STUDY OF THE INFLUENCE OF THE ARRANGEMENT OF THE CONVEYOR SCREW OF AMONIUM NITRATE ON HOURLY OUTPUT CASE OF THE COMPANY SICODEX

KISANGUKA PANDAKUFUA Henry[1], ILUNGA WA NSANKI André[2], MAYAYA BOY John[3], KIBALE MUSENGE Franck[4], LUMBA WA NYUNGU Séraphin[5], MUTEBA MALAMWANGA Joseph[6], MALEMBA KATANGA Laurent[7], MUSALE MUYABALA, Ephraïm[8], KIKOSA WA NKABI JOHN[9], NTEPE KISANGUKA Olivier[10]

Resume: **Le présent travail s'inscrit dans le cadre de l'étude de l'optimisation des systèmes de spirale utilisés dans les industries de transformation. IL Porte particulièrement sur l'influence de l'angle d'inclinaison sur le rendement horaire d'une spirale de transport de nitrate d'ammonium à SICODEX. L'efficacité d'un transporteur à vis dépend non seulement de ses caractéristiques géométriques (diamètre, pas, vitesse de rotation), mais également de son inclinaison.**

L'analyse comparative a montré que le rendement diminue progressivement avec l'augmentation de l'angle, conséquence des effets de gravité et de frottement qui réduisent la capacité effective de la vis.

Mots clés : spirale, rendement horaire et nitrate d'ammonium

Summary: **This work is part of the study of the optimization of spiral systems used in the processing industries. It particularly focuses on the influence of the angle of inclination on the hourly output of an ammonium nitrate transport spiral at SICODEX. The efficiency of a screw conveyor depends not only on its geometric characteristics (diameter, pitch, rotation speed), but also on its inclination.**

The comparative analysis showed that the efficiency gradually decreases with increasing angle, a consequence of the effects of gravity and friction which reduce the effective capacity of the screw.

Keywords: **spiral, hourly output and ammonium nitrate.**

---

[1] KISANGUKA PANDAKUFUA Henry : : Head of works at the school of industrial engineers, University of Likasi.

[2] ILUNGA WA NSANKI ANDRE : Assistant at the Higher Pedagogical and Technical Institute of Likasi

[3] MAYAYA BOY John : Assistant at the school of industrial engineers, University of Likasi

[4] KIBALE MUSENGE Franck : Assistant at the school of industrial engineers, University of Likasi de Likasi

[5] LUMBA WA NYUNGU Séraphin : Assistant at the Higher Pedagogical and Technical Institute of Likasi

[6] MUTEBA MALAMWANGA Joseph : Civil mining engineer

[7] MALEMBA KATANGA Laurent, Assistant at the Higher Pedagogical and Technical Institute of Likasi

[8] MUSALE MUYABALA Ephraïm, Assistant at the Higher Pedagogical and Technical Institute of Likasi

[9] KIKOSA WA NKABI JOHN, Assistant at the Higher Pedagogical and Technical Institute of Likasi

[10] NTEPE KISANGUKA Olivier, Assistant at the Higher Pedagogical and Technical Institute of Likasi

1. INTRODUCTION

In modern industrial systems, bulk material handling constitutes a strategic function to guarantee the continuity and efficiency of production processes. Among the equipment used for this purpose, the transport spiral, or endless screw, is widely adopted for its mechanical simplicity and its ability to move powdery or granular materials over specific paths.

Within the SICODEX company, which specializes in the processing and distribution of ammonium nitrate, the transport spiral plays a key role in transporting this substance to the packaging units. The proper functioning of this spiral depends on several technical parameters, including the angle of inclination directly influences the hourly output of the system

2. MATERIAL AND METHODS

2.1 Hardware

2.1.1 Investigation site: The SICODEX company

Based in the Haut-Katanga province in the Democratic Republic of Congo, SICODEX is a company specializing in the manufacturing, marketing and distribution of civil explosives, used mainly in the mining sector. Born from a partnership between AUXIN Holdings (Hong Kong) and AFRIDEX, it today occupies a strategic place in the Congolese industrial landscape.

1°Brief history

SICODEX (Sino-Congolese operating company) is a joint venture created by AUXIN HOLDINGS (HONG KONG) LIMITED and L'AFRICAINE D'EXPLOSIFS (AFRIDEX), it is registered in the city of Likasi in the Democratic Republic of Congo since April 21, 2017. AUXIN is the largest Chinese import-export company in civil explosives, the leading manufacturer and supplier of civil explosives offering its blasting services worldwide. Today AUXIN has numerous subsidiaries, notably in Australia, Burma, Guinea, Mongolia, Namibia, Ecuador, Tanzania, Pakistan, etc. Order No. 16/051 of May 3, 2016 defines AFRIDEX as the public authority in charge of the explosives industry in the DRC.

SICODEX is authorized to produce, sell, import and export all explosives and accessories for civil use, to provide its mining services as well as all services related to this activity throughout the national territory of the Democratic Republic of Congo (DRC). 2°Ammonium nitrate

Is a white crystalline salt, composed of ammonium ($NH4^+$) and nitrate ($NO3^-$) ions, with the chemical formula $NH4NO3$. It is very water soluble and hygroscopic, meaning it absorbs moisture from the air.

It is mainly used as a nitrogen fertilizer in agriculture, providing an essential nitrogen source to plants. Ammonium nitrate is also a powerful oxidizing agent, promoting the combustion of combustible materials, and it is used in the manufacture of industrial explosives.

It is stable at room temperature (between 18 and 32°C) but decomposes above 170°C, releasing toxic and flammable gases, which requires special precautions during storage and transport.
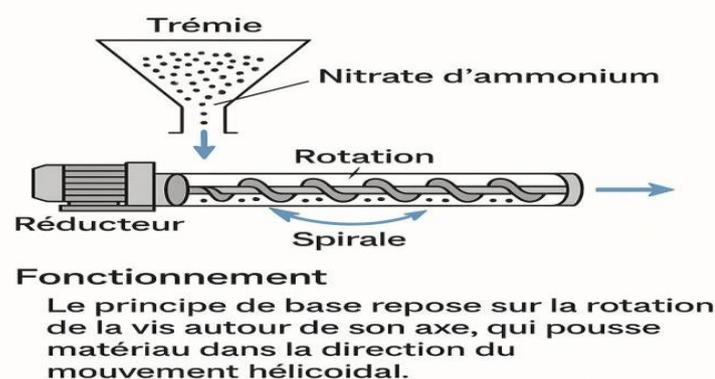
2.1.2 Presentation of the conveyor spiral

Figure 1: Configuration of the transport spiral

Material is fed into one end of the screw and transported along the rotating helicoid until it exits. The rotation speed and angle of the trough directly influence the flow rate and transfer efficiency.

2.2 Methods

Our approach began with the presentation of the study environment and its characteristics and is followed by the calculation of the theoretical and real debates for the seven provisions of the screw. The different results recorded allowed us to target the best arrangement which corresponