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WATER CAPTURE WELL PROBLEMS AND PERSPECTIVE "Case of Kampumpineighbourhood; city of Likasi in the Democratic Republic of Congo"

KIKUNI N'SUBI Clément (1)

Abstract

This scientific work presents the results of a study conducted in the KAMPUMPI district, one of the six neighbourhoods in Likasi commune in the city of Likasi.

The study resulted in the sizing of a well drilling unit to be used to supply water to several houses in order to improve the living conditions of the inhabitants of this entity since the hydraulic network of the "Regideso"(National Water Distribution Company in DR Congo) is in a state of obsolescence.

The results obtained are to be generalized to the other districts of the city of Likasi which, moreover, suffer from the insufficiency of drinking water supply by the public distribution network. These dwellings will thus benefit from the erection of well-water-secure wells which can offer a relatively prolonged longevity and drinking water may be within their reach despite the cuts or non-supply of this food by Regideso is facing multiple problems with ever-increasing demands.

It should be noted that access to drinking water can make a significant contribution to reducing mortality among the population and in particular for children aged 0-5, by reducing the prevalence rate of waterborne diseases.

Proper management of the drinking water well can also prevent the recurrence of diseases such as cholera that are repeated each year in the city of Likasi.

In our methodical approach, we first list the population of the KAMPUMPI district, the number of existing water catchment wells and their characteristics before proposing the economic well drilling unit that could allow the erection of wells for that water is accessible to many, long-term without worrying about the water provided by Regideso.

Keywords:

WATER CAPTURE WELL,
KAMPUMPI district,
METHODICAL APPROACH

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INTRODUCTION

In the article presented today, it is a question of proposing a water well drilling unit for domestic use.

1. **Problems**

It should be noted that:
- The water of the Regideso is not accessible to all the population of the district KAMPUMPI.
- The population travels a great distance in search of drinking water and the quantity collected is often far from meeting the many daily domestic needs.
- Those who have a little way build wells at home sometimes without consideration of certain standards in technical, hygienic and environmental.

Considering these findings, it makes sense to ask why so many people can not help themselves by having a well of water drilled at home to be autonomous and no longer rely on Regideso.
The answer to this concern is positive, but most of them problem of financial means.

2.State of the question

In the KAMPUMPI neighbourhood, we record the great mass that runs here and there with yellow cans by hand or on vans to fetch water. Some will go straight for water in the surrounding stream, KAMILOPA without worrying about the risks of diseases that can be caused by pathogens carried by this type of water.
Failing to go to this stream, groups of women gather in front of the few taps of the Regideso that still run water or on some wells mechanically drilled, or still on the wells dug by hand that the neighbourhood is full of .
From these gatherings it follows a waste of time, disputes, in short problems on the social level.
These problems deplore the lack of equitable water distribution through a sustained network.
This helps to provide a drilling unit that can allow the erection of several water wells in the neighborhood at lower costs.

3. Goal
This study was conducted in order to encourage the less fortunate neighbourhood to have a water well at home for daily needs.

4. Methodology

To achieve this goal it seemed efficient to have statistical data on the demography of the population of the district, the total number of houses and that of houses with a supply of water wells through an interview with the chief. neighbourhood and the physical finding of wells, then move on to the sizing of the drilling unit to be designed.

5. Subdivision of work

Apart from the summary, the introduction and the conclusion, this work has been written following the structure below:
First: the collection of statistical data.

Second: the dimensioning of the drilling unit.

I. COLLECTION OF STATISTICAL DATA

Through direct observation, by being present in the field, the following information has been gathered:

The commune of Likasi is full of eight neighbourhoods that are the central districts city, Kampumpi, Simba, niche, Sncc, Kitabataba and the neighbourhood Mission.

The Kampumpi district is delimited according to the cartography: to the north by the boulevard de l'Independence; to the south by the avenue of the Panda clinic; to the east by the Sncc national railway and to the west by Kasongo avenue Michel.

Demographic situation of KAMPUMPI district: 54,092 inhabitants end of 2015

Number of inhabited plots: 6,496

Number of plots with tap water taps Regideso: 1,652

Number of wells: 42 including 3 wells and 39 wells.

We note that 1652/6496 = 0.25 or only 25% of houses are Served by Regideso; while undergoing at any time the non-supply of water as a result of the distribution of water load shedding.

