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"Design, Modeling and performance Analysis of combine system for threshing and dehulling of pigeon pea"

Niteen T Kakade[1], Dr.Achal S Shahare[2], Dr.G K Awari[3]

[1,2]Department of Mechanical Engineering G H Raisoni University Amravati, India

[3]Department of Automobile Engineering, Government Polytechnic, Nagpur, India

[1] Tulsiramji Gaikwad Patil college of Engineering and Technoplogy, Nagpur

Abstract:-

A combine machine for separating and threshing split pulses to obtain a processed Pigeon Pea (Tur Dal). The combine machine includes a pod separator that is configured to separate pods from a legumes. A threshing unit that is configured to separate turf and seeds from the pods. A rotating meshed cylinder that is configured to temper the seeds. The rotating meshed cylinder is attached to a motor of the combine system. Moisture addition or removal required in the system, an emery roll dehuller that is configured to split the seeds and remove hull from the seeds and a segregation mesh that is configured to separate processed and un-processed seeds.

Keywords:- Pulses, Pigeon pea, pod separation, dal making, threshing.

INTRODUCTION:-

A Pigeon Pea/Tur Dal/ Arhar Dal is the main food of world. Most of the world use tur dal to fulfill the need of protein, carbohydrates and fibers. In India various processes are used to obtain seeds from crop and dal from seeds. For threshing in village there are various processes for obtaining seeds from crop.

1) Workman removing bean from Crop manually by using wooden stick, after removal of beans collected and start separation of seed and turf manually. A mixture of turf and seeds exposed into air, due to air force turf separates from seeds as they are light in weight. This is very time-consuming process, required very hard work, process output is very low.

2) Workman removing beans from crop manually by using wooden stick and then separate the seeds and turf by using threshing machine. Threshing machine separates sees and turf from beans with speed and ease. Again, separation of beans from crop is time consuming and hard work process.

3) In this process tur crop is directly inserted into power operated thresher machine, which is generally take power from tractor. Advantage of such system is can use where electric power not available, but loss of seed due to high power machine is more as well as turf and biomass waster mixed together which cannot feed to animals, only it can be used for fertilizer after composting.

Like threshing mini dal mills are used for dehulling and milling or converting seeds into dal. Mini dal mill having small capacity which can fulfill the need of villages. Mini dal mills are mostly situated in big size village and it is having business of 3 to 4 months only rest of the year it is idle, it consumes space round the year. Dal making is very time consuming and tedious job as we understand the process of making dal in mini dal mill, they first sort the seed, removes spoiled seeds, then dry it for at least 12 hours, then soaking into water for 24 hours, then drying for 2 days in sun light, after that it is ready for milling, during milling husk/turf removed and seed is split into two parts. Some of seed are still left uncrushed, then process of soaking, drying and milling repeated. After making we can polish the dal through polisher machine or manual, we can rub with oil and water mixture.

Both above processes are done separately, threshing and making dal.

As we know farms are divided into small pieces of land in India due to high population increasing rate. Individual farmer cannot afford the machines, they always seeking for rented ones. As soon as his work completed, he will no longer to take services or not in a position to create any liability.

The non-limiting embodiments shown in the accompanying figures and described in greater depth in the following discussion provide context for the many characteristics and advantages of the embodiments described below. So as not to detract from the embodiments described, descriptions of well-known components and processing methods have been removed. There are many ways in which embodiments herein may be implemented, but these examples are meant to help those skilled in the art better appreciate how the embodiments herein can be put into effect. To avoid misunderstandings, the examples in this document should not be taken to restrict what is described below.

For the purposes of processing split pulses, a combine machine is still needed to break up and thresh split pulses. A pod separator/threshing unit combination is provided herein to separate and thresh the split pulses, as described in the examples.

DESIGN OF MACHINE: -

Design of machine is mainly considering the major processes like pod separation, threshing, seed sorting, tempering, addition/removal of moistures, dehulling, dal sorting etc.

Pod separation

The pod separator is made up of spikes of metals which are welded over the metal drum which helps to separate the pods from crop. The figure 1 shows the pod separator takes power to rotate from a main shaft of the combine machine. The power is reached through a belt drive of the combine machine.

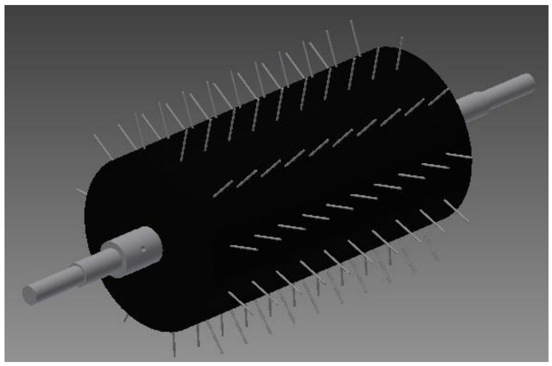


Figure 1 – Pod Separator

Seed Separation

The threshing unit is configured to separate turf and seeds from the pods separated. In some embodiment, threshing is a second step in the process of obtaining processed split pulses. In the threshing process, pods are inserted into a threshing drum of the threshing unit. The threshing drum is having spikes of bolts and is attached with a seed filtration mesh. The narrow space between the threshing drum and the seed filtration mesh crushes the pods of the seeds. And the spiky surface of the threshing drum in the threshing unit helps to separate the turf and seeds from the pods. The turf obtained after separation is blown out using a blower. The seeds obtained after separation are passed through a seed filtration mesh which is connected to a shaft of the combine machine. The shaft of the combine machine allows only reciprocating movements of the seed filtration mesh. The reciprocating movement and a double layer of the seed filtration mesh filters the seeds from impurities. In some embodiment, the seeds obtained after separation contains some impurities. In some embodiment, fine seeds are obtained after removing impurities and are collected in a seed collector using a gravitational and a reciprocating force of the seed filtration mesh.

