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RESEARCH ARTICLE

INTEGRATION OF THE GRINDING FUNCTION WITH A CEREAL THRESHER FOR THE RECOVERY OF CROP RESIDUES IN COMPOSTING

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Abstract

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The objective of this article is to design and characterize the technical performance of the agricultural residue grinding function integrated into the operation of a multi-purpose cereal thresher. For the farmer, this equipment will have the advantage to realize out threshing, grinding, and water pumping. Water pumping will allowwatering the agricultural residues after their grinding.The Functional Analysis (FA) was used to identify new useful functions and technical solutions for the grinding function to be integrated into the design. The multifunctional thresher-grinder has been designed and manufactured. Grinding performance tests compared to manual machete cutting of corn and rice residues were performed. The results show that production times per tonne of the broyats are higher than those of manual machete cutting more than 61%. The size of the broyats is reduced from 17 to 72%, and the diameter from 71 to 80% compared to manual machete cutting. These results will be used as benchmarks for testing other types of residues.

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Introduction:-

In Sub-Saharan Africa (SSA), man remains the main source of agricultural energy. It provides 65% versus 25% per animal and 10% per engine[5]. The weakness of agricultural motorization, which is stagnating, is linked to the disappearance of state programs and private takeover [16]. This situation negatively impacts agricultural productivity and food security, in the context of growing food and economic needs [7]. In addition, land degradation, which affects 46% of the African continent's surface area and 65% of the population, is a factor that limits the technical and economic performance of agriculture in this region. The region loses 3% of its agricultural gross domestic product (GDP) annually as a result of land degradation [9].

And yet, land degradation dynamics are accelerating in Burkina Faso, from 113,000 ha/year between 1983 and 1992 to 469,000 ha/year between 2002 and 2013. Thus, degraded or in the process of degradation land represents 31% of the national territory, while those that are heavily degraded cover 24% of the country's area, or 6,498,610 hectares

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that are to be recovered and restored [14]. In this context, appropriate organic amendments represent one of the necessary responses, as organic matter is essential for sustainable use of tropical soils [10]. Therefore, it urges to lift of bottlenecks which limit the production of organic manures. These include the lack of equipment, labour, water and technical mastery, and above all the arduousness of the work [2-16].

The above suggests that mechanization, or even the motorization of agricultural activities, remains a major challenge. For more than half a century, measures to promote agricultural mechanization have produced mixed results: the use of tractors and tillers remains marginal, and the majority of motorization experiments in agricultural production have been failures [15]. In contrast, animal traction continues to develop in favourable areas [17].The same applies to the mechanization of post-harvest operations, such as threshing and processing. For example, threshers are among the most widely used agricultural machinery in West Africa. On dénombre plusieurs milliers de batteuses et égreneuses à céréales (riz, maïs, mil et sorgho) entraînées par des moteurs diesel de 5 KW à 20 KW that one moves from a threshing site[21].

In Burkina Faso over the past few decades, threshers that were imported for threshing rice or maize have gradually been adapted for other crops such as sorghum, millet, cowpea, soybeans, etc. For example, several types of "versatile" threshers exist in the field: paddy rice thresher Votex [19], corn thresher [13], thresher SG 2000, poly-cereal thresher PoegaKorgho" and Seguinbana 2 [20].However, the profitability of these agro equipment remains a challenge in order to incite producers or agricultural entrepreneurs to invest in them. To this end, the diversification of equipment functions is an option that will reduce the chain of equipment and correlatively facilitate their acquisition at low cost. It is in this sense that the present study proposes a thresher-grinder, because the difficulty associated with the grinding operation is such that it is necessary for specific equipment, which the producer cannot, however afford. In this context, the specific objective of this study is to integrate the grinding function with a thresher in order to recover agricultural residues. Eventually, plant residues can be collected and ground for composting or livestock feed [4].

Materials and Methods:-

In order to generate equipment meeting the needs of the beneficiaries, the methodological process involved a multidisciplinary team of agronomists, breeders, and industrial engineering engineers. These works were carried out in several successive phases, namely the definition of a functional specification, the modeling of the 3D design and the manufacture of the equipment. Finally, crushing tests validated the functionality of the equipment and defined its functional characteristics.

Materials:-

These are essentially the raw materials needed to manufacture the equipment and plant residues for grinding tests.

Methods:-

Functional Analysis (FA)

Functional analysis is known as an aid to equipment design and has been used in various works [1-3-11]. It is a useful tool to address the expectations of users of poly-cereal or multipurpose threshers. Thus, in the beginning, the overall function was identified with the help of the horned beast. Then, the functions of uses of the grinding and water pumping function to be integrated into the thresher were identified and characterized using the octopus diagram. These functions have been translated into Functional Specifications (FS).