Hence, 42 houses have seen fit to have water wells for daily needs and this is not enough for us. It is then necessary to allow a majority to have also modern wells.

Note however that the development of a well at home must be considered in two aspects: the location and construction of it. In fact, the location of the well will be chosen so as to minimize the risk of flood contamination and runoff. For this it will occupy the highest part of the terrain in the non-flood zone preferably. It will be located upstream and far from any possible source of pollution, while respecting the neighboring wells.

II. SIZING THE DRILLING UNIT

II.1. Presentation of the design

The rotation of the electric motor drives the worm which in turn drives the toothed wheel fixed on the same axis with the driving pulley of the belt transmission system.

The movement received by the driven pulley is keyed onto the shaft to which the extensions are fixed beforehand, which receive at the bottom end the drilling tool.

Thus, the rotational movement of the tool and its advance downwards makes it possible to obtain the drilled hole. When the penetration sufficiently reaches the level of underground water tables or aquifers the operation is stopped. Then the different extensions and the tool can be removed from the hole.

To protect the well, cross-linked polyethylene tubing equipment that is modern plumbing is required.

The withdrawal of water will be provided by a submerged electric pump, the useful water reserve will be guaranteed by a balloon also called balloon bladder.

II.2. Calculation of main organs

II.2.1. Drilling parameters

a) Drilling torque of the drilling tool: C_1
This couple takes into account the hardness of the formation which is here mainly "Shale": C_1 = 1519 Nm.
b) Diameter of the tool: D_1
The drill to be used is reinforced steel or diamond for a adopted efficiency. The stitching tip must also be of quality to allow precise drilling. D_1 adopted = 114 mm.
c). Turning speed adopted N_1 = 208 rpm; linear velocity of penetration
Adopted V_1 = 0.50 m / min
d). Likasi City Hall Standard: 8 people per family and per plot (house).
e). Standard of OMS (World Health Organization): water consumption: 20 to 50 liters / person / day
An average of 35 liters / person / day, so 35 liters x 8 = 280 liters / house / day: Q_1
Q_1 = 280 liters / house / day = 0.28 m^3 / house / day.
f). Well height: H_1
Starting from a domestic artisanal well of the said district, having as characteristics:
Diameter of the well: 1m
Height h_1 average well: 15m
Height h_2 of water in the well: 1 m (the aquifer has been reached at about h'_2 = 14m below the outer surface).
The quality of instant drinking water in the well:

$$Q = h_2 \frac{\pi d^2}{4}$$

$$= 1 \ \frac{3.14 \ x 1^2}{4}$$
$$= 0.785 \ m^3$$

Note that: $Q > Q_1$, daily consumption of a house that the drilled well must guarantee. That being so, H_2 height of water from the well to be drilled will be calculated from:

