American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-12, Issue-2, pp-135-145
www.ajer.org
Research Paper Open Access

Wind generator.From design to learning

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ABSTRACT: *World has changed, curricular relevance is no longer sufficient to compete with technoscientific advances. In this respect, this paper brings a reflexive contribution dealing with the theoretical and conceptual dimension of a mechanical interface of a wind generator aiming not only at the technological aspect of the object, but also at the pedagogical reframing in front of the technological movement and evolution.Authors approach the subject from the theoretical knowledge of the object, it is not a question of a study of design, nor of relevant information of this one, but it is a reflection, with the objective to want to change the pedagogical practice to the teaching-learning of the technological sciences in the institutions of technological formations through an inductive approach.*

KEYWORDS:*wind generator, conceptual and cognitive framework, practice modernization, mechanical interface.*

Date of Submission: 13-02-2023 Date of acceptance: 26-02-2023

I. INTRODUCTION

World is currently in an energy transition, not only because of the rising price of oil, but also because of the damage created by the abundant emission of carbon dioxide on a global scale. Renewable energy is the only alternative energy source for the common good of modern society. In the present study, we approach the subject from the historical, theoretical and epistemological frameworks favoring the apprehension of the readers in its technical, conceptual and technological dimension on the one hand. After that, the didactic aspect highlights the reframing of the practice requiring a pedagogical modernization through an inductive approach on the other hand.

We will limit ourselves to the mechanical interface of the wind generator, that is, from the kinetic energy to the output of the gearbox. Generally, the sensor absorbs part of the wind energy, it is the driving energy of the wind turbine and its power is limited by Betz's law. A part of this energy is converted into mechanical loss, and the remaining one is converted into electrical energy through the synchronous, asynchronous or dual power generators[1, 2].There is a lot of literature on the theoretical, conceptual and technological aspects of wind turbines, however, the didactic aspect is still less emerging and the pedagogical practice is stagnating around a technological dimension. The socio-cultural, environmental and educational dimensions are often overlooked in the techno-scientific literature, as researchers tend to satisfy their hypotheses to meet their often-hypothetical presuppositions, but which are not recognized as adequate by practicing teachers (Russell, 1973) cited by Goyette [3].

Furthermore, this work highlights the synergy between the technological and pedagogical dimensions inducing a reframing of teaching and curricular practice where appropriate. Our reflection is articulated with the perception of John Dewey, who constantly supports collaboration between researchers and practitioners in the field in order to better identify educational issues on the one hand, and to call on all actors in the field (engineers, technicians, scientific community, etc.) to participate in the concretization of teaching-learning aiming at a co-creation of technological objects starting from a learning and evaluation situation [4] for educational and technological purposes.

II. HISTORICAL BACKGROUND

Wind energy takes its name from the ancient Greek wind master Aiolos. Wind seems to be the techno-scientific inspiration of the clean energy producing device of our time and the previous one. Its presence testifies to many scientific discoveries in the field of energy since the birth of the famous kinetic energy theorem. The wind is also one of the elements that have been used to extract energy for many mechanical operations (grinding grain, pumping water, propelling ships, etc.) since ancient times. The historical dimension seems relevant in order to illuminate the epistemological framework of the science, its birth and the governing laws and theories. In this framework, kinetic energy was exploited since more than 30 centuries B.C., in particular and in abundance on the propulsion of ships. However, the aero-motor was born in the operations of pumping and crushing around the year 620 in Persia and spread in Europe from the 11th century. During the medieval period, some improvements were gradually made to European windmills to increase the aerodynamic lift. By the end of the 17th century, windmills were the equivalent of today's electric motor and provided about 1.5 gigawatts of power, marking the beginning of the wind energy revolution.At the end of 1887, Charles Brush built the first fully automated 17[m] high wind turbine with 144 blades, which produced electricity for charging batteries. According to the review, the rotor of wind turbines had several blades until 1920. From 1891, Paul La Cour conducted numerous experiments and discovered that a turbine with fewer blades produced more electricity than a slow-moving turbine with many blades. He designed the first modern wind generator using the principle of aerodynamics.In the 1920s, Albert Betz developed his research in the practical use of kinetic energy, and he formulated a law in his name that is recognized by learned societies to this day. Later, in the same period, Georges Darrieus developed the concept of a vertical axis rotor and these machines also bear his name. The development of small wind turbines began in the 1930's, and in that time these machines brought to light another paradigm, another way of seeing and designing towards an ecological and sustainable dimension. The wind energy represents an alternative energy in front of the shortage of oil which began at the end of the two world wars, even until our days. Since the middle of the 20th century, many manufacturers have been competing and the demand for power has been increasing. Wind power remains in second place after hydro power in terms of global clean and renewable energy production. In this work, our ambition is articulated not only on the techno-scientific dimension starting from the epistemological framework of science, but also on the transfer of intellectual heritages transposed to the 21st century. The wind energy seems multi and transdisciplinary, we question not only on the choice of the contents in the technological educational institutions, that is to say the didactic transposition [5] of the pedagogical grains of its institutions, but also articulates to the perceptions of Law [6], of Fourez [8, 9] and that of Fensham [10] anchored in the social dimension, of scientific and technological literacy allowing to offer a set of competences so that we can immerse ourselves in diverse dimensions of our activities through many other virtues of more consequent importance than the contents, such as the desire to engage in a process of investigation, the social and environmental conscience [11], and also the positive and negative impacts of science itself.