Internal Functional Analysis (IFA)

It made it possible to make the transition between the Functional Needs Analysis and the detailed design through the development of the Functional Analysis and Technical System (FATS) diagram [8-18]. The FATS diagram defined the technical functions followed by the technological choices. The components have to contribute to the functionality of the various technical functions that will perform all the service functions to satisfy the need of the grinding function. From the FS and FATS diagram, new service functions have been identified to be added to the operation of the thresher so that it can grind residues.

Sizing, 3D modeling and manufacturing of the thresher-grinder multifunctional

AutoCAD software, was used to model the 3D design of the multifunctional threshershredder. The modeling of the 3D design solution took into account the needs of energy supply and in situ mobility. The design was based on static, kinematics, and dynamics. The prototype of the multi-purpose thresher-shredder was manufactured in the ASEC mechanical manufacturing facility[6]. The manufacturing and installation of the equipment werecarried out under the supervision of the industrial engineering team.

Results:-

Equipment functional specifications

The specification is the final result of the functional analysis based on the horned beast (Figure 1) and octopus diagram (Figure 2). Thus, by the horned beast, the overall function of the equipment was specified in response to the need of the producers. In addition, the functions of use of the grinding function and water supply integrated into the poly-cereal thresher are recorded in the octopus diagram below (figure 2).

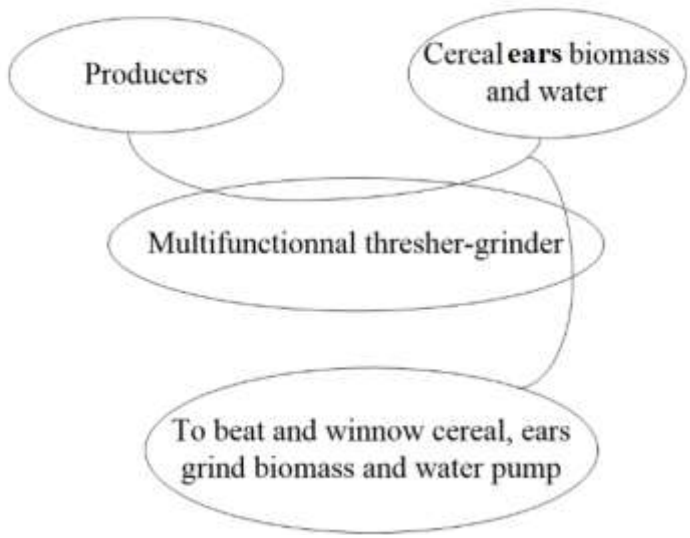

Figure 1:- The horned beast serving to identify the overall function of the equipment.

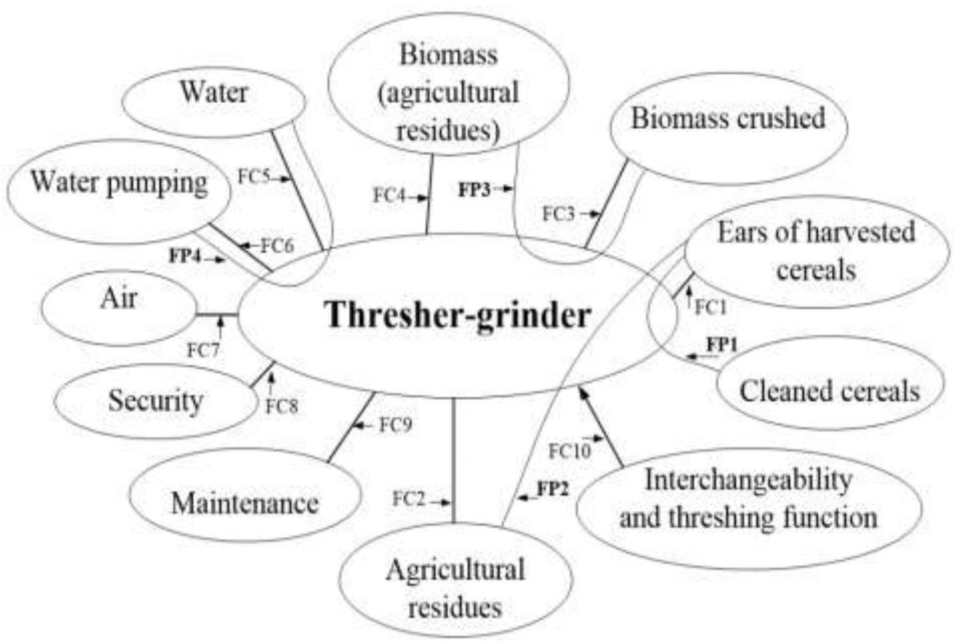

Figure 2:- Identification of equipment service functions by octopus diagram.

Table 1:- The Functional Specifications (FS) of the multifunctional thresher-grinder.

Functions	Criteria	Level	Limits/flexibilities
FP1: Beat cereal cobs	Hourly corn threshingcapacity	1000 kg	± 30
	Hourly rice threshing capacity	1500 kg	± 30
FP2: Winnowcereal	Hourly corn winnowingcapacity	1000 kg	± 30
	Hourlyricewinnowingcapacity	1500 kg	± 30
FP3: Crush biomass	Crushing capacity of post-harvest stems	200 kg/h	± 50 kg/h
	Post-harvest straw crushing capacity	140 kg/h	± 20 kg/h
FP4: Pump water from a pump	Water pumping flow rate	35 m^3/h	± 10
FC1: Respect threshing and winnowing parameters	Percentage of corn not despatches	100 %	± 20
	Percentage of envelopes of corn not despatches must be dry	100 %	± 20
	The rice must be with the straw	100 %	± 20
	Rice straw must be dry	100 %	± 20
FC2: Respect the low impurity level of the winnowed products	Impunity rate for winnowed corn	5 %	± 3 %
	Impunity rate for winnowed rice	5 %	± 3 %
FC3: Respect grindingparameters	Moisture rate of biomass	14 %	± 20
FC4: Grind must meet compost production particle size	Corn stalk size (T) and diameter (D)	T : 4.5 cm D : 0.5 cm	± 2 cm
	Size (T) and diameter (D) of rice straw	T : 7.25 cm D : 0.4 cm	± 2 cm
FC5: Accessing a water point	Suction distance from surface water (marigot, river, etc.)	8 m	± 2 m
	Suction distance from well water	5 m	± 2 m
FC6: Adjust the air flow	Adjustable with a degree of opening	90°	± 5°
FC7: Follow the safety instructions	Transmission mechanismclosure rate	100 %	± 5 %
FC8: Maintenance by local producers and artisans	Availability in the local refill parts market	100 %	± 5 %
FC9: Maintenance by local producers and artisans	Integrated first and second level maintenance	NF X 60-000 (2016)	-
FC10: Ensure operation of threshing and grinding functions on the same equipment	The threshing and grinding rotors are mounted in the same cage. The inner ring of the bearing is mounted tight on the shaft.	D : 35 mm	± 0,05 %

New integrated water pumping and grinding functions

Functional Analysis and Technical System (FATS) offers technical functions followed by technological choices. It suggests the components that will contribute to the functionality of the various technical functions that will perform all the service functions to satisfy the need of the grinding function. Thus, new functions of crushing and water supply have made it possible to propose technological solutions recorded in Figure 3.

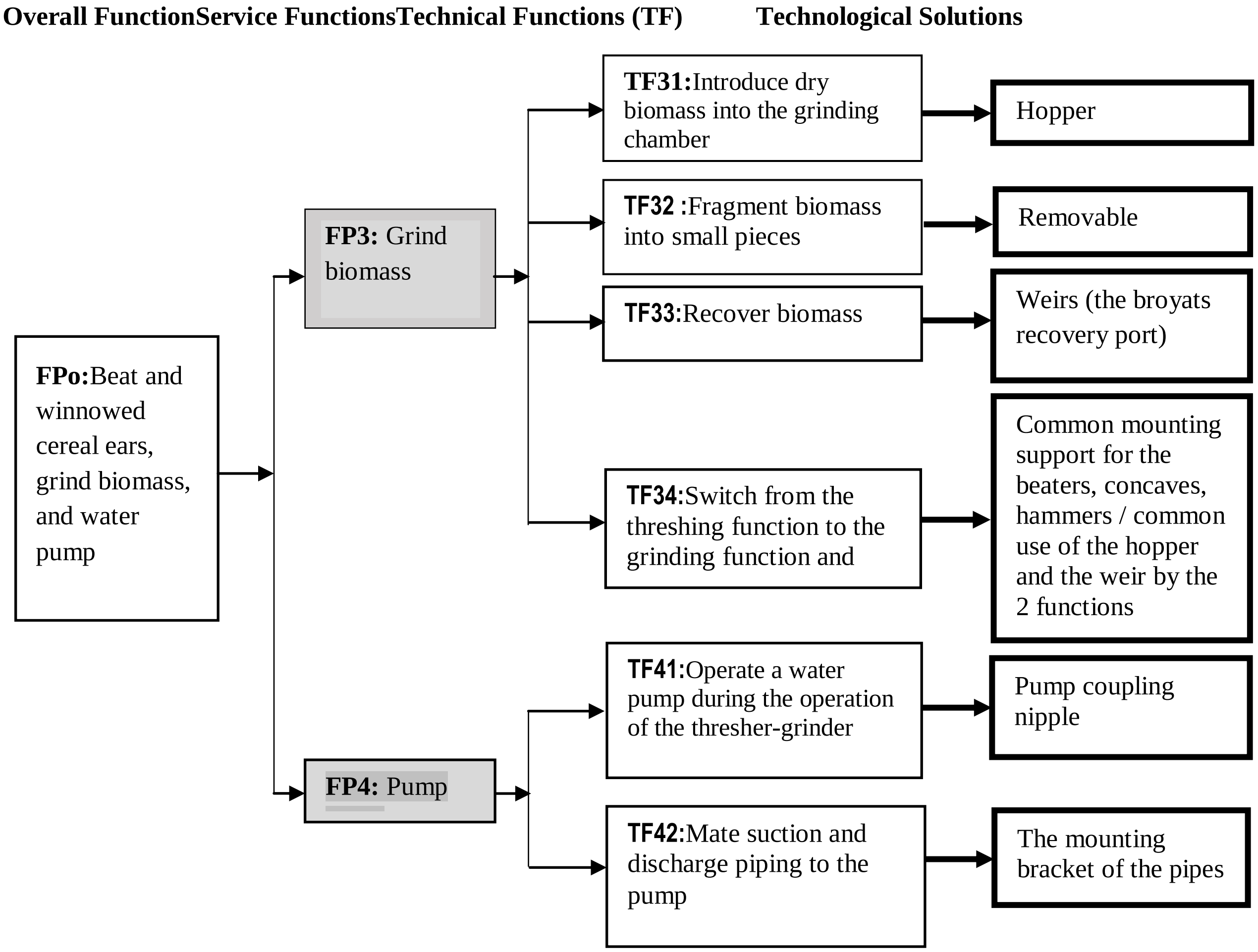

Figure 3:- Technical functions and technical solutions identified and integrated in the thresher.

Technical functions and technological solutions

From the FS and the FATS diagram, the new service functions (Table 2) have been added to the operation of the thresher-grinder to perform the crushing of the residues. The FP3, FP4, FC4 and FC6 functions are the new functions to be considered. It was these new technological solutions that inspired the design of the 3D equipment.

Table 2:- Service functions and constraints.

Functions	Definition
FP1	Beat the ears of cereals (corn, rice, etc.)
FP2	Winnow the seeds
FP3	**Grindbiomass**
FP4	**Pump water from a pump**
FC1	Respect the threshing and winnowing parameters
FC2	Respect the low level of impurities of winnowed products
FC3	Respect the compost production granulometry
FC4	**Respect the grindingparameters**
FC5	Access to a water point
FC6	**Pump surface and well water**
FC7	Adjust the airflow
FC8	Observe safety instructions
FC9	Ensure maintenance by local producers and artisans
FC10	**Ensure the operation of the threshing and grinding functions on the same equipment**

Sizing of the grinding rotor axis

The dimensioning of the axis of the grinding rotor was carried out as follows:

a)Isolate the shaft from the rotor and apply the outside forces to it (Figure 4):

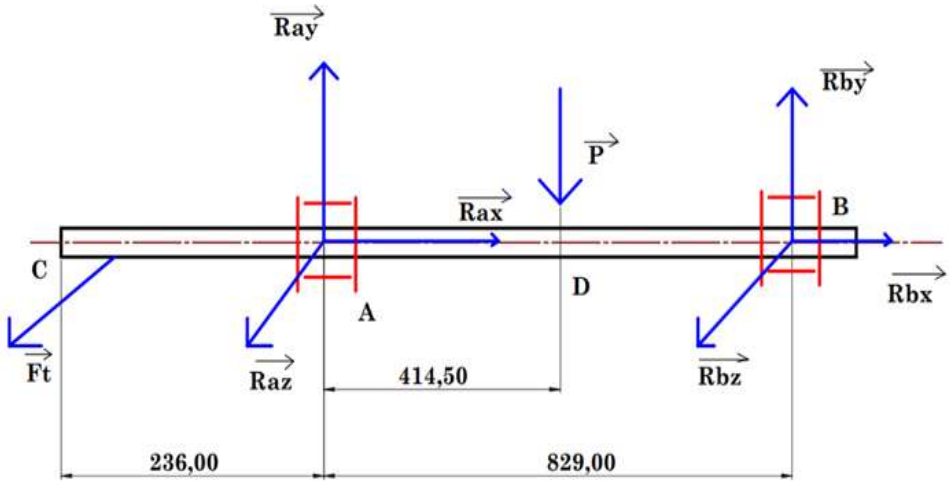

Figure 4:-Forces applied to the rotor shaft.

b) Determine the weight Pt exerted by the pulleys; the hammers; the discs carry the hammer and the axis of the rotor.