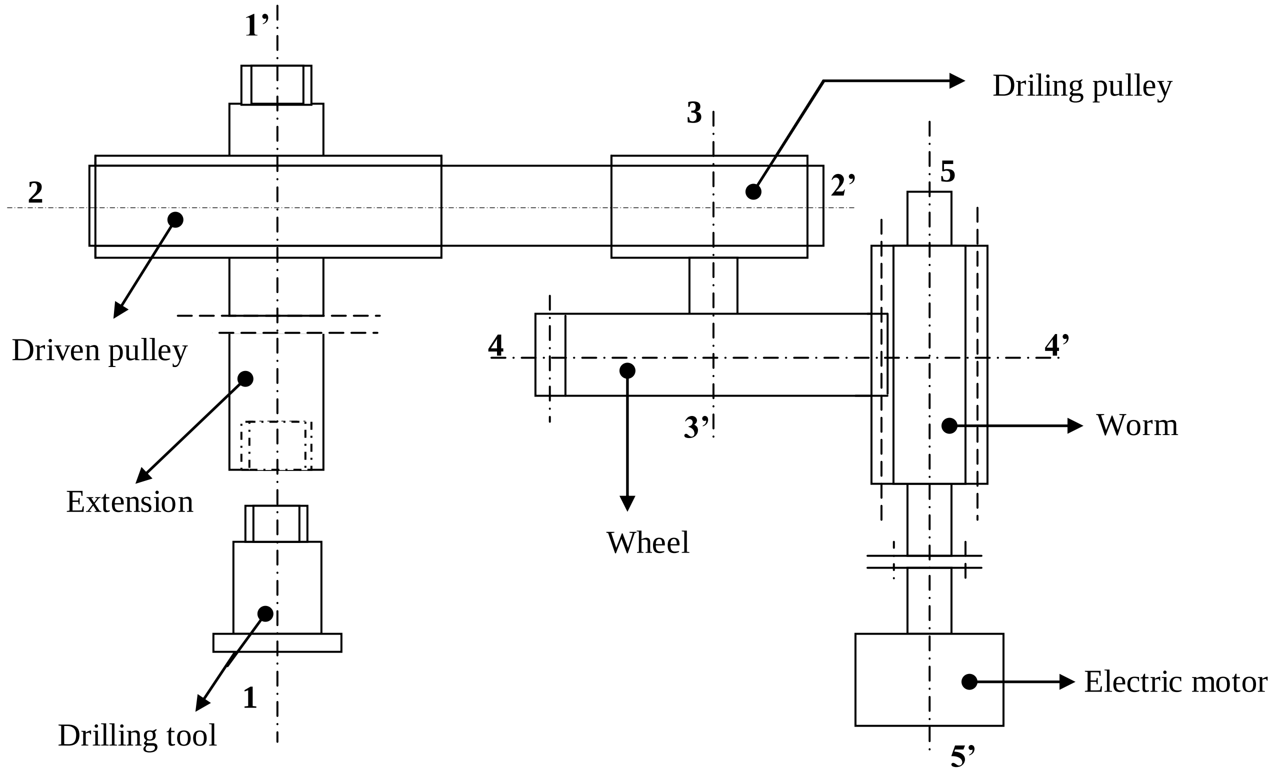
$$Q_1 = H_2 \frac{\pi D_1^2}{4} \ ; \qquad H_2 = \frac{4 Q_1}{\pi D_1^2}$$
$$= \frac{4 \ x \ \ 0.28}{3.14 \ x \ \ 0.114^2} \ ; \qquad H_2 = 27.44 \ m$$

The height of attainment of the aquifer h'_2 being 14 m, the total height H_1 of the well = h'_2 + H_2
H_1 = 14 + 27.44 = 41.44 m ; rounded to 42 m.
- Therefore, the number of extensions needed to drill this well: 15 extensions of 3m each.

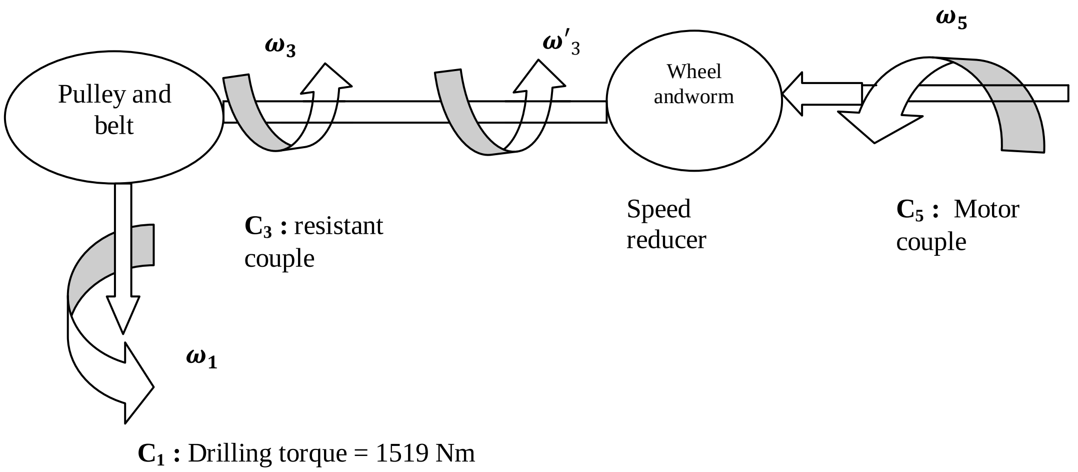
II.2.2. sizing

II.2.2.1. mechanical power transmission chain

This chain is intended to put in motion the drilling tool which opposes to this movement a resistant pair of variable intensity.



Schematically



II.2.2.2. transmissions

a) 1-1' : well drilling.

Drilling tool:

- resistant torque C_1 = 1519 Nm

- Diameter D_1 = 114 mm
- Rotation speed N_1 = 208 rpm
- Linear speed: V_1 = 0.50 m / min
- piercing force: $F_1 = \frac{2C_1}{D_1} = \frac{2\,,1519}{0.114}$

$$F_1 = 26{,}649.12\ N$$
$$F_1 = 26.64\ KN$$

b) 2-2' : Leather flat belt transmission

The transmission ratio between the shafts 3-3 'and 1-1' is given by:

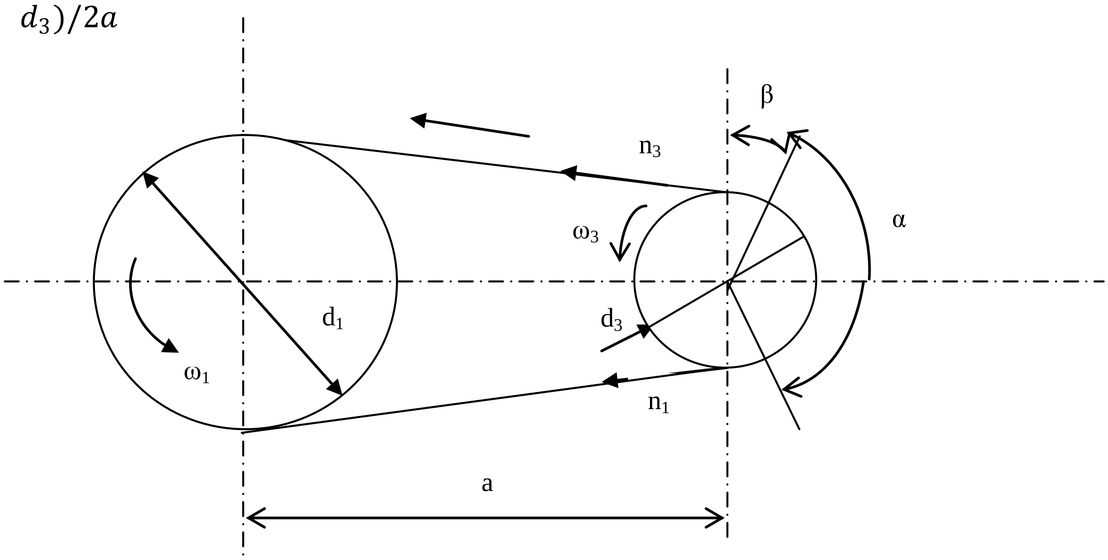
$$i_{22'} = \frac{\omega_3}{\omega_1} = \frac{d_1}{d_3} \qquad (\,adopt\ i_{22'} = 2.5)$$

With: $\omega_1\ et\ \omega_3$: angular speeds of the driven and driving pulleys.
$d_1\ et\ d_3$: Diameter of pulleys led and leading
Using a flat leather strap with d_3 = 150 mm
The driven pulley will have a diameter $d_1 = 2.5d_3 = 2.5\ x\ 50 = 375\ mm$

- The minimum center distance: $a_{min} \geq d_1 + d_3 + 1\ meter$

$$a_{min} \geq 375 + 150 + 1000 = 1525\ mm$$

- Angle of contact on the small pulley: $\propto = 180° - 2\beta \quad with\ sin\beta = (d_1 - d_3)/2a$



$$sin\beta = \frac{375\ x\ 150}{2\ x\ 1525} = 0.0737704$$
$$\beta = 4.23°$$
$$\alpha = 180° - 2\,,4.23° = 171.54° \quad \text{(there is a good adherence).}$$

NB: avoid a winding angle <150 ° for leather belts.

- The length of the belt between axes 1-1' and 3-3'

$$l \cong \frac{1}{2}(d_3 + d_1).\pi + 2a + (d_1 - d_3)^2/4a$$

$$l = \frac{1}{2}(150 + 375)\ 3.14 + 2\ x\ 1525 + \frac{(375 - 150)^2}{4\ x 1525}$$

$$l = 824.25 + 3050 + 8.29$$

$$l = 3882.54\ mm = 3.88\ m$$

- The speed of rotation N_3 :

$$\frac{N_1}{N_3} = \frac{d_3}{d_1} \ \rightarrow\ N_3 = \frac{N_1 d_1}{d_3} = \frac{208\ ,\ 375}{150} = 520\ rpm$$