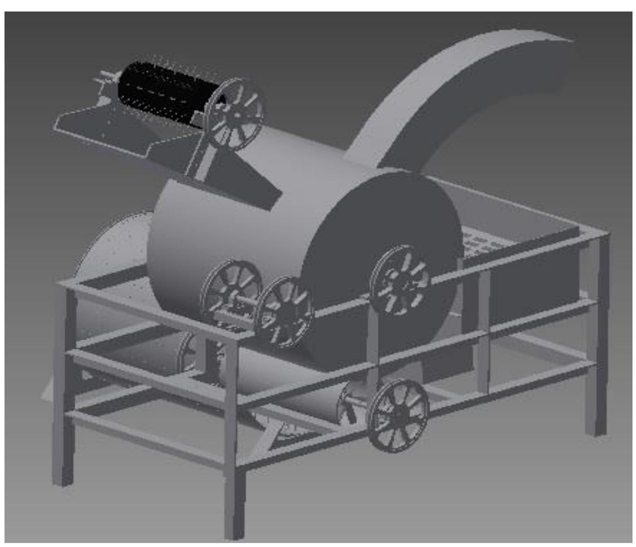


Figure 2 – Seed Separation (threshing)

Seed Tempering

The fine seeds collected in the seed collector are then inserted into the rotating meshed cylinder which is configured to temper the seeds obtained at the threshing process. The rotating mesh cylinder having small screws are welded in the combine machine for a seed tempering process. The rotation and the mesh of the rotating mesh cylinder filter a muted seed from the good seeds. The good seeds obtained are further sent for a dehulling process. In some embodiment, the rotating mesh cylinder is driven by a motor attached to the threshing unit. The motor transmits the power to the rotating mesh cylinder using a v belt.

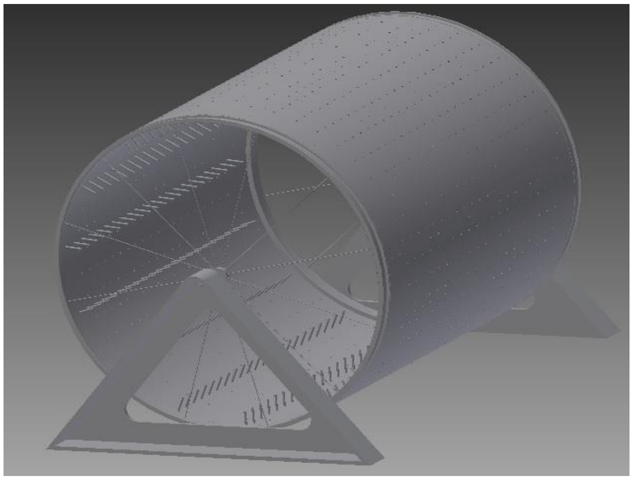


Figure 3 - Seed Sorting and Tempering

Adding Moisture/Removal of Moisture

When the seeds obtained are dried beyond the required condition for dehulling, a mixture of additional water an oil are sprayed in the rotating mesh cylinder during the seed tempering process. In some embodiment, when the seeds are moist beyond the required conditions, a solar operated air dryer is used to remove the moisture and water from the seeds during the seed tempering process. In some embodiment, a moisture detecting sensor is place between the threshing unit and the rotating meshed cylinder to detect the presence of moisture in the seeds. In some embodiment, a moisture detecting sensor is place between the threshing unit and the rotating meshed cylinder to detect the presence of moisture in the seeds.

Dehulling

The good seeds sent for a dehulling process are inserted into the emery roll dehuller. The emery roll dehuller is configured to split the seeds and remove hull from the seeds. In some embodiment, a rubbing action between the seed and the surface of the emery roll dehuller 108 removes the hull from the seeds. The rotating movement of the emery roll dehuller uniformly removes the hull and splits the seeds simultaneously. In some embodiment, the rubbing action between the seed and the surface of the emery roll dehuller over crushes some part of the seeds and coverts the seeds into a powder form. The powder of the seeds and the hull obtained are removed using the blower.

The split seeds obtained during a dehulling process are passed through a segregation mesh. The segregation mesh is configured to separate processed and un-processed seeds. The processed seeds obtained are collected in a pulse collector for further process of marketing. In some embodiment, the processed seeds are called pulses. The unprocessed seeds separated by the segregation mesh are sent back to the emery roll dehuller to repeat the dehulling process.

Combined Machine

Figure 4 and 5c- A flow chart of method of separating and threshing split pulses using the combine machine. At first step, pods are separated from legumes using a pod separator in some embodiment, a pod separator is used to separate pods from leguminous plants. At step, turf and seeds are separated from the pods using a threshing unit. In some embodiment, threshing is a process of loosening the edible part of the pods. After that the seeds are tempered using a rotating meshed cylinder. The rotating meshed cylinder is attached to a motor of the combine system. In some embodiment, the hull of the seeds is loosen during a seed tempering process through the rotating meshed cylinder. In next step, the seeds are split and hull from the seeds are removed using an emery roll dehuller. In some embodiment, the seed tempering and dehulling process are called as pulse milling process. At step, processed and un-processed seeds are separated using a segregation mesh.