$$Pt = Mt \times g \quad (1)$$

With: Mt, the total mass of the rotor assembly : Mt = 68,09 kg

A.N : Pt = 68,09×9,81

Pt = 667,96 N

c) Let's determine the power

Calculation of the linear speed V of the system belt

$$V = \frac{\pi \times Nm \times dm}{30 \times 2} \quad (2)$$

With: dm the diameter of the driving pulley ; dm =150 mm

Nm, the speed of rotation of the driving pulley

A.N : $V = \frac{\pi \times 2200 \times 150}{30 \times 2}$

V=17278,75 mm/s≈ 17,27 m/s

The permanent power Pp of the assembly

$$Pp = \frac{Pt \times V}{\eta\,(belt, pulley)} \quad (3)$$

With : V = 17,27 m/s

Pt = 667,96 N

For η belt pulley efficiency = 0,95

A.N : $Pp = 667,96 \times \frac{17,27}{0,95}$

Pp = 12142,80 W≈12,14 KW

d) For the rotor axis

• Let's determine the reactions to the supports

• Calculation of the load exerted on the axis of the rotor

$$P = Pt - Pp \quad (4)$$

With: Pt, weight of the whole : Pt = 6667,96 N

Pp, pulley weight : Pp =137 N

A.N : P = 530,96 N

• Belt Tension Force Calculation Ft

The motor runs at a speed of 2200 rpm to provide a power of 17896.8 W or 17.89 KW

$$F_t = \frac{C \times 2,75}{0,75 \times Rr} \quad (5)$$

And $C = \frac{30 \times P}{\pi \times N}$ (6)

With : P =17896,8 W
C : torque in N
N : engine speed; N = 2200 rpm
R_r : driven pulley radius ; R_r= 0,135 m
A.N : $C = 30 \times 17896{,}8/\pi \times 2200$
C = 77,68 Nm
$F_t = 77{,}68 \times 2{,}75/0{,}75 \times 0{,}135$
F_t=2109,82 N
At A: pivot connection: We have :$\overrightarrow{R_{AX}}$;$\overrightarrow{R_{AY}}$;$\overrightarrow{R_{AZ}}$;$\vec{M}=\vec{0}$(7)
In B: pivot connection: we have :$\overrightarrow{R_{BX}}$;$\overrightarrow{R_{BY}}$;$\overrightarrow{R_{BZ}}$;$\vec{M}=\vec{0}$(8)
Balance of forces applied to the shaft $\sum\vec{F}$
By projecting the forces into the frame (A ;$\vec{x}$;$\vec{y}$;$\vec{z}$)

$$\vec{F}\begin{cases} R_{AX} + R_{BX} = 0 & (9) \\ -P + R_{AY} + R_{BY} = 0 & (10) \\ F_t + R_{AZ} + R_{BZ} = 0 & (11) \end{cases}$$

Balance of moments applied to the shaft $\sum\overrightarrow{M}$

$$\sum\overrightarrow{M_{/A}}=\overrightarrow{M_{A/A}}+\overrightarrow{M_{D/A}}+\overrightarrow{M_{B/A}}+\overrightarrow{M_{C/A}}=0 \quad (12)$$

$$= 0+\overrightarrow{F_t} \wedge \overrightarrow{CA}+\overrightarrow{AB}\wedge\overrightarrow{R_B}+\overrightarrow{AD}\wedge\vec{P}=\vec{0}(13)$$

By projecting these moments in our spotted

$$(F_t)_z\wedge CA_{\vec{x}}+(AB_{\vec{x}}\wedge R_{BY\vec{Y}}+AB_{\vec{x}}\wedge R_{BZ\vec{Z}})+AD_{\vec{x}}\wedge(-P)_{\vec{y}}=0 \quad (14)$$

$$(F_t \times CA)_{\vec{y}}+(AB\times R_{By})_{\vec{z}} -(AB\times R_{BZ})_{\vec{y}} -(AD\times P)_{\vec{Z}}=\vec{0}(15)$$

$$[(F_t \times CA)-(AB\times R_{BZ})]_{\vec{y}}+[(AB\times R_{By})-(AD\times P)]_{\vec{z}}=\vec{0}(16)$$

$$\overrightarrow{M}_{Fext}\begin{cases}[(F_t \times CA) - (AB \times R_{BZ})]_{\vec{Y}} = \vec{0} & (17) \\ [(AB \times R_{By}) - (AD \times P)]_{\vec{Z}} = \vec{0} & (18)\end{cases}$$

Determine R_B using the equations

$$R_{BZ}=\frac{F_t\times CA}{-AB}\vec{Y} \quad (19)$$

A.N :$R_{BZ}=\frac{2109{,}82\times 236}{-829}$
$R_{BZ}=-600{,}6$ N

$$R_{BY} = \frac{-AD\times P}{-AB}\vec{Z} \quad (20)$$

A.N : $R_{BY} = \frac{414{,}5\times 5300{,}96}{829}$
R_{BY}= 265,48 N
Let us deduce R_A using the equations

$$R_{AY} = P - R_{BY} \quad (21)$$

A.N: $R_{AY} = 530{,}96 - 265{,}48$
R_{AY}=265,48

$$R_{AZ} = -F_t - R_{BZ} \quad (22)$$

A.N : $R_{AZ} = -2109{,}82 - 600{,}6$
$R_{AZ}=-2710{,}42$ N

Table 3:- Summary of cohesion forces on the rotor shaft.

