© OCT 2019 | IRE Journals | Volume 3 Issue 4 | ISSN: 2456-8880

Design and Stress Analysis of Threshing Cylinder Drum for A Combine Paddy Harvester (25HP)

WINT WINT THET[1], SOE KYAW[2], MYINT MYINT SEIN[3]
[1, 2, 3]*Department of Mechanical Engineering, Pyay Technology University*

Abstract- Threshing is the most important function of grain harvester. Grain loss and damage in harvesting are significantly related to threshing theory and technology. There are four kinds of threshing principles including impact, rubbing, combing and grinding. Four types of contact models between grain and threshing components have been constructed correspondently. Grain damage can be regarded as a function of peripheral velocity and contact pattern of impacting. Tangential and axial threshing technologies have been applied in grain threshing system widely. The purpose of this paper is to design the threshing cylinder for combine paddy harvester (25hp) and to analysis the shear stress distribution in threshing cylinder due to applied torque in it. This paper discusses about the threshing cylinder of combine paddy harvester as axial flow type produced in Industrial Zone at Pyay. The threshing cylinder is attracted with threshing discs, bars and teeth. The threshing cylinder is constructed with mild steel and threshing teeth are made with medium carbon steel. The speed of the threshing shaft is 540rpm at power supplied 8kW. The theoretical results are achieved shear stress is 5.49MN/m² and the angle of twist is 0.297. The validation of model is compared with the theoretical and simulation results of shear stress and the angle of twist are within the limits. Weight of threshing cylinder, power, pulley design, belt design, shaft diameter, threshing torque, torsional moment, bearing design, and critical speed are considered in this paper.

Indexed Terms- Grain Harvester, Axial flow stress analysis, Critical speed, Power, Shaft diameter

I. INTRODUCTION

A threshing machine or a thresher is a piece of farm equipment that threshes grain, that is, it removes the seeds from the stalks and husks. It does so by beating the plant to make the seeds fall out.

Before such machines were developed, threshing was done by hand with flails: such hand threshing was very laborious and time-consuming, taking about one-quarter of agricultural labour by the 18th century. [1]Mechanization of this process removed a substantial amount of drudgery from farm labour. The first threshing machine was invented circa 1786 by the Scottish engineer Andrew Meikle, and the subsequent adoption of such machines was one of the earlier examples of the mechanization of agriculture. During the 19th century, threshers and mechanical reapers and reaper-binders gradually became widespread and made grain production much less laborious.

Separate reaper-binders and threshers have largely been replaced by machines that combine all of their functions that is combine harvesters or combines. However, the simpler machines remain important as appropriate technology in low-capital farming contexts, both in developing countries and in developed countries on small farms that strive for especially high levels of self-sufficiency. For example, pedal-powered threshers are a low-cost option, and some Amish sects use horse-drawn binders and old-style threshers.

As the verb thresh is cognate with the verb thrash (and synonymous in the grain-beating sense), the names thrashing machine and thrasher are (less common) alternate forms.

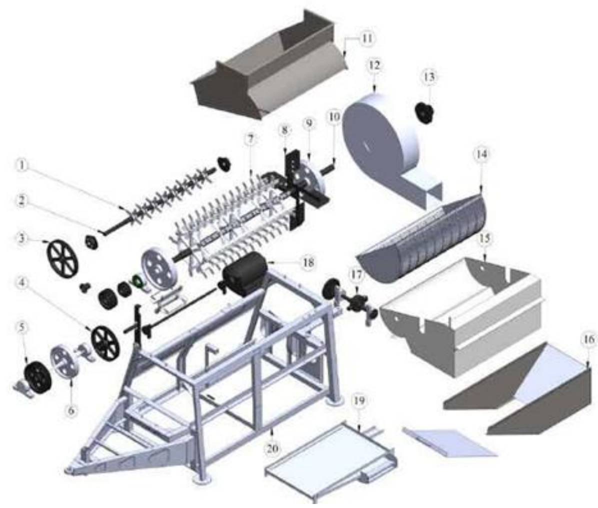


Fig.1. Exploded view of various components of conventional thresher[11]