III. THEORETICAL AND CONCEPTUAL FRAMEWORK

From the point of view of conception and education, science often refers to an organized body of knowledge related to a category of phenomenon. Science has two related technical aspects such as scientific activity (search for similarity, observation of events or phenomenon, problem solving, hypothetical perception, etc.) and scientific knowledge (constitution of observation statement, laws, theories, concepts and models) which are usually the results of scientific activities [12].Starting from the literature review, the analysis model begins with the scientific knowledge of kinetic energy, aligning with Galileo's perception around 1602. He said that nature is written in mathematical language, if we really want to understand the phenomena organized by nature, we will have to use it, and the scientists are aligned with this idea.

Towards the end of the medieval period, E. Torricelli (1608-1647) demonstrated the presence of the weight of the atmosphere and exerted pressure, later B. Pascal (1623-1662) announced that the atmospheric pressure decreased with altitude and Edmond Halley stressed that the wind derives from the difference in pressure and temperature. The wind is the result of natural convection around the globe generated by solar energy. It represents a material point having a mass and producing energy at its displacement. Generally, the wind energy derives from the kinetic energy of the wind of mass m during its displacement x and that represents half of its mass with the square of its speed, illustrated by figure 1.

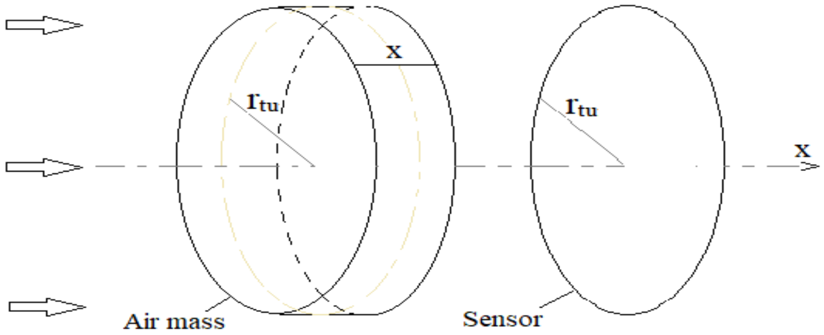


Figure 1. Association of the air mass with the wind sensor

$$E_c = \frac{1}{2}\rho_{air}\pi r_{tu}^2 x V^2 \quad (1)$$

ρ_{air}, r_{tu} and x, represent the air density, the turbine radius, and the position or thickness of the dummy air mass, respectively.

The quantity $\rho_{air}\pi r_{tu}^2 x$denotes the air mass passing through the dummy sensor. The derivative of the kinetic energy with respect to the position x, the only variable, would be the instantaneous or theoretical power output of the aero-motor.

$$P_{th} = \frac{dE_c}{dt} = \frac{1}{2}\rho_{air}\pi r_{tu}^2 \frac{dx}{dt} V^2$$

$$P_{th} = \frac{1}{2}\rho_{air}\pi r_{tu}^2 V^3 \quad (2)$$

1. Wind energy conversion (Betz law)

The theory of the wind engine was established by Albert Betz in the 1920s. He assumed that the wind engine is placed in air with an upstream velocity V_1 and a downstream velocity V_2 as shown in figure 2.

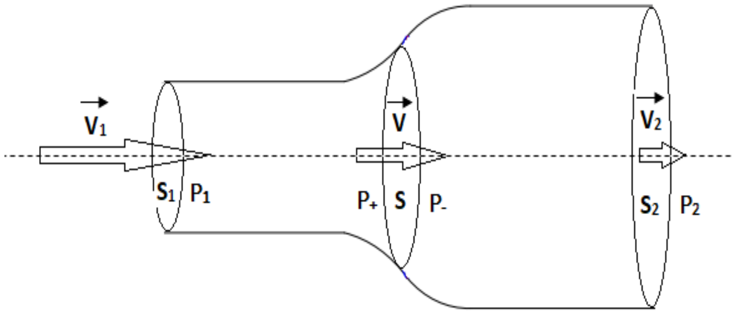


Figure 2. Current tube through the actuator surface

The kinetic energy consumed by the wind sensor is the difference of the kinetic energies of the air stream upstream and downstream of the sensor. The kinetic energy collected by an ideal wind sensor is limited by Betz' law. Assuming the incompressibility of the fluid, we write:

$$P_{th} = \frac{dE_{c1}}{dt} - \frac{dE_{c2}}{dt} = \frac{1}{2}\rho_{air}\pi r_{tu}^2 \frac{dx}{dt}(V_1^2 - V_2^2) \quad (3)$$

The usable power extracted by the wind is obtained in several ways, using Euler's theorem [13], by applying Bernoulli's equations upstream and downstream of the actuating surface hinging on the principle of conservation of energy and momentum [14, 15]. The theorem of variation of momentum in classical mechanics dictates the conservation of the momentum of an object corresponding to an effort F from the time derivative thereof [16] and defined by:

$$F = \rho_{air}\pi r_{tu}^2 \frac{dx}{dt}(V_1 - V_2) \quad (4)$$

The wind speed through the rotor is equal to the average between the undisturbed wind speed upstream V_1 and the disturbed wind speed downstream V_2 defined by$V = \frac{V_1+V_2}{2}$, and by multiplying the relationship (4) by this speed, we obtain the power:

$$P_{th} = F.V = \rho_{air}\pi r_{tu}^2 V^2 (V_1 - V_2) \quad (5)$$

By introducing the induction factor $k=V_1/V_2$, the power can be expressed as follows:

$$P_{th} = \frac{1}{2}\rho_{air}\,\pi r_{tu}^2 V_1^3 (1+k)^2(1-k) \qquad (6)$$

The driving power of the aero-motor is the theoretical power defined in equation (6), it is maximum if $\frac{dP_{th}}{dk} = 0$,resulting in two values of k:

$k = -1$, value of the induction illustrating an obstacle causing a fluid backflow, and is of no interest to our study;

$k = \frac{1}{3}$, value of the maximum induction corresponding to the Betz limit of the relation (6).

The power recovered by the sensor is ideal when the output speed of the sensor V_2 is three times smaller than the input speed V_1. Then, the maximum driving power is the maximum power absorbed by the wind sensor, defined by:

$$P_m = \frac{1}{2}\left(\frac{16}{27}\right)\rho_{air}\,\pi r_{tu}^2 V_1^3 \qquad (7)$$

This expression shows that for an ideal collector, less than 60% of the wind energy can be extracted. The maximum amount of kinetic energy of the flow passing through an actuator surface corresponds to the Betz limit and also called the power factor, often noted by C_p and its limit not exceeding $(\frac{16}{27})$. However, C_p is variable depending on the geographical location, the rotation speed of the turbine, and can also express as a function of the specific speed or tip speed ratio λ and the pitch angle β, when the latter is constant:

$$C_p = C_p(\lambda, \beta) \qquad (8)$$

The speed parameter or tip speed ratio λ grows with the regression of the number of the blade. it represents by the ratio of the blade tip speed to the wind speed [23].

$$\lambda = \frac{R\omega}{V} \qquad (9)$$

In our case, the wind speed $V=V_1$, where R and ω represent the radius of the sensor and the angular velocity of the turbine tip respectively.

The evolution of C_p is specific to each type of wind turbine and its approximate value from a survey is given by the following relationship [17], cited by [18]:

$$C_p = 0.22\left(\frac{116}{\lambda_i} - 0.4\beta - 5\right)\exp^{\left(\frac{-21}{\lambda_i}\right)} \qquad (10)$$

With$\lambda_i = \frac{1}{\lambda+0.08\beta} - \frac{0.035}{\beta^3+1}$

Wind turbines are generally classified according to tip speed ratio:

λ< 3 for the slow wind turbine (Savonius and multiblade);

λ> 3, for the fast wind turbine (two-blade and three-blade).

The power of the turbine, which is the output power of the sensor, is usually written as a function of this efficiency, commonly called the power or performance coefficient C_p:

$$P_{turb} = \frac{1}{2}C_p(\lambda,\beta)\rho_{air}\,\pi r_{tu}^2\, V_1^3 \qquad (11)$$

The wind potential defined for a territory is expressed in units of mechanical and electrical power potential. The power transmitted to the generator is written:

$$P_{tra} = \frac{1}{2}C_p(\lambda,\beta)\eta_{mec}\,\rho_{air}\,\pi r_{tu}^2\, V_1^3 \qquad (12)$$

Finally, the relation (13) expresses the useful power of the wind generator.

$$P_u = \frac{1}{2}C_p(\lambda,\beta)\eta_{mec}\,\eta_{elec}\,\rho_{air}\,\pi r_{tu}^2\, V_1^3 \qquad (13)$$

η_{mec} and η_{elec} represent the mechanical and electrical efficiencies respectively.

The total efficiency of the wind generator is written:

$$\eta_{total} = \eta_{elec} * \eta_{mec} * \eta_{Betz} \qquad (14)$$

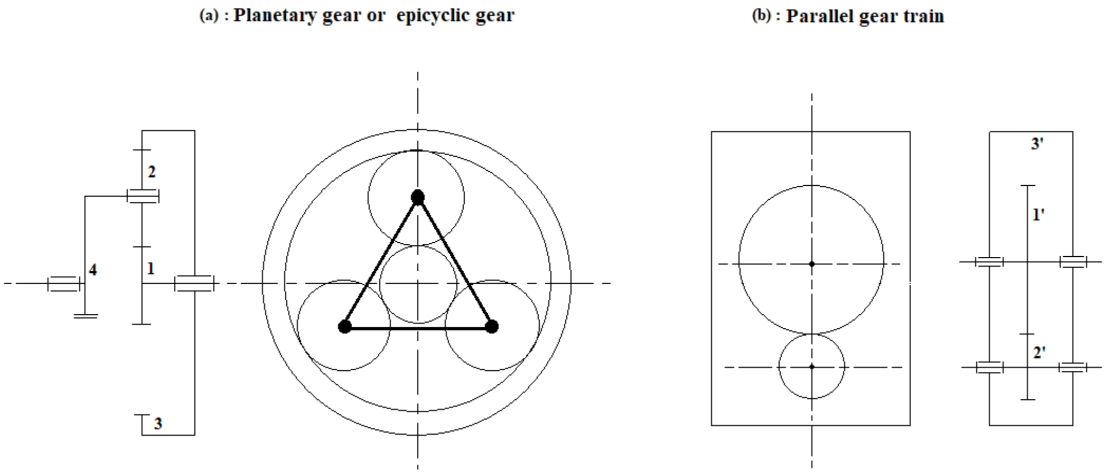
With $\eta_{Betz} = C_{p,max}$

Generally, this value does not exceed 52% in theory, and the Betz efficiency is represented by the maximum power factor$C_{p,max}$.

In this work, we focus on a horizontal axis sensor for a reason of performance in terms of productivity. Currently, the orientation of the sensor is organized with a rudder for small turbines, and with servomotors for large ones. Up to now, there are two ways to control the power output, the first one is based on a passive control of the power, obtained simply from the shape of the blade (twist and profile) and the second one thanks to a mechanism actuating the variation of the blade pitch angle contributing to the aerodynamic stall theory. Wind-motors are designed to start at wind speeds of 3-5 m/s, usually at this point it is called starting speed. They are also designed to stop automatically when the wind blows above 25 m/s, and often depends on the configuration of the manufacturer, to avoid any damage to the device, and the speed at which they stop is calls the cut-off speed.

2. Modeling and characteristics of the speed multiplier

Speed multipliers generally use cascaded gear stages to obtain high speed or multiplication ratios, especially for wind generators in the Megawatt range. The gear stages are made up of either a planetary gear set, also called epicyclic gear set, or a parallel gear set as shown in the following figure.



(a) 1:planetary gear or sun gear, 2:satellites or planet gears, 3: planetary ring gear, 4: satellite carrier;
(b) 1' et 2': gear wheels, 3': Frame and shell.

Figure 3. Different types of gear trains.

The single gear train is two gears in contact, is not bulky, but we have only one contact. However, the speed ratio is relatively low, it depends only on the ratio of the number of teeth between the two gears. The speed ratio increases if the assembly is organized in series, that is to say, an assembly of single trains in series, from one to several stages allowing to increase the reduction or multiplication ratio, and the latter increases with the growth of the stage numbers. However, multi-stage parallel trains can reach the ratio conditioned by the generator, but this generates an overload of the nacelle which would lead to an oversizing of the tower, certainly impacting the economic aspect of the construction.

The generator receives the torque and speed output from the gearbox. The optimal number of revolutions conditioned by the generators are generally in the order of 40 to 60 times that of input, hence the reason towards a choice of planetary type for large wind generators, because the latter is not cumbersome, less heavy and have relatively high ratios of reduction or multiplication and they are much more resistant than a parallel train that has only one point of transmission of torque. In a planetary gear train, the forces are distributed between several contact points between the satellites and the planetary gears. The current structures used by manufacturers such as Siemens, Flender and Hansen, include either combinations with two planetary stages coupled to a parallel stage, or combinations with three planetary stages. On the other hand, in the power range below 0.5 MW, the trains used are of the parallel type for economic reasons.

3. Kinematic configuration and theoretical illustration of the Willis input-output law

Let's take the case of figure 3.a, a simple planetary gear set with three planet gears. The use of several planet gears does not change the kinematics of the planetary gear set (increase or reduction of the ratio), but they are added to eliminate the radial forces on the shafts and reduce the forces on the gears. This article is not the object of a demonstration of laws or theories or models leading to a new scientific knowledge or research of a hypothesis of resolution of an event or phenomenon of a scientific activity, but it is a reflection starting from the epistemological framework towards a design process not only technological, but also socio-scientific of the interested.Next, let's put an overview on a theory that can solve a transmission ratio requested from another device starting from the minimums of data like the number of revolutions per minute of an input shaft (output of the sensor or aero-motor) and the sufficient number of revolutions of the output shaft (input of the generator). The point of intersection of these two interfaces (Figure 4) is the limit of the aeromechanical or classically mechanical reflection of this paper.