Position	**C at A (mm)**	**A at D**	**D at B (mm)**
Change of x	$0 \le x < 236$	$0 \le x < 650.5$	$0 \le x < 1065$
T_y(N.mm)	0	$-(-R_{Ay}) = 256{,}48$	$-(-R_{Ay} + P) = -256{,}48$
M_f(N.mm)	0	$-(-R_{Ay})x = 256{,}48x$	$-(-R_{Ay} + P)x = -256{,}48x$
T_z(N.mm)	0	$-R_{AZ} = 2710{,}42$	$-(R_{Ay} + R_{BZ}) = 2109{,}82$
M_f(N.mm)	0	$-R_{AZ}x = 2710{,}42x$	$-(R_{Ay} + R_{BZ})x = 2109{,}82x$
$M_{t(x)}$(N.mm)	0	0	0

Position	A	B
T_y (N.mm)	256,48	-256,48
M_f(N.mm)	172694,74	-282736,2
T_z(N.mm)	2710,42	2109,82
M_f(N.mm)	1763128,21	2246958,3

The section to the right of A being the most loaded both on bending moments along the y axis and on z, we will size the shaft according to bending moments.

Determine rotor shaft diameter
The maximum normal stress must always be less than the elastic practical resistance
Rpe of the material.
$R_{pe} = \frac{R_e}{s}$with $R_e$the apparent elastic limit and s the safety factor[13].
Condition of resistance :

$$\sigma_{max} \le R_{pe} \quad (23)$$

$$\sigma_{max} = \frac{M_f}{I/\vartheta_0} \quad (24)$$

$$\frac{M_f}{I/\vartheta_0} \le R_{pe} \quad (25)$$

$$\frac{I}{\vartheta_0} = \frac{\pi \times d^3}{16} \quad (26)$$

$$\sigma_{max} = \frac{16 \times M_f}{\pi \times d^3} \quad (27)$$

$$\frac{16 \times M_f}{\pi \times d^3} \le R_{pe} \quad (28)$$

We'll have : $d \ge \sqrt[3]{\frac{16 \times M_f}{\pi \times Rep}}$
With :

- σ_{max} , thenormal stress
- M_f, the bending moment , M_f= 2246958,3
- $\frac{I}{\vartheta_0}$, the quadratic moment

We choose a high alloy steel for a low yield strength and made of mechanical construction steel type E335 with a minimum yield strength. We know that 1MPa = 1N/mm^2
$R_{pe} = \frac{R_e}{s}$(29)
With :

- Re = 335 MPa
- Sthe safety factor ; S = 2,5

An: $R_{pe} = \frac{335}{2,5}$
$R_{pe} = 135 \text{ N/mm}^2$
From whered $\ge \sqrt[3]{\frac{16 \times 2246958,3}{\pi \times 134}}$ $d \ge 44,03$ mm
To ensure a good resistance of the shaft, we will take in diameter 50 mm made of steel of mechanical construction E335. Shoulders of diameter 35 mm will be machined to accommodate the bearings and pulley.
• Selection of bearings for rotor shaft bearings
The grinding rotor shaft shall be supported by two bearings each containing a bearing at points A and B. Calculation of the maximum RB force applied to the bearings.

$$RB = \sqrt{R_{Bz}^2 + R_{By}^2}$$

An : $R_B = \sqrt{(-600)^2 + 256,48^2}$
$R_B = 653,07$ Nou 65,30 daN

Calculations show that the axial force is zero. However, in the case of misalignment of the pulleys or at start-up, after the belt has been installed, axial stresses may arise. They must then be absorbed to ensure a good life of the

bearings. For this reason, the choice is for ball-bearing bearings with clamping sleeves, as they support relatively high radial and axial loads.
We will then choose two SKF bearings of reference SNL 508 TA for ball bearing type 2208 EK with clamping sleeve type H 308 corresponding to an internal diameter D_{arbre} = 35 mm.

The mechanical stresses on the grinding rotor axis are greater than those on the driving rotor axis after verification. We will retain the dimensions of the grinding rotor axis for the driving rotor axis. The interchangeability of the rotor without modification of the supports confirms the multifunctionality of the thresher-grinder.

Description and operation of the multifunctional thresher-grinder
The multifunctional thresher-grinder developed is described below (Figure 5).