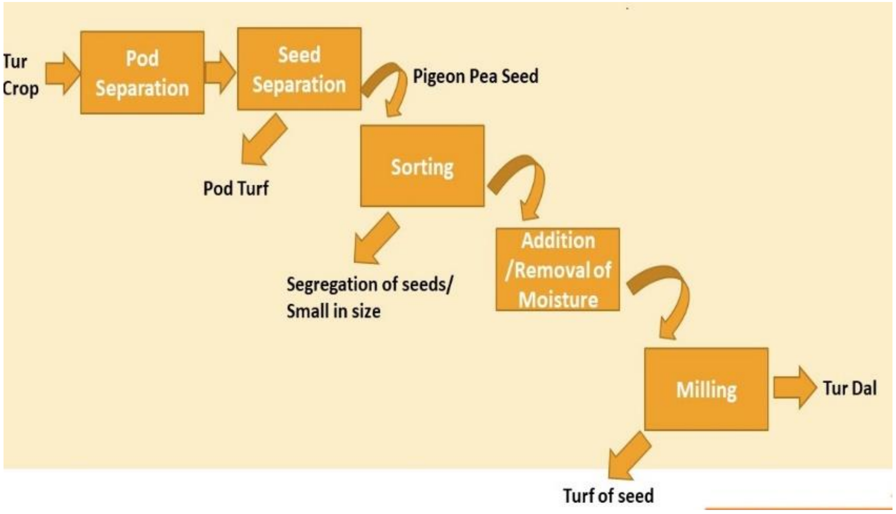


Figure – 4 Flow Diagram of Process

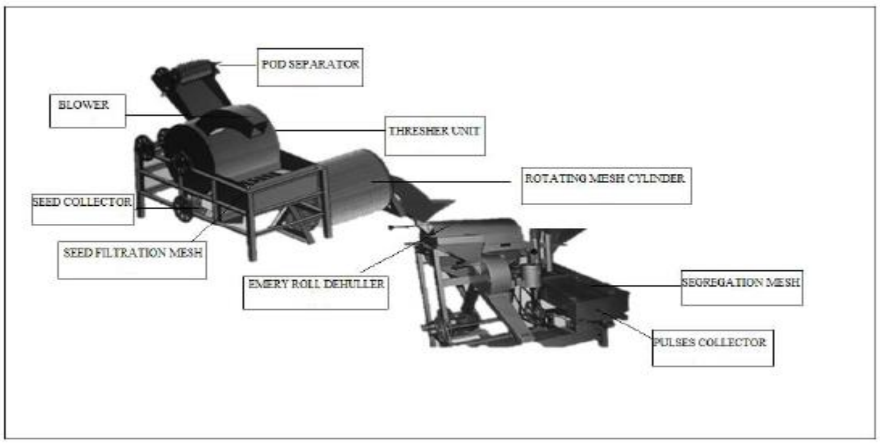


Figure – 5 CAD Model of process flow

Design Calculations

By using standard formula following data obtain useful for fabrication of the experimental setup,

Result Data of Shelling Shaft

Parameter	Symbol	Value	Unit
Weight of shelling cylinder	Wc	158	N
Weight of pulley	Wp	314	N
Weight of fan blade	WF	69.22	N
Speed of cylinder pulley	N2	302	rpm
Angle of lap of smaller pulley	θ	2.15	rad
Tension in tight sight	T1	182.335	N
Tension in slack sight	T2	85.72	N
Maximum bending moment	Mb	140.771	N-m
Maximum torsional moment	Mt	23.187	N-m
Permissible shear stress	τ	82.8	MPa
Diameter of shaft	d	25	mm

Design of Flywheel

1. THRESHER MACHINE SPECIFICATION

Type: Spike Tooth.

Feeding System: Hopper

Power Required: 3.5 H.P.