Parts Description

1 1 Star blade
2 Star shaft
3 Star shaft pulley
4 Idler pulley
5 PTO Pulley
6 Flywheel
7 Conventional beaters
8 Pedal fan blower
9 Flywheel
10 Main cylinder beater shaft
11 Feeding chute
12 Casing of fan blower
13 Pulley
14 Concave sheave
15 Frame for sheave
16 Feeding frame
17 Cam for vibrating motion of mesh
18 Small cleaning chaff blower
19 Vibrating mesh
20 Main frame of thresher

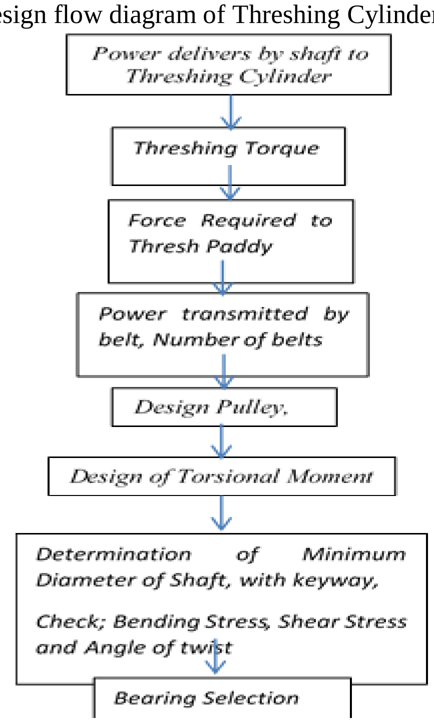
In order to mechanize this process, two main types of stationary threshing machines have been developed. They are “through-flow” type combine harvester and “axial-flow” type combine harvester.The mechanical threshing operation becomes a customary practice now. The effect of cylinder speed on threshing performance is highly significant all machine settings. Power consumption and broken grains increase and unthreshed grains decrease with the increase in cylinder speed. Though the unthreshed grainlosses decrease but the total grain losses increase with the increase in cylinder speed [9].

Zakaria developed the threshing drum in a local stationary thresher to suit separation of flax capsules. The machine was tested under feed rates of 8.57, 12.86, 17.14 and 21.43 kg/min, and four drum speeds of 24.25, 25.81, 27.33, and 28.85 m/s. The results showed that the optimum performance was at drum speed of 28.85 m/s, feed rate of 8.57 kg/min, drum fingers of 12 and separation time of 15 seconds where the threshing efficiency was 96.92% [06Zak].

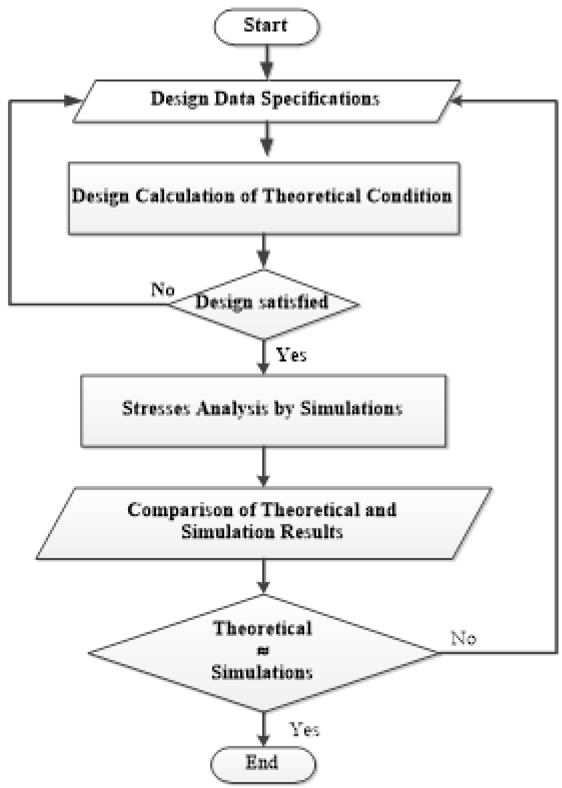
El-Sharabasy mentioned that using both full and partial mechanization system for harvesting and threshing rice crop at the higher forward speeds and lower grain moisture contents, recorded minimum consumed energy and cost requirements. Also using partial or full mechanization for harvesting rice crop saved time, effort, and total cost requirements and also cleared the rice crop from the field as fast as possible than traditional manual system [07Eis].