- The actual speed of the driving pulley:

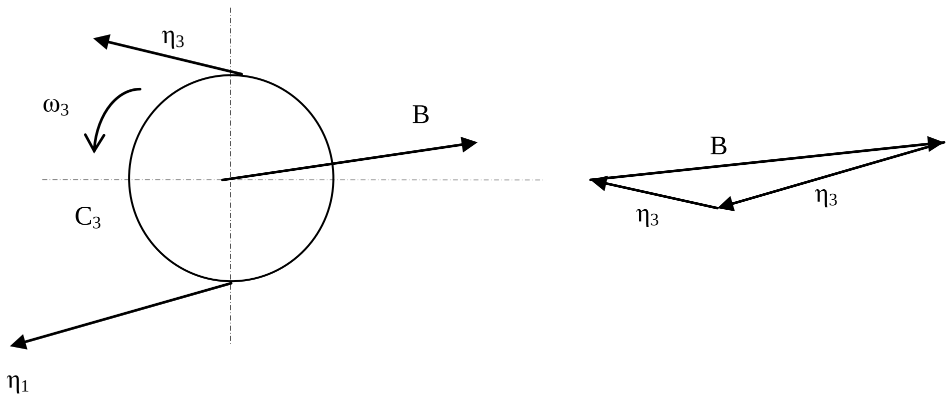
Taking into account slippage (transmission by leather belt) of up to 2%,

$$N_3' = N_3 + N_3\ x\ 0.02$$
$$N_3' = 520 + 520 x\ 0.02 = 530.4\ rpm$$

Couples :

- The driven pulley resistant torque; $C_1 = \frac{1}{2} d_1 F_t \quad et \quad C_1 = \frac{F_t \mu_1}{\omega_1}$

with F_t : tangential force transmitted by the belt on the pulley (this is the difference of normal efforts in both strands) $F_t = n_1 - n_3$



B: the action of the landing. $B = 3n_3 = 3F_t \quad and \quad n_1 = 2n_3$

μ_1 = tangential velocity in the belt at the driven pulley
μ_3 = tangential velocity in the belt at the driving pulley
$\mu_1 = \mu_3 = \mu$, if there is no slip between the belt and the pulleys

$$\mu_1 = \frac{1}{2} d_1 \omega_1 = \frac{1}{2} d_1 \frac{2\pi N_1}{60}$$

$$= \frac{1}{2}\ 375\ \frac{2\ x\ 3.14\ x 208}{60} = 4082\ {}^{mm}/_{sec} = 4.082\ m/sec$$

$$C_1 = \frac{F_t\ \mu_1}{\omega_1} \quad \rightarrow\ F_t = \frac{C_1\ \omega_1}{\mu_1} = \frac{1519\ x\ 2\ x\ 3.14\ x\ 208}{4.082\ x\ 60}$$
$$F_t = 8101.3\ N = 8.101 KN$$
$$B = 3F_t = 3\ x\ 8101.33 = 24303.99\ N = 24.30\ KN$$

- Couple at the driven pulley:

$$C_3 = \frac{1}{2} d_3 F_t = \frac{1}{2} 150\ x\ 8101.33 = 607599.75\ Nmm$$

$$C_3 = 607.59\ Nm$$

$$n_3 = F_t = 8.10\ KN$$

$$n_1 = 2n_3 = 2\ x\ 8.10 = 16.2KN$$

- The section of the belt; the tension in the leading strand. the normal stress must verify the following relation:

$$\frac{n_1}{s\ b} \leq R_p\ \text{(practical resistance)}$$

$$s\ b \geq \frac{n_1}{R_p}$$

For leather belts: R_p= 250 to 350 N /Cm^2

Considering $R_p = 350 \frac{N}{Cm^2} \rightarrow s\ x\ b \geq \frac{16200}{350} = 46.28\ Cm^2$

$$s\ x\ b \geq 4628\ mm^2$$

Adopting a belt thickness s = 20 mm, the width $b \geq \frac{4628}{20} = 213.4\ mm$

It is therefore a flat leather belt of length 3882.54 mm and of section 20 mm x 231.4 mm

Note that at rest, without motor torque, the voltage in each strand is identical

$$n_{10} = n_{30} = \frac{1}{2}(n_1 + n_3) = \frac{16.2\ KN + 8.10\ KN}{2} = 12.15\ KN$$

- The flat belt pulleys will be light alloy, to minimize the weight. The thickness of the rims shall be approximately increased by ± 2 mm; the outer profile generally curved on the large pulley, flat on the small pulley.

c) 3-3 ': automatic PTO.