Flywheel: Single

RPM: 900 Drive: Belt

2. Material Property of flywheel

Material ---- gray cast iron

Density (ρ) = 7200 kg/m^3

Young's modulus =710GPA

Poisons ratio (υ) = 0.28

3. Geometrical Property

Outer diameter of flywheel = 31 inch= 787 mm

Diameter of shaft = 1 inch = 25 mm

mass of flywheel (m) = 96 Kg

Radius of gyration(k) = 22.53 inch = 576.256 mm

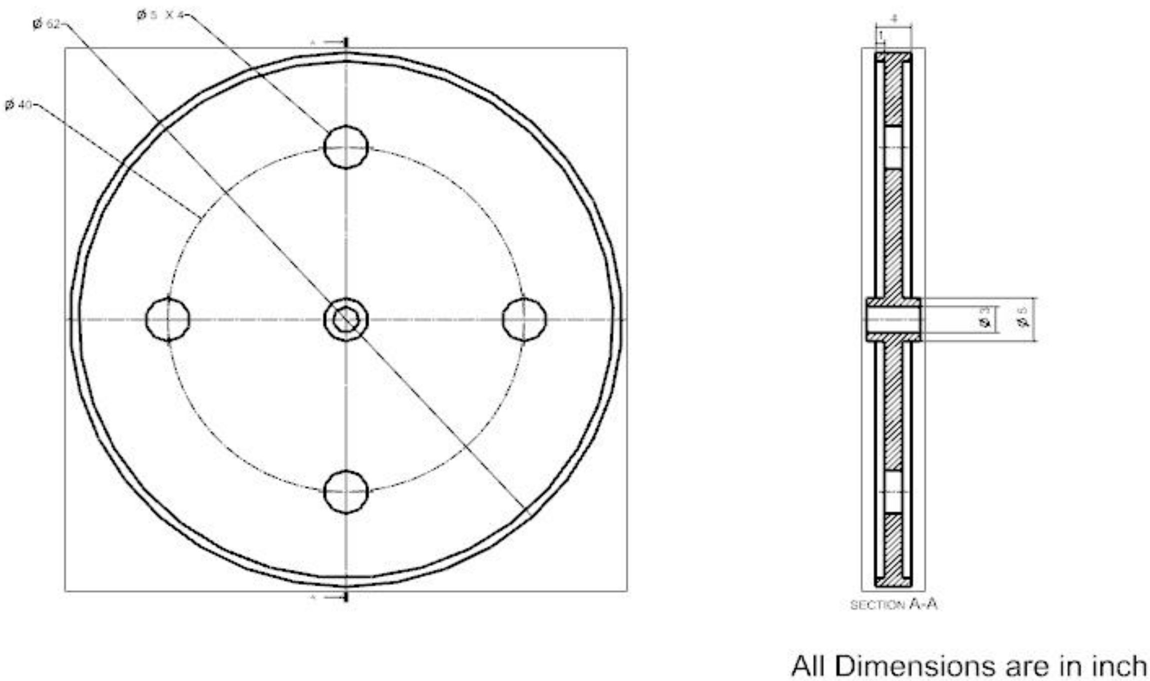


Fig. Drawing of flywheel

1. **Various Functional values flywheel**

Angular velocity (ω) = 2×π×N/ 60

= 2×π×900 / 60 ω

= 94.25 rad/sec

Moment of Inertia (I)= mass X k^2

= 125 X $(576.25)^2$

= 41.436 kg- m^2

Surface speed (Vs) = π×D×N / 60

$= \pi\times0.786\times900/ 60$

Vs= 37.06 m/s

Energy stored in flywheel (Ek) = ½ × Itotal× ω^2

= ½ × 41.436 ×99.25^2

Ek = 0.2041 MJ

Specific energy (Ek,m) = Ek/ Mtotal

= 0.2041/ 125 = 0.00163 MJ/kg

Energy Density (Ek,v) = (Ek/ Mtotal)× ρ

= 0.00163×7200

=11.736 MJ/ m^3

Design of Experimentations:-

For mathematical modelling we are using backinghum Pi method is used, in which grouping of n parameters they can arranged into n-m parameters independent dimensionless ratios (term as π parameters) the numbers normally equal to minimum number of dimensions. Log-log plot is two dimensional graph of numerical data that uses logarithmic scales on both horizontal and vertical axes.

Following parameters are considering for design of experimentations:

Variable	Name of Variable	Unit	MLT form	Form of Variable
F	feed rate	kg/hr	$M^1L^0T^{-1}$	Independent
A	Angle of feeding	Radian	$M^0L^0T^0$	Independent
a	air flow rate	m/s	$M^0L^1T^{-1}$	Independent
N	Speed	RPM-	$M^0L^0T^{-1}$	Independent
Dm	Mean Diameter of Roller	m	$M^0L^1T^0$	Independent
ρ_b	Bulk Density	kg/m^3	$M^1L^{-3}T^0$	Independent
PR	Production rate	kg/hr	$M^1L^0T^{-1}$	Dependent
μ	Moisture rate	Kg/Kg of dry air	$M^0L^0T^0$	Dependent

Formation of Pi Terms

Total Variable = 8

No. of Pi term = 8 - 3 = 5

$\pi_{01} = P.R.$

$\pi_{02} = Moisture$

Repeating Variable = $D_m,\ \rho_{b,}\ N$

Pi- term	Dependent / Independent
$\pi_1 = \frac{f}{\rho_b D_m^3 N}$	Independent
$\pi_2 = A$	Independent
$\pi_3 = \frac{aN}{D_m}$	Independent
$\pi_{01} = \mu$	Dependent
$\pi_{02} = \frac{PR}{\rho_b D_m^3 N}$	Dependent

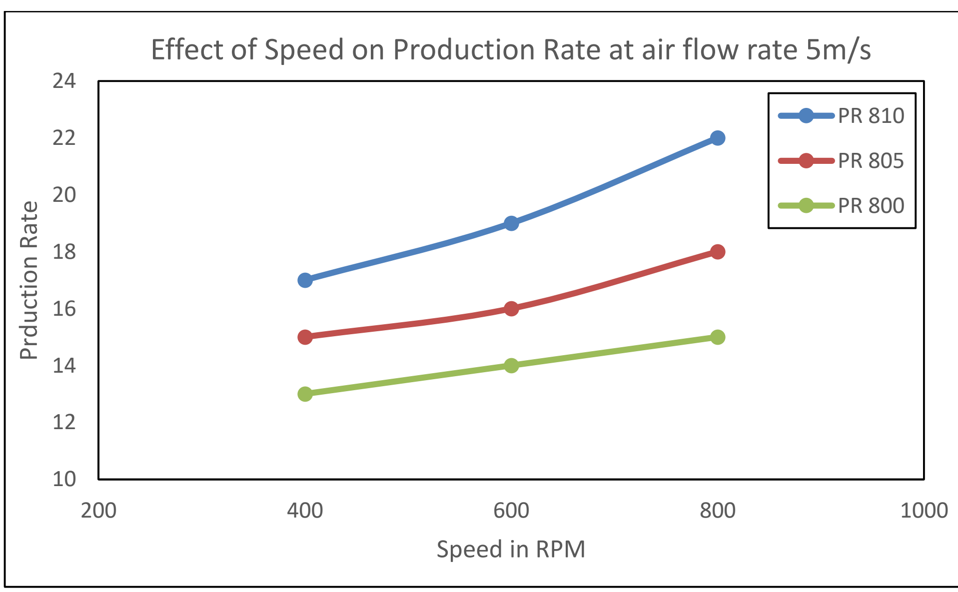
Mathematical Formula

$$\pi_{01} = 0.02809 X \, \pi_1{}^{1.8533} X \, \pi_2{}^{0.64801} X \, \pi_3{}^{0.4189}$$

$$\pi_{02} = 0.0001023 X \, \pi_1{}^{0.02354} X \, \pi_2{}^{-0.0023} X \, \pi_3{}^{-0.000035}$$