It allows beating the cereals to separate the grain from the straw but also to crush the post-harvest stems and residues that can be used for the production of compost or livestock feed.

For the grinding function, the grinder is fed through its feed port with agricultural residues (straw, rice, corn, sorgo, etc.). These residues are grinded by a removable hammer rotor driven by a diesel engine. These 30 mm flat iron hammers are responsible for grinding agricultural residues against the tree on which they are mounted in the grinder chamber. The large mesh square iron sieve 170x30 mm, allows the passage of well grinded residues to the outlets. The grinded residues are propelled by a valve that acts as a turbine. A separator is placed to contain the products in the grinding chamber.

To ensure the watering of the compost in production or of the crops, the thresher-grinder is equipped with a removable centrifugal pump coupled to the axis of the winnower. It allowspumping surface or well water.

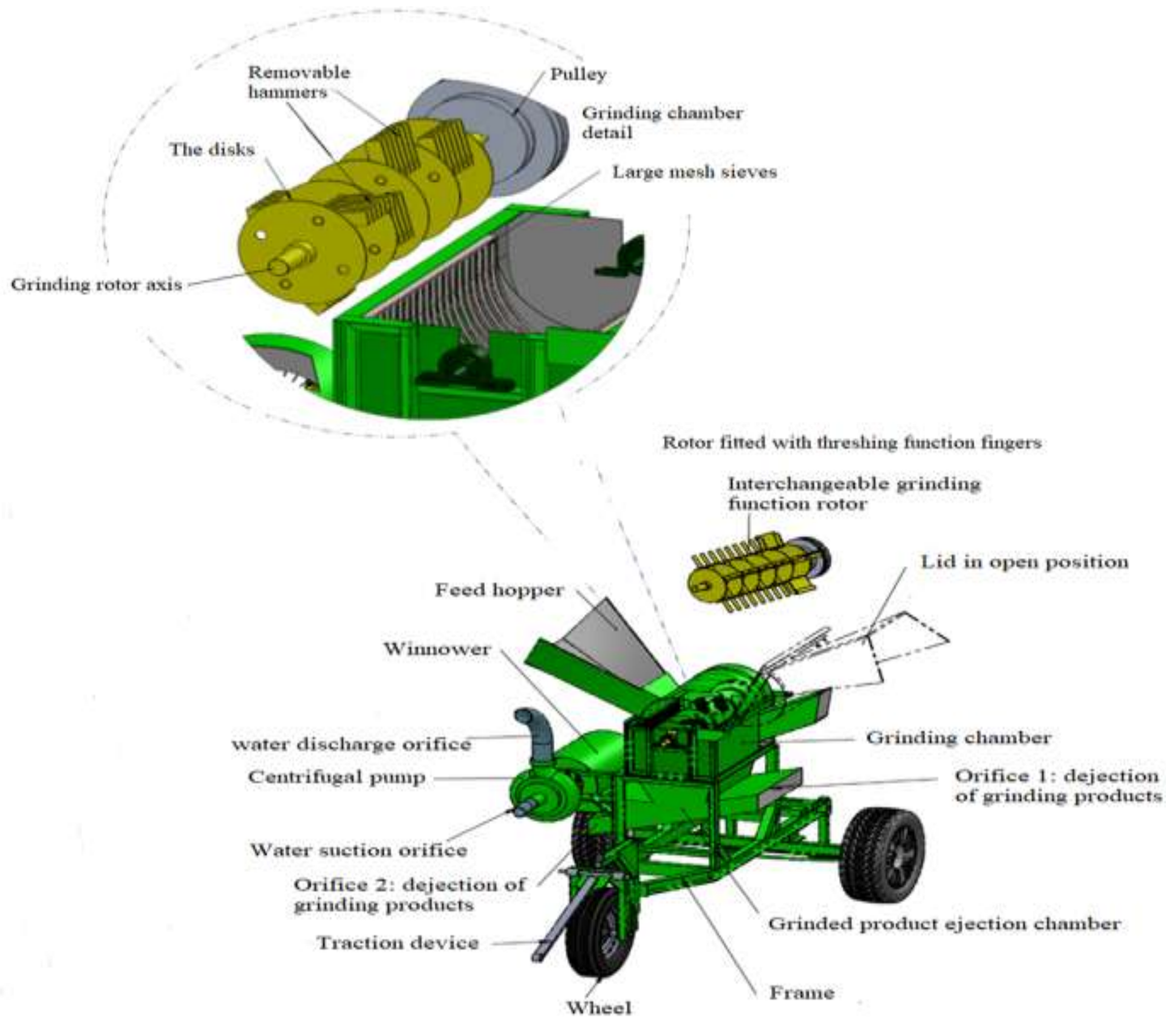

Figure 5:- Description de la batteuse-broyeuse multifonctionnelle.