The transmission goes from the toothed wheel to the driving pulley via their axis on which they are secured in movement by keys. The resistive torque is transmitted in full, the torque at the toothed wheel $C_4 = C_3$ = 607.59 Nm

d) 4-4 ': transmission by wheels and worm.

Worm gears transmit torsional torques between left-handed shafts that generally intersect at right angles: Σ = 90 °

Torque transmission is spread over several lines of contact. The mechanism is relatively silent

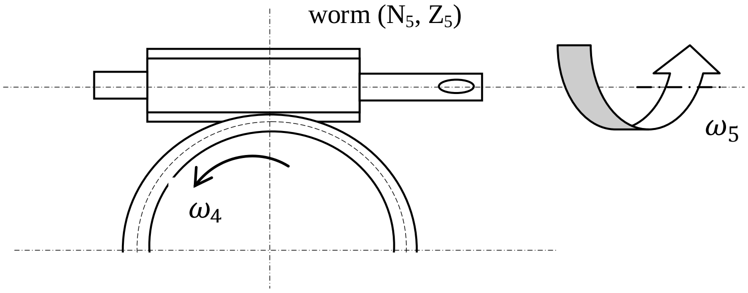
Lubrication by a damped liquid layer particularly vibrations and jolts between the input shaft and the output shaft.

The gear ratio is the angular velocity ratio of the worm ω_5 to the angular velocity of the wheel ω_4

$$i_{44'} = \frac{\omega_5}{\omega_4} = \frac{N_5}{N_4}$$

$$\text{others by:} \quad \frac{N_5}{N_4} = \frac{Z_4}{Z_5}$$

With: N_5 and N_4 : rotational speeds of the worm and the wheel
Z_5 : number of threads per step of the worm
Z_4 : number of teeth of the wheel



The principle is that if the worm has Z_5 threads, when it makes 1 turn, the wheel turns Z_5 teeth.

$$\text{where ;} \quad N_5 = \frac{N_4 Z_4}{Z_5} \quad and \quad N_4 = \frac{N_5 Z_5}{Z_4}$$

$$or \;\; N_4 = N'_3 = 530.4 \, rpm$$

$$adopt \quad i_{44'} = 2.7 \quad , \; then \; \frac{N_5}{N_4} = \frac{Z_4}{Z_5} = 2.7$$

$$N_5 = 2.7 \qquad N_4 = 2.7 \; x \; 530.4 = 1432.08 \, rpm$$

Taking in the table of general recommendations for the wheel and the worm: Z_5 = 10 nets
so$Z_4 = 2.7 \; x \; 10 = 27 \; teeth$

- Proportions for the teeth:

Propeller tilt $\gamma_m < 15°$ ⟹ projection ha = ma (axial module of the screw), hollow hf = 1.2 ma, pressure angle:

$$\alpha_n = 20° \; , \qquad m_a = 7$$

dms = nominal diameter of the screw

$= Zf \; x \; m_a \;\; (with \; Zf: number \; of \; teeth \; compared)$

= 10 x 7 = 70 mm

And therefore, the geometrical magnitudes of the worm wheel in the table below:

magnitude	relationship	Calculate value
Primitive diameter	$d_4 = Z_4 m_a$	$d_4 = 189\ mm$
Head diameter	$d_{a_4} = d_4 + 2ha$	$d_{a_4} = 203\ mm$
Foot diameter	$d_{f_4} = d_4 - 2hf$	$d_{f_4} = 172.2mm$
Width of the bronze wheel	$b_4 \approx 0.45(dm_5 - 6m_a)$	$b_4 = 12.6\ mm$
Gear center distance	$a = (dm_5 + d_4)/2$	$a = 129.5\ mm$
Outside diameter	$d_{e_4} \cong d_4 + 3m_a$	$d_{e_4} = 210\ mm$

- Power on the gear wheel

$$\mathcal{P}_4 = C_4\omega_4 = 607.59\ Nm\ \frac{2\pi\ x\ 530.4}{60}\ {rad}/{sec} = 33.730\ KW$$

