cost = Material cost + manufacturing cost +bought out part

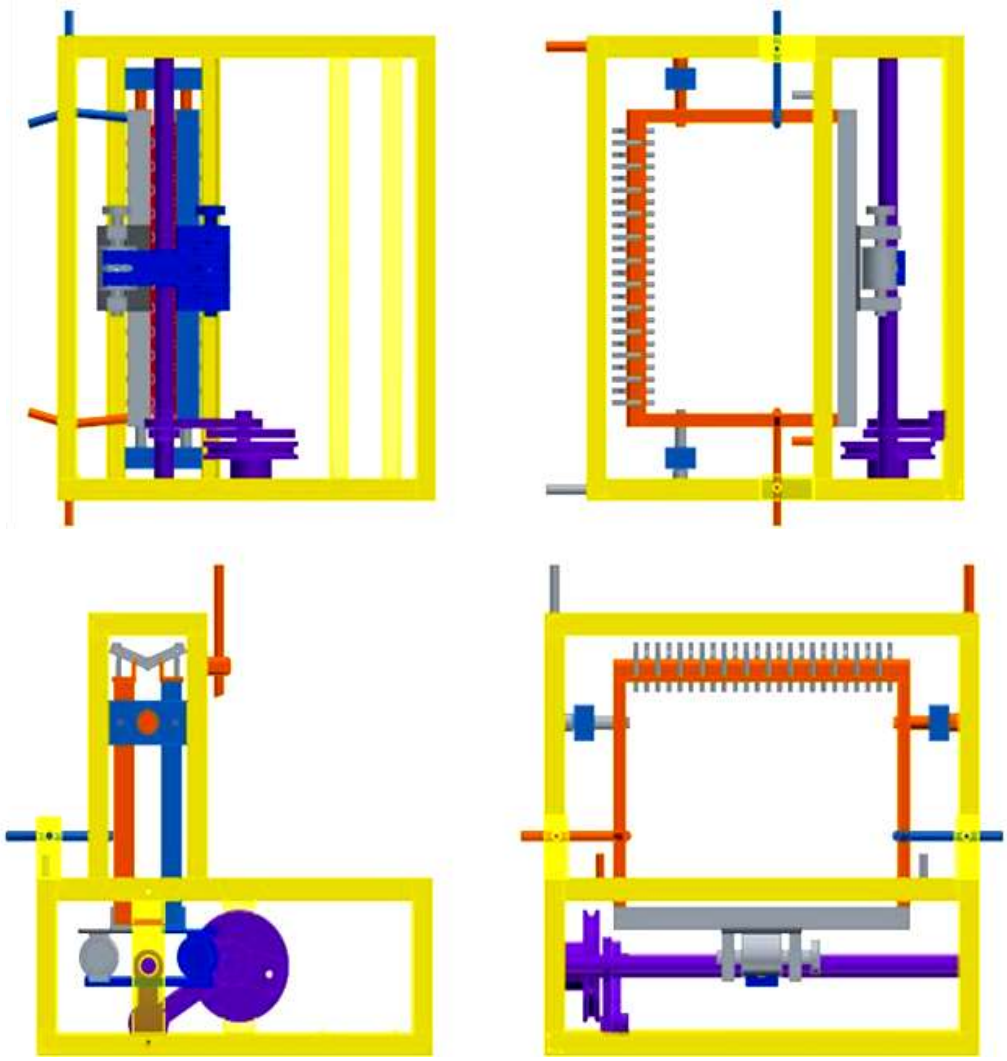
= 34500+15800+21390

Total cost = 71690

3D Drawing



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RESULTS

For shaft:

Material used for shaft =40C8

Maximum bending moment=934.4 NM

Maximum twisting moment=178.18NM

Inner diameter of shaft=70mm

Outer diameter is=80mm

For motor selection

Power = 0.7729 hp

Rated power ≅1 hp

Bearing selection

We have selected bearing of SKF which is UCF20Q

Module Name: Design and Development of Bread Slicer Machine.

ADVANTAGES

1. Ease of handling.
2. Quick and rapid operation.
3. Aesthetic and ergonomically designed product.
4. Adjustable Bread size.

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5. Synchronized production process.
6. Reduce administration.
7. Easy to install and less maintenance
8. Economic Product.

Acknowledgement

The authors acknowledge the support of the Department of Mechanical Engineering

CONCLUSION

We conclude that, this project will helpful for small scale industries as it is easy to operate with less cost and indirectly it will save the labour cost. Savings resulting from the use of this machine will make it pay for itself with in short period of time.

This work has actually gone within the limits of its scope to design and construct bread slicing machine for small scale indigenous baking industry through the historical development of bread slicing machine, bread preparation processes and development of bread slicing machine. This design analysis, material selection, construction, maintenance and performance evaluation of the machine was also checked.

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