For the threshing function, the finger rotor is mounted. The thresher is fed through its cereal feeding hole (ears of rice and corn.). These cereals are beaten by a fixed finger rotor driven by a diesel engine. The 20 mm round iron torus fingers are responsible for releasing the grains from the waste in the threshing chamber. These released grains pass through a sieve of mesh depending on the grain size of the grain concerned and end up in the winnowing chamber. The residues remaining in the threshing chamber are conveyed through the baffles and propelled by the ejectors at the exit of the large residues. The grains and light residues are in the winnowing chamber to be separated. The winnower blows air through its vanes which separate the grains from the light residues. The residues pass through the light waste outlet and the winnowed grains are collected at the level of the grain spillway.

Technical characteristics of the grinding function

The in situ grinding tests validated the functionality of the thresher-grinder. The technical characteristics of the grinding function are recorded in Table 4.

Table 4:- Technical characteristics of the grinding function and the water pump.

Parameters	Technical specifications	
	Corn straw	Rice straw
Energy consumption (diesel) (l/h)	1,20 ± 0,10	1,36 ± 0,10
Grinding flow (kg/h)	223 ± 14	209 ± 9

Grinding rate (%)	100	100
Working speed (rpm)	1753	1450
Dimensions (L x W x H) (mm)	2200 x 2000 x 2000	
Engine rated speed (rpm)	2200	
Engine power (HP)	24	
Pump water flow (m^3/h)	20 à 40	

The grinding rate is 100% for both corn and rice as the results show (Table 4).
In addition, mechanical grinding is more effective than manual cutting with a machete in reducing the dimensions of the broyats (Table 5, Figure 6).
The length of corn broyats is significantly reduced by manual grinding. For rice, the length of the broyats is less differentiated between the two types of grinding. On the other hand, the diameter of the broyats is reduced in proportion from at least 3 for rising to more than 5 for corn by changing from manual to mechanical grinding.

Table 5:- Average dimensions of broyats and grinding time

Straw type	Grinding type	Length (cm)	Diameter (mm)	Duration Per Tonne of Residues (DPTR)
Corn	Manual machete cut	16,60	23,82	13 h 20 mn
	Thresher- grinder	4,77	4,57	5 h 00 mn
Rice	Manual machete cut	4,58	26,72	20 h 33 mn
	Thresher- grinder	3,78	7,25	7 h 13 mn

Figure 6:- Products from the mechanical grinding of rice straw (a) and corn (b) and manual grinding of rice (c) and corn (d)

Discussion:-

The equipment grinding function is operational. The grinding rate obtained for both types of residues (100%) as well as the water pumping rate (20 to 40 m^3/ h) are in line with the expectations of the beneficiaries recorded in the functional specification. Also, the results obtained after the grinding and water pumping test are in accordance with the initial specifications. Thus, the multi-functionality of the equipment (threshing, grinding, water pumping) to strengthen the technical-economic performance of the operation while reducing the investment costs. Moreover, it is clear that mechanical grinding is more efficient in terms of the dimensions of the aggregates intended for composting, and especially in terms of time savings compared to manual machete at grinding. Because the time it takes to crush a tonne of residues is reduced by a ratio of 3 to 5 for rice and corn respectively. Thus, rice straw is more demanding in grinding due to its relatively more fibrous nature. This explains why these straws are difficult to compost without reducing the size of the aggregates. However, it remains necessary to assess the impact of mechanical grinding on composting performance in order to fully justify the relevance of investment in grinding equipment.

In the rest of Africa, threshers have been developed to relieve users. However, they do not necessarily integrate the three functions taken into account by the thresher-grinder to be multifunctional. Also, most is dedicated to a cereal, so not versatile. Indeed, a thresher was designed and manufactured to shell corn and separate the ear of grain. At an affordable cost, it has a 99.2% yield, but does not integrate the grinding function [12].

Conclusion:-

At the end of this study, it was found that the integration of the grinding function in the operation of the multifunctional thresher is an alternative to facilitate the production of compost by farmers. The equipment not only allows to have residues of sizes less than 20 cm, but also to reduce the cutting time. With this equipment, the producer will be able to do the threshing and then make his compost. He will also have the possibility to pump water during the operation of the equipment either to water his compost or plants. The threshing function does not interfere with the performance of the grinding function and vice-versa since the rotors are interchangeable respectively. Also, the water pumping function does not alter the engine torque either during the driving period or that of grinding. The integration of the grinding function followed by the water pumping function in the thresher will allow the producer to save in terms of equipment acquisitions. This technological innovation is aimed at agricultural producers and young agricultural entrepreneurs for the production of compost and post-harvest services. The integration of the grinding function contributes to the promotion of the thresher and the valorization of the agricultural residue crushers. Grinding performance and impact on composting will be evaluated to complement the evaluation of agroequipment.

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