II. DESIGN OF THRESHING CYLINDER DRUM FOR A COMBINE PADDY HARVESTER

A. Design flow diagram of Threshing Cylinder Drum



B. Flow Chart diagram of Threshing Cylinder Drum Stress analysis



III. DESIGN SPECIFICATION AND RESULTS

Input data for design calculations is obtained from Kyaukse Industrial Zone. They are;

TABLE I. SPECIFICATIONS FOR DESIGN CALCULATION

Parameters	Symbol	Unit	Value
Diameter of bar	D_b	mm	31.75
Length of bar	L	mm	1339.
Number of bars	n	-	6
Outer diameter of outside disc	D_o	mm	472.4
Inner diameter of outside disc	D_i	mm	444.5
Length of cylinder	D_o	mm	1358
Diameter of teeth	D_i	mm	12
Thickness of discs	t	mm	4
Number of discs	n	-	3
Diameter of teeth	D_t	mm	14
Length of teeth	L	mm	86
Number of teeth	n	-	108
Speed of threshing cylinder	N	rpm	540

TABLE II. RESULT TABLE FOR THRESHING CYLINDER

Parameters	Symbol	Unit	Value
Weight of threshing discs	W_{discs}	N	19
Weight of threshing teeth	W_{teeth}	N	80
Weight of threshing bars	W_{bars}	N	489.14
Weight of threshing shaft	F	N	39.744
Weight of threshing cylinder	F	N	622.22
Threshing Power	P	kW	8
Threshing Torque	T	N-m	141.67
Angular velocity	ω	rps	56.55

TABLE III. RESULT TABLE FOR V-BELT DESIGN

Parameters	Unit	For Threshing Pulley	For Blower Pulley	For Auger Pulley
Power input	kW	8	3.62	2.314
Tension in tight side	N	1137.795	334.645	274.085
Tension in slack side	N	308.779	32.256	2.30
Velocity of weaker pulley	m/s	20	12	8.944
Length of belt	m	1.01	2.23	1.01
Mass of per length	kg	0.224	0.224	0.87
Dansity of rubber belt	Kg/m^3	1140	1140	1140
Power rating	N	32.236	3.62	2.319

Number of belt	-	3	2	2

TABLE IV. RESULT TABLE FOR SHAFT DESIGN

Parameters	Symbol	Unit	Value
Torsional Moment	M_t	N-m	141.4
Diameter of the shaft	d	mm	43
Bending Stress	σ_b	MN/m²	22
Shear Stress	τ	MN/m²	5.49
Angle of Twist	θ	degree	0.297
Deflection	δ	mm	8.654×10-5

TABLE V. RESULT TABLE FOR BEARING DESIGN

Parameters	Symbol	Unit	Value
Life in working hours	L_n	hr	8000
Loading ratio	C/P	-	7.81
Equivalent bearing load	P	N	2662.836
Basic dynamic loading	C	N	20796.75
Bearing number	SKF-6280		
Inner race max; diameter	d	mm	40
Outside diameter	D	mm	80
Width	B	mm	18

IV. STRESS ANALYSIS OF THRESHING CYLINDER

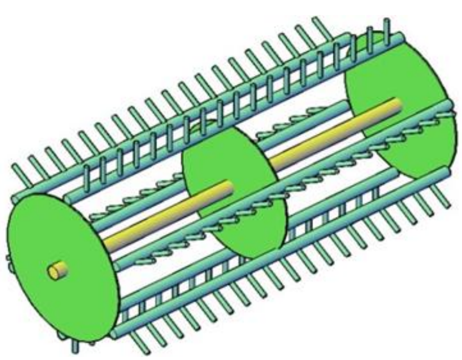


Fig. 2. Three Dimensional Drawing of Threshing cylinder using Solidworks software