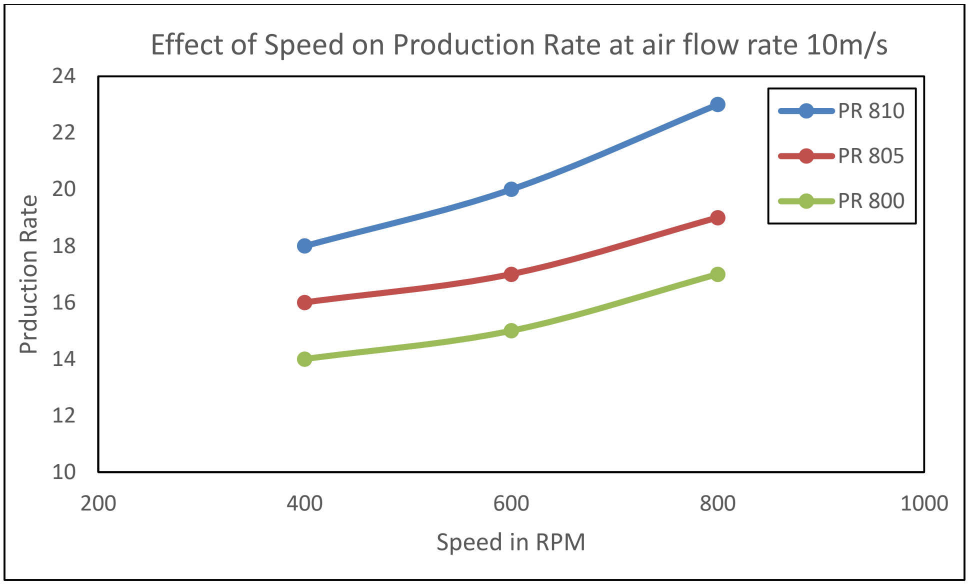
Experimental Results:

The actual experimentation done on fabricated experimental setup, the variables are taken during experimentation are speed of motor, feed rate, angle of feed, air flow rate and output of the process is measured in the production rate per hour. The graph indicates the various variable taken into consideration during experimentation at various reading production rate is measured. The result of actual experimentation shown by graph 1- 12.

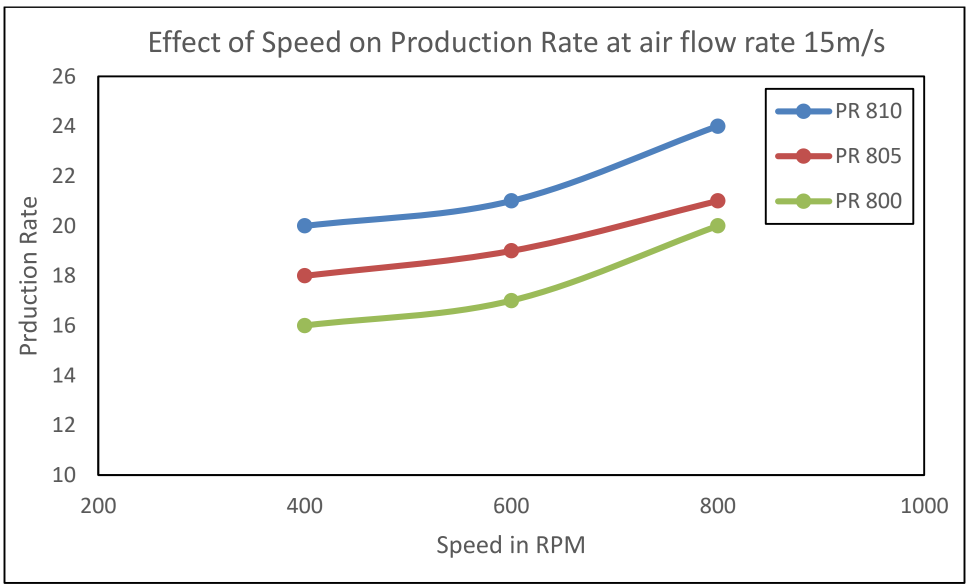


experimentation

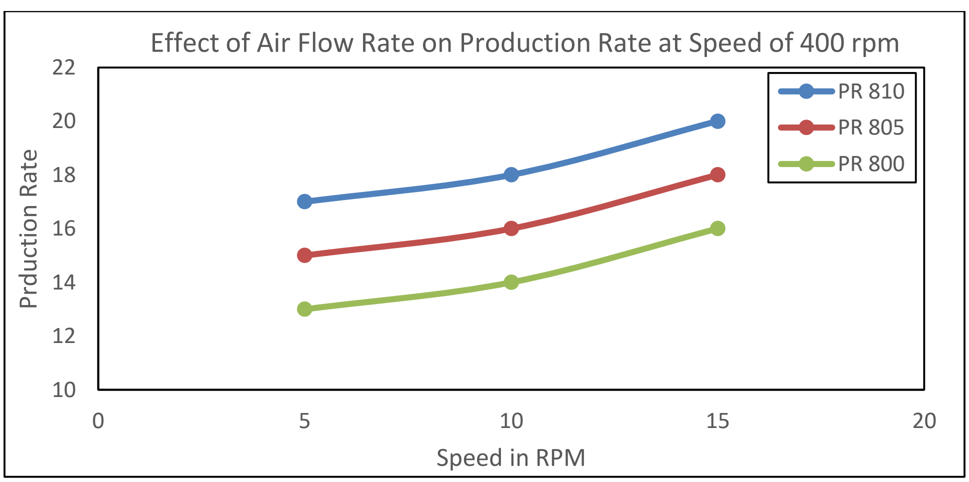
Graph 1 - Effect of Speed on Production Rate at air flow rate 5m/s