- Torque on the worm C_5 is equivalent to the torque C_4
  $C_5 = C_4 = 607.581$ Nm
- Power on the worm:

$$\mathcal{P}_5 = C_5\omega_5 = 607.81\ x\ \frac{2\pi\ N_5}{60}$$

$$\mathcal{P}_5 = 607.581\ x\ \frac{2\pi\ \ x\ 1435{,}08}{60} = 91070.94\ {Nm}/{sec}$$

$$= 91.07\ KW$$

- Reducer efficiency $\rho = \frac{\mathcal{P}_4}{\mathcal{P}_5} = \frac{33.73\ Kw}{91.07\ Kw}$

$$\rho = 0.37 \quad 0r\ 36\% < 50\ \%$$

which insinuates the irreversibility of the system under static load is ensured.

e) 5-5' : training by an electric motor.

To meet the high demands of drive mechanisms, the DC motor was once long used, despite its main weakness related to the presence of the collector.
Thanks to advances in power electronics and microelectronics, AC motor drives are nowadays commonplace.
They can now deliver dynamic performance as good as conventional DC drives, while being more rugged and less serviceable.

Among AC motors; the asynchronous cage motor stands out for its simplicity, good performance, excellent reliability and robustness.
This type of engine is now used in all power ranges for both high performance drives and common industrial applications. The choice of motor will take into account the load power $\mathcal{P}_{ch}$ requested by the drive mechanism:

$$\mathcal{P}_{ch} = P_5$$

$$= 91.07 \text{ Kw.}$$

An inappropriate choice of the motor leads to economic losses due either to the reduction of the life of the engine (insufficient power) or to the increase of installation costs (power too big).
Generally, the motor is chosen such that its nominal power $\mathcal{P}_n$ is greater than the load power $\mathcal{P}_{ch}$ and it depends on the services.
$\mathcal{P}_n$ = 1.1 to 1.3 $\mathcal{P}_{ch}$
Let's take the average, that is, $\mathcal{P}_n$ = 1.2 $\mathcal{P}_{ch}$; $\mathcal{P}n$ = 1.2 x 91.07 Kw
= 109.284 Kw
The useful power (on the motor shaft):

$$\mathcal{P}_u = P_n . \eta_{motor}$$

With η_{motor} : Engine efficiency at nominal speed which varies between 0.96 and 0.97.
Taking the average yield η_{motor} = 0.965

$$\mathcal{P}u = 109.284 \text{ x } 0965$$
$$= 105.45 \ Kw$$

The engine will be powered under 380 V that has the homes powered by SNEL (National Electricity Company of the DR Congo). This motor will have to absorb a nominal current " In" for a cosφ = 0.8

$$I_n = \frac{\mathcal{P}_n}{v_n \sqrt{3} \cos\varphi}$$

$$I_n = \frac{109.284 \ x \ 10^3}{380 \ x \sqrt{3} \ \ x \ 0.8}$$

= 207.54 A (ampere))

CONCLUSION

The present work has exposed the problem of obtaining water for the need domiciliary and in perspective, he proposed a well water well drilling unit to serve the population of Kampumpineighbourhood in particular and that of the community of Likasi city in general.

An electric motor with a rated power of 109.284 KW and a 380 V power supply must provide, through the wheel and worm gear systems, pulleys and belts, the seamless transmission of the power required to drive the power tool. drilling to withstand drilling effort F_1= 26.64 KN.

The drilled well will be of a total height H_1 = 42m guaranteeing the production of water necessary for the daily consumption of a family.

It must be protected by cross-linked polyethylene tube equipment and the water will be withdrawn by an electric pump immersed in a bladder balloon.
Its regular maintenance must be required to ensure good water quality, to avoid the recurrence of repetitive diseases in the city of Likasi, such as cholera.

This work, which is only a study phase, will serve as a light for a preliminary project or a project by introducing the calculations of all mechanical parts such as keys, bearings, supports, screws, pulleys, couplings, extensions , drilling tools ... etc, especially in approaches to their internal and external solicitations as well as in the considerations of vibrations generated. This work will also serve as a scientific research paper in the mechanical field.

This research does not conclude or close all studies related to the erection of water catchment wells or the design of a drilling unit.
Thus, the constructive remarks or suggestions will be welcome so that this present is enriched so that it can render a service as much as possible to the different researchers in the field of engineer.

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