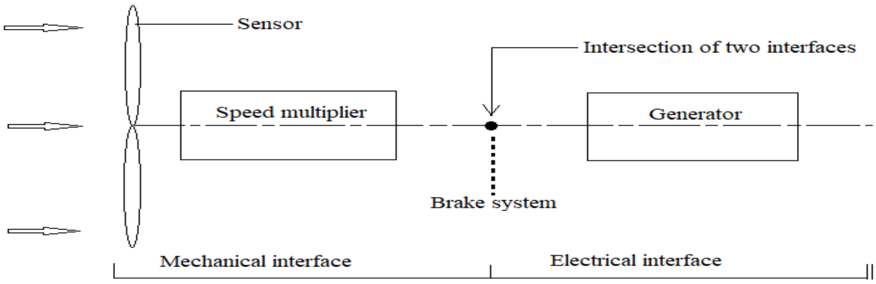


Figure 4. Schematic illustration of the interfaces

Generally, if the number of revolutions is reduced, it is a reduction gear (increase in torque and power) and the reverse is a multiplier. In this system, the operation is only possible if one of the three fundamental elements (1, 3 and 4) is blocked or driven, and the classical way to calculate the reduction or multiplication ratio is developed by Willis. Given the nomenclature of the system under consideration (Figure 3.a), and if the input power is applied to the sun gear, the general basic reasons are written:

$$\frac{n_1-n_4}{n_3-n_4} = \frac{\omega_1-\omega_4}{\omega_3-\omega_4} = (-1)^y \frac{z_3}{z_1} = r \qquad (15)$$

n_i, ω_i, z_i,represent respectively the numbers of revolutions, the speeds of rotations, the numbers of teeth of the fundamental elements previously mentioned in the nomenclature, for i varying from 1 to 4.
y and r denote the contact point of the outer teeth and the reduction or multiplication ratio respectively.

The number of teeth of the planet carrier z_2 is not shown in the expression (15), this indicates that it acts as a reversing wheel. The blocking of the planetary ring gear 3 is common practice, allowing the planetary gear 1 to manage the input and the ring gear 4 would be the output or vice versa for our case. In this condition, we have three contact points, the frequency of rotation $n_3$and the speed rotations $\omega_3$are zero, and the Willis formula is written:

$$\frac{n_4}{n_1} = \frac{\omega_4}{\omega_1} = \frac{z_1}{z_1+z_3} = -\frac{c_1}{c_4} \qquad (16)$$

c_1 and c_4,represent the torques exerted on the planetary gear and the satellite carrier respectively.

If the planetary gear is blocked, then n_1 and ω_1 are zero, we write:

$$\frac{n_4}{n_3} = \frac{\omega_4}{\omega_3} = \frac{z_3}{z_1+z_3} = -\frac{c_3}{c_4} \qquad (17)$$

$c_3$represents the torque exerted on the ring gear.
If the satellite carrier is blocked, n_4 and ω_4 are zero, we write:

$$\frac{n_3}{n_1} = \frac{\omega_3}{\omega_1} = -\frac{z_1}{z_3} = -\frac{c_1}{c_3} \qquad (18)$$

The torques exerted on elements i to n^{th} compartment are written:$c_{i,n} = \frac{P_{i,n}}{\omega_{i,n}}$.
If the efficiency is substantially or equal to 1 hypothetically, the model presented in figure 5 allows us to write that c_{2a} is the driving torque on wheel 2a and c_{1a} is the receiving torque on wheel 1a. We can also write that P_{2a} is the driving power at wheel 2a and P_{1a} is the receiving power at wheel 1a and $P_{2a} = P_{1a}$ in the first compartment and$\frac{c_{1a}}{c_{2a}} = \frac{\omega_{2a}}{\omega_{1a}}$.
$P_{i,n}$ and $\omega_{i,n}$, are the input power and rotational speed of the number i wheel at n^{th} compartment respectively.

The relationship to link the pitch diameters of the two planetary (pinion and ring gear) and satellite, as they mesh together, their modulus m is identical, we write:

$$d_{3,n} = d_{1,n} + 2d_{2,n} \qquad (19)$$

Or, $mz_3 = mz_{1,n} + 2mz_{2,n}$

Then, $z_{3,n} = z_{1,n} + 2z_{2,n} \qquad (20)$

Knowing the number of revolutions at the input of the multiplier defined by the wind speed V_1 considered and translated into rotational movement ω of frequency n by the aero-motor, the number of revolutions of the output of the multiplier is easily obtained by manipulating the formula of Willis, and depends on the condition of rotational frequency requested by the chosen generator. Then, we write:

$$r = \frac{n_{sortie}}{n_{entrée}} = \frac{n_{gen}}{n_{tu}} = \frac{\omega_{gen}}{\omega_{tu}} \qquad (21)$$

The basic reason r is the speed ratio conditioning the type of gear trains:
r>1: speed multiplier;
r<1: speed reducer.

n_{gen} , ω_{gen} , n_{tu} andω_{tu} , are the rotational frequencies and speeds of the generator and turbine respectively.
In our case, the satellite carrier 4a is the input port of the sensor power, and it exits through the planetary gear 1n as shown in the following figure:

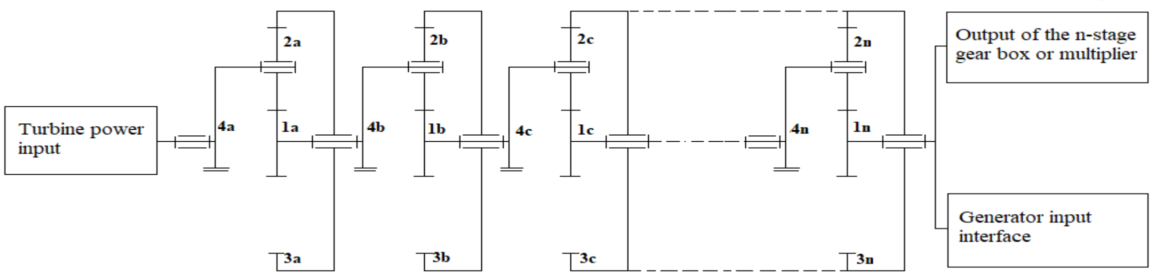


Figure 5. Input and output interfaces schematic representation for the n-stage multiplier.

The output frequency of the first stage becomes the input frequency of the second stage and the concept of calculations continues until the desired n^{th} stage and depending on the chosen blocking of the basic elements, most often and our case, the blocking of the ring gear. Considering the case of figure 3a, but the input power is applied to the satellite carrier 4a and out through the planetary gear 1c to the third stage, and to 1n to the n^{th} stage (figure 5). If the structure and characteristics of the stage elements are identical, the reason r would be the inverse of the relationship (16), since the satellite carrier becomes the input port for the turbine power. For a single to multi-stage multiplier, the Willis formula is written:

$$r = \frac{n_{1a}}{n_{4a}} = \frac{z_{1a}+z_{3a}}{z_{1a}}, \text{ for one stage} \quad (22)$$

$$r = N\frac{z_{1a}+z_{3a}}{z_{1a}}, \text{ for n stages} \quad (23)$$

And N represents the number of stages, and the expression (23) would not be valid that:

$$\text{If } \begin{cases} z_{1a} = z_{1b} = z_{1c} = \cdots = z_{1n} \\ z_{3a} = z_{3b} = z_{3c} = \cdots = z_{3n} \end{cases} \quad (24)$$

Finally, the ratio of the stepped gear block would be the product of the ratios of all the stages. The cutting parameters (modulus, addendum, dedendum, pitch diameters, height and width tooth, pitch, tooth thickness, dedendum and addendum circles, fillet radius, distance between axes, etc.) are also calculated in a classical and direct way according to their expressions in the guides (books of standards, guides of mechanical constructions and manufacturing) and many other related literatures.The strength of the material used is obtained from the modeling of the teeth, subjected to bending by a tangential force due to contacts, applied to the end of the tooth. The permissible stress or maximum strength of the material is obtained in several ways, using the Hertz pressure, superposition of stresses according to Guest, Von Mises, use of the direct strength condition of Willis, etc. In our discussion, we will keep the model of Willis knowing the tangential force F_t which is defined by:

$$F_t = F_{2/1}\cos\alpha \quad (25)$$

$F_{2/1}$ and α, represent the force of wheel 2 applied to wheel 1 and the pressure angle of the gearing respectively.
F_t is the origin of the transmitted torque, and with the similarities of the characteristics of the elements in each compartment, we write at each output:

$$c_1 = F_t r_1, \text{ and } c_2 = F_t r_2 \quad (26)$$

The radial force is defined by: $F_r = F_t\tan\alpha$ (27)

And the stress on the gearing is written:

$$F_d = \frac{F_t}{\cos\alpha} = \sqrt{F_t^2 + F_r^2} \quad (28)$$

The strength condition is achieved if the maximum stress is less than the practical strength of the building material $R_{pe,mat}$.

$$\sigma_{max} = \frac{F_t}{b_i m Y k_\upsilon} \leq R_{pe,mat} \quad (29)$$

$$\text{And } k_\upsilon = \frac{6}{6+V_c} \text{ et } V_{ci} = \frac{\pi d_i n_i}{60} = \frac{\pi r_i n_i}{30} \quad (30)$$

d_i, n_i, b_i, V_{ci} andk_υ, represent the pitch diameter of wheel i, the rotational frequency of wheel i, the width of the gearing of wheel i, the circumferential or angular velocity of wheel i, and the correction coefficient to account for the effects of circumferential velocity, respectively.
The coefficient Y is obtained from the reference graph.

4. Mass control of the speed multiplier

Many authors deal with overload problems of the nacelle caused by the excessive mass of the transmissions and mechanical links, in particular the speed multiplier block. The volume and mass of the gearbox depending on the rated torque at the output, the number of stages responding the gear ratio [16].The common approach to minimize the mass of the gearbox allows optimizing not only on the kinematic organization of the gear trains, but also on the geometry of the teeth to achieve a high-density transmission [18] citing the work of Kapelevich[19]. The mass of a planetary type gearbox with one multiplication stage can be expressed as follows [16]:

$$M_{mult\,/étage} = \frac{3.2\, C_{n,mult}\; F_s F_m}{1000} \qquad (31)$$

$C_{n,mult}$, F_s and F_m , are respectively the nominal output torque of the gearbox on the fast shaft, the service factor that takes into account the mechanical stresses during an operating cycle and the mass factor.

The cited author proposed a relation describing the mass factor against the satellite number z and the multiplication ratio r_m:

$$F_m = \frac{1}{z} + \frac{1}{z r_r} + r_r + r_r^2 + 0.4\frac{1+r_r}{z}(r_m - 1)^2 \qquad (32)$$

With $r_r = \left(\frac{r_m}{2}\right) - 1$

z represents the number of satellites.

In the following paragraph, we bring a reflection on the teaching-learning of the discipline to the techno-scientific target of the wind energy in the mechanical interface of the subject to contribute to the new methodological perception in the engineer training.This section identifies a research question related to the new practice in education, not only on the conceptual level of the technological object, but also on the construction of the learner's scientific culture and on the teaching approaches that seem to us to be relevant to the renewal of the didactic practice in the face of technological evolutions.

IV. REFLECTION AND PEDAGOGICAL REFRAMING OF THE WIND GENERATOR

The inductive approach currently represents one of the most effective methods in the teaching-learning system of technological sciences to bring learners to a self and co-construction of their own knowledge, and to encourage them to invest in a design process.Learners require a different methodological perspective that refers to their lives, to everyday reality, to socio-economic and environmental demands. The technological design approach makes learners more autonomous in their planning and development of their ideas. In the presence of suitable materials, they would be able to manage their construction or fabrication of an object and evaluate the technological quality of that object [20].The technological design approach will reinforce the scientific and technological culture allowing the technician learners, student teachers and engineers to become more autonomous not only in the framework of technicality, but also in intellectuality. Many authors have called for the dissemination of scientific knowledge based on international criterion-referenced standards to soften students' apprehension of the variability of socio-scientific issues and also of the conceptual and paradigmatic collaboration of their technocratic worldview.

In this paper, we share the common questioning reframing the aerodynamics of wind turbines and the speed multiplier organ that manages the basic reason r at the input of the electrical interface. However, we offer the incentive elements of answers related not only to the design of the object, but also to the learning of the questioned discipline.

1. Presentation

Project-based learning, sometimes linked to prototyping using the FabLab, based on co-construction in a learning and evaluation situation, is of great interest in our time. North American and European universities have been aligning themselves with this perception for a decade. This approach is based as much on a collaborative design process between researchers, practicing teachers, engineers and learners in order to obtain a new change in the conception of the learner in their cognitive functioning through a collective realization of technological object.In this context, it is enough to simply give an open specification, with however a contextualized technological information.

We will limit ourselves here, on the mechanical interface of the subject and more particularly to the input and output of the wind sensor and the gearbox.The power of the sensor is governed by aerodynamic forces, the lift often noted C_L in the literature and the drag C_D. It is no longer a question of the aerodynamics theory without mentioning these two forces.

2. The aerodynamics of the sensor and the effect of the number of blades

Information extract 1

More blades, the smaller the distance between two vortices and the slower the sensor speed, we find [21]:
- Theoretically, one can approach the Betz limit with a sufficient number of blades;
- Increasing λ makes the sensor more efficient up to the theoretical limit value;
- For an efficient wind turbine in light winds, high torque at start-up is required, tip speed ratio λ of low design are preferred and the operating range over the wind speed is maximized (utilization factor).

This is a conceptual and informative aspect that seems sufficient for a team in a learning context, it is the learners who will complete and study the theories from the appropriate materials (physical and digital references, peer exchanges, etc.).

Information extract 2

In this part, the relevant questions and elements of answers would activate a complementary construction of knowledge that will transform into a skill to be developed.
- Why most large wind turbines have only 3 blades, why not one or two or more;
- How to maximize the power factor and the range of use in wind speed;
- How to minimize the effects of vortex systems, turbulence and noise.

Fictional answers elements and context of technological, economic and social performance of the subject

The single-blade wind turbine is constantly undergoing a dynamic balancing stress, however the two-blade wind turbine encounters a torsion phenomenon on the mast or tower caused by the difference in forces between the upper and lower blade, since the air speed increases with altitude.In addition, the three-bladed wind turbine is of great interest not only economically and aesthetically, but also and especially on the load balancing in motion contributing to the optimization of the power coefficient and noise pollution according to the adopted standard of a country or commonly.

3. Gear trains: conceptual, technological and cognitive values

In this part, we want to introduce a flexible and user-friendly design environment to the conquest of technological objects. The organization of the sequence in the workshops and laboratories is often solicited to reinforce inductive learning in order to bring the learners to build their own knowledge from a theory, law and standard known beforehand or not.The technician students, specialized teachers and engineers of the 21st century must situate themselves in a socio-scientific and environmental context in their discoveries. The inductive approach would easily train a new generation of scientists that would still be needed to meet the technocratic needs of modern societies.In this aspect, the approach is the same as that of the sensor aerodynamics. The group work articulating on the technical, historical, epistemological, environmental and cognitive dimensions of the object will certainly bring an inductive element of answer to the techno-scientific activities.

Conceptual framework and information extract

A gear is not a wheel as we often think of it, it is rather a set of two wheels transmitting a power by obstacle, generally, it is a transmission organ.The deductive approach requires an enormous amount of time for knowledge transfer, and this no longer meets the demand for initial and continuous training in the face of the large amount of technological information circulating on the web, the competition from manufacturers, and also in the variability of international technological standards requiring a technological advance in the contemporary world. The inductive and informative relevance of the specifications seems more significant to the co-construction of techno-scientific knowledge. It is enough to deactivate the curiosity, the spirit of commitment, the sense of autonomy, organization and cooperation of the individual or group from the questions, fictitious answers and incentive information as:
- Since when the man used this organ, in which Continent, why to make and it evolves how;
- Among the mechanical power transmission organs (by flexible links, by frictions or by obstacles), which advantages, disadvantages and returns it brings;
- How were developed its variants, who are the actors favoring their developments, by which theory or laws implemented.

The prompting questions, the fictitious answer elements and the informative data represent as an extract of inductive knowledge tools derived from collaborative bibliographic research of the group in a learning context. Moreover, theoretical and conceptual knowledge does not seem to be sufficient for a responsible citizen of tomorrow, it is necessary to add a convention of international standardization so that these citizens can open up to the international labor market in modern technocratic literate societies.Globalization requires us to live in a society that imposes regulations and standards on scientific and technological activities. In their designs, the learners must take into account numerous international conventions and standards that relate to the technological object to be designed, through questions such as:

- What are the manufacturers in technological competition of the questioned object;
- Among these products (gear trains and epicyclic), what are the characteristics of the existing variants that we can use freely. How to organize the criterion of choice to reach a relevant, informed, collegial, scientific and democratic decision;
- The volume and the mass of the multipliers represent one of the major concerns of the designers, how to regulate this context, is there a law, theory or correlation optimizing these values.

These elements remain as a prerequisite before the collective self-construction of the new knowledge that could be transformed into a developable skill deriving from numerous attempts, operations, errors, trials, testing, modeling, generally from the lived experience in a socio-constructivist and recreational era.The approach would allow the learners to know how to cross the scientific and socio-environmental dimension of science. The review, the documentary research, the participation in a scientifically and technologically literate group, and the respect to the social regulation system will give birth to the conceptual and technological performance of the individual, who invests in an approach aiming not only at technological concerns, but also those of ethics, socio-cultural and environmental of the questioned discipline.In this reflection, let us appeal to Fourez[7] proposal on the renewal of teaching practice to offer equal opportunities and a better future to tomorrow's citizens.

V. CONCLUSION, LIMIT AND PERSPECTIVE

On our part, the reframing of practice seems eminent to trace a new methodological, metacognitive, technological and democratic perspective in a system of teaching-learning of technological sciences.Theoretical knowledge is no longer of interest to the young people of the 21st century. Theories and practices must mesh together in their organizations to offer the true meaning of scientific educational activity.In this paper, we have established the historical and theoretical framework of the mechanical interface of the wind generator to make more sense of the epistemological dimension of the subject on the one hand, and the pedagogical and techno-didactic investigative approaches relying on collaborative research between actors in the field have been offered as a dialectical reflection aimed at the technological educational practice of the scientific teaching community on the other.The remainder of this paper will focus on the treatment of the electrical interface not only from a technological point of view, but also from a techno-informative, didactic and pedagogical point of view.It is necessary to call upon citizens and future leaders to bring their judgments to the techno-scientific discovery and to contribute to the exchanges with peers and the scientific community, and also to the public debates [22], since the negative technocratic fallout is the generator of many technological risks.In this respect, the insertion of the psycho-preventive component of impact of techno-scientific application in the societal citizen culture is emphasized and supported by this reflection, so that future leaders can make informed, rational, ethical and democratic decisions in their applications.

Together, let's change the practice, for the good of the offspring.

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