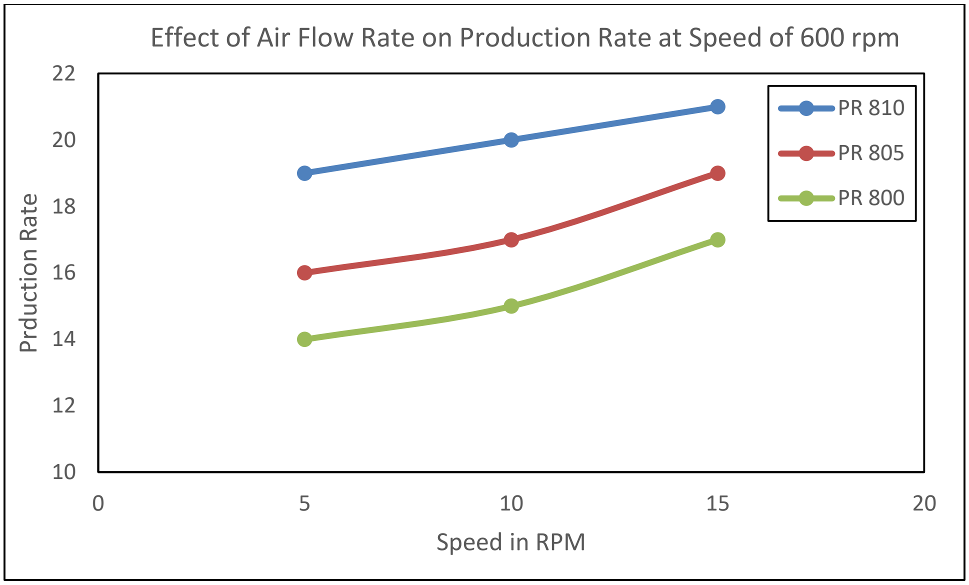
Graph 2- Effect of Speed on Production Rate at air flow rate 10m/s



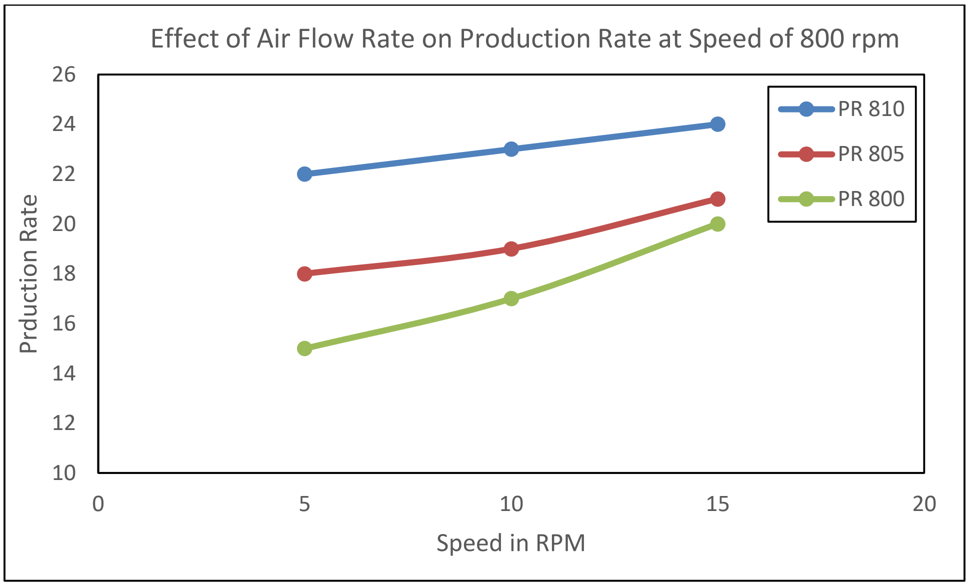
Graph 3 - Effect of Speed on Production Rate at air flow rate 15m/s