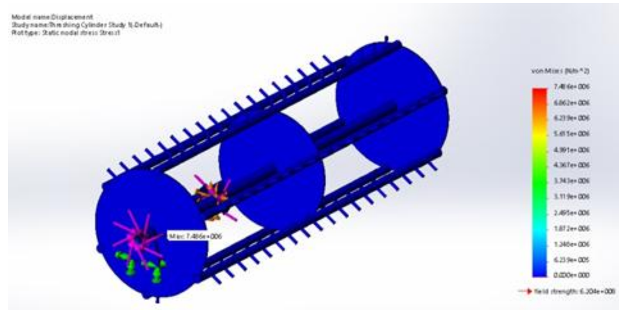


Fig. 3. Simulation Results of Stress due to torque on Threshing Cylinder using Alloy Steel

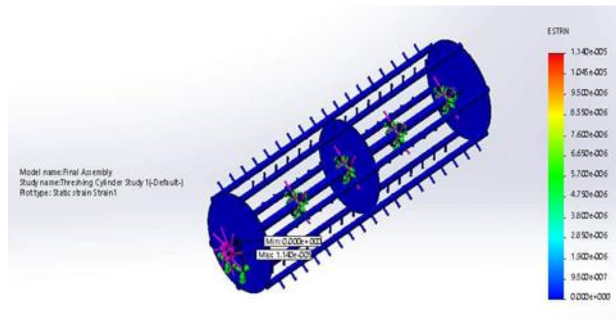


Fig. 4. Simulation Results of Strain due to torque on Threshing Cylinder using Alloy Steel

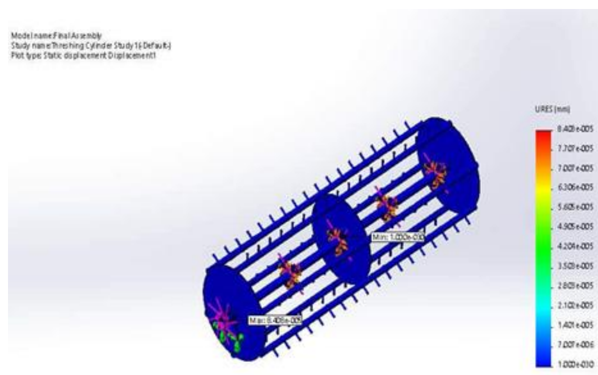


Fig. 5. Simulation Results of Deflection due to torque on Threshing Cylinder using Alloy Steel

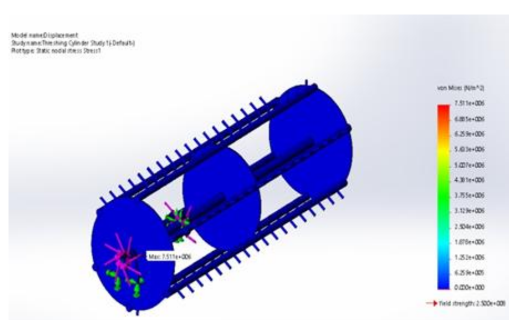


Fig. 6. Simulation Results of Stress due to torque on Threshing Cylinder using A36 Steel (or) Mild Steel

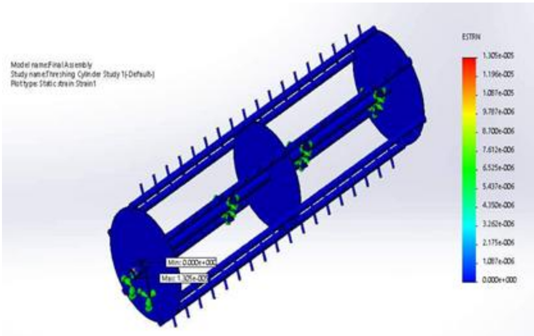


Fig. 7. Simulation Results of Strain due to torque on Threshing Cylinder using A36 Steel (or) Mild Steel

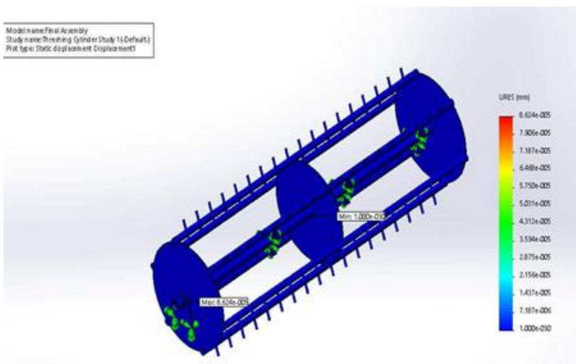


Fig.8. Simulation Results of Deflection due to torque on Threshing Cylinder using

TABLE VI. RESULT OF STRESS, STRAIN AND DISPLACEMENT DUE TO TORQUE

Sr. No	Type of Materials	Stress (NM/m2)	Strain	Deflection (mm)
1	Ally steel	7.786	1.140×10^{-5}	8.408×10^{-5}
2	A36 Steel (or) Mild Steel	7.511	1.305×10^{-5}	8.624×10^{-5}

V. RESULT AND DISCUSSION

In the threshing cylinder design, total cylinder weight, threshing power, threshing speed, threshing torque and moment was calculated. In the design calculations of power transmission shafts, calculations are made by assuming that the shafts are in the state of torsion and bending only. In V-belt drive calculation, the appropriate belt type to be used and the number of belts was calculated. In bearing design and selection, the appropriate bearing numbers was calculated for each bearing. After checking the results, existing theories and calculated results are nearly the same. In the simulation results, the calculation value of shear stress and angle of twist are existed at the limited value of simulation results.

So, design is satisfactory. But there are some weak points in the design calculations of the machine. Because calculations are made by considering only load conditions on the driving shaft and other forces are not considered such as dynamic, vibration effect so on. And also feed rate and moisture content of paddy are not considered in this paper. In addition, calculations of critical speed of shaft and, deflection are considered. The stress analysis is made by using SolidWorks Simulation.

VI. CONCLUSION

This paper is designed of threshing unit for combining paddy harvester with 472 mm diameter and 1339.85mm length cylinder from the Pyay Industrial Zone and got the specification data from it. Design calculations of these machines are necessary to decide whether they are fitted with standards or not. After checking the simulation results, existing theories result are achieved within the range of the simulation results. So design is satisfied.

REFERENCES

[1] Abdulkadir Baba Hassan, Matthew Sunday Abolarin. “The Design and Construction of Maize Threshing Machine,”Niger State Nigeria. 2009.

[2] PSG Tech. “Design data. Faculty of Mechanical Engineering,” Poolamedu Sathankulam Govindsamy Naidu College of Technology (PSG Tech), DPV Printers, Coimbatore, India.1989.

[3] Oni, K.C.; and Ali, M.A. “Factors influencing the threshability of maize in Nigeria.”Agricultural Mechanization in Asia, Africa and Latin America (AMA) 17(4): 39-44. 1986.

[4] Kaul,R.N.;and Egbo,C.O “Introduction to agricultural Mechanization Macmillan,” London, England, UK. pp. 128-41. 1985.

[5] Robert L. Mott, P.E, 1985. “Machine Elements in

Mechanical Design, Macmillan Publishing Company," New York.

[6] Black, P.H.; and Adams, O.E., Jr. "Machine design. 3rd ed. McGraw-Hill,"New York, NY, USA. 1968.

[7] Robert L. Mott, P.E,. "Machine Elements in Mechanical Design, Macmillan Publishing Company," New York. 1985.

[8] International Rice Research Institute (IRRI), "Standard Paper of Throw-in Type Thresher," Drawing and Test .1981.

[9] Lambert Henry Wilkes, M.S.,"Farm Machinery and Equipment."McGraw-Hill Book Company, New York. 1961.

[10] Williams, W.A. "Mechanical power transmission manual."Conover-Mast Publ., New York, NY, USA. 1953.

[11] https://www.academia.edu/35679133/DESIGN_OF_BEATER_WHEAT_THRESHER_COMPONENTS.