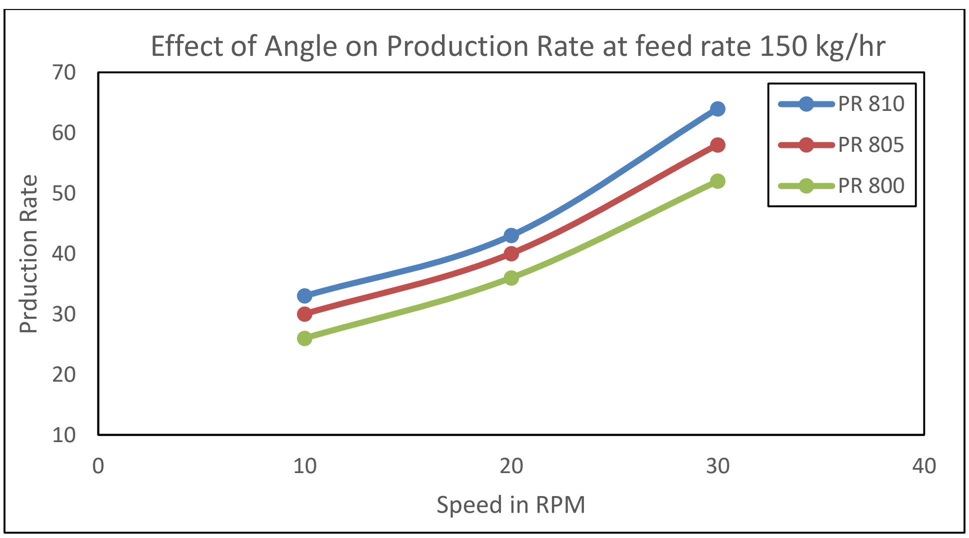
Graph 4 - Effect of Air Flow Rate on Production Rate at Speed of 400 rpm



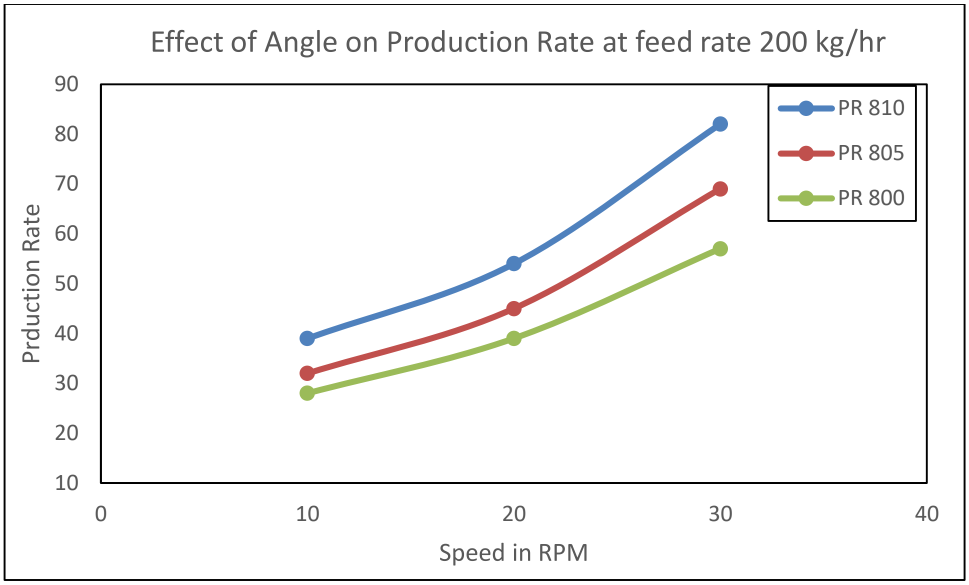
Graph 5 - Effect of Air Flow Rate on Production Rate at Speed of 600 rpm



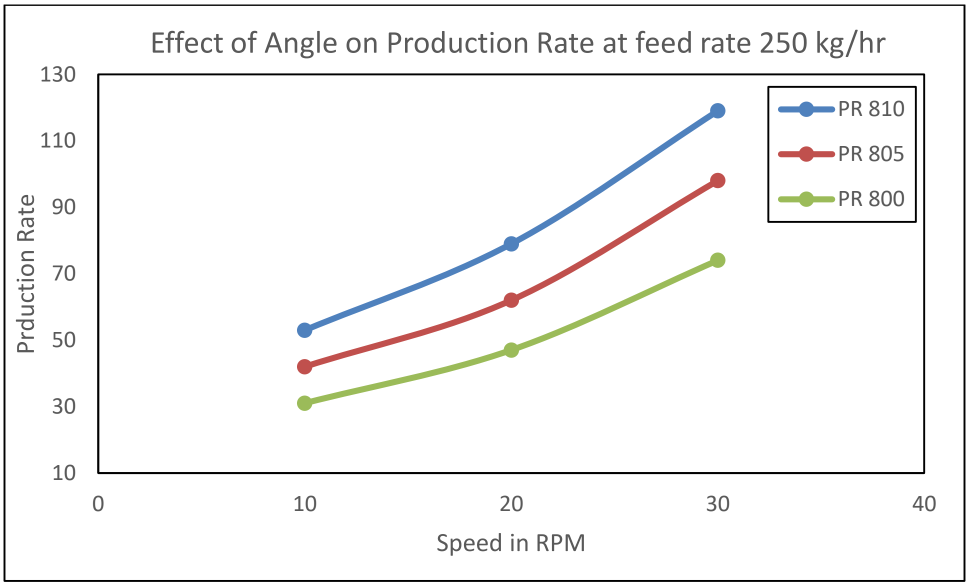
Graph 6 - Effect of Air Flow Rate on Production Rate at Speed of 800 rpm



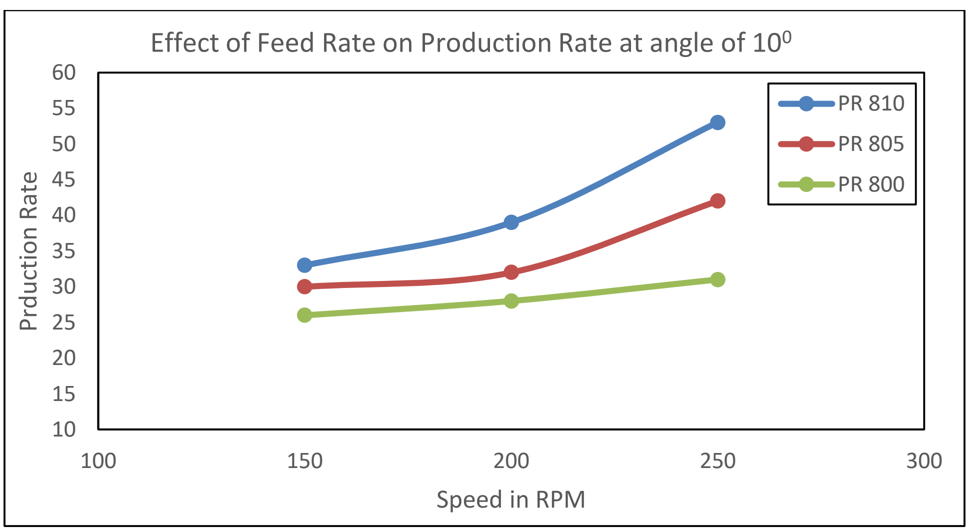
Graph 7 - Effect of Angle on Production Rate at feed rate 150 kg/hr



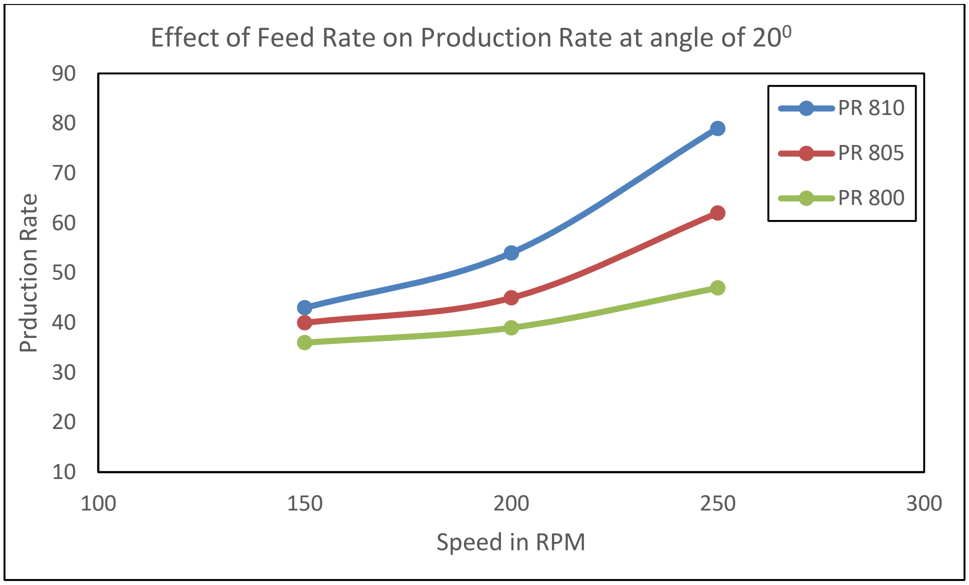
Graph 8 - Effect of Angle on Production Rate at feed rate 200 kg/hr



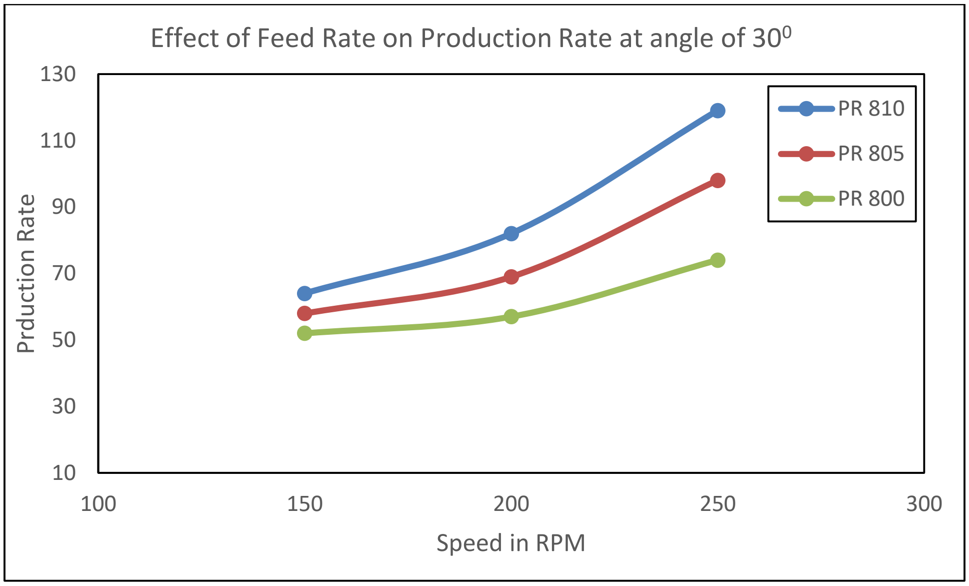
Graph 9 - Effect of Angle on Production Rate at feed rate 250 kg/hr



Graph 10 - Effect of Feed Rate on Production Rate at angle of 10^0



Graph 11- Effect of Feed Rate on Production Rate at angle of 20^0



Graph 12 - Effect of Feed Rate on Production Rate at angle of 30^0

Result and discussions:

Process is combining the two process and main output is production rate of the machine for tur dal, the actual production rate is calculated by experimentation. On the other hand results are calculated through derived formula. By experimentation or through mathematical modelling when variables changing its value, we get different output. The optimized process can be developed by using more combination of results which is useful for future perspective. The optimized process guiding the combination of operations of tur dal making processes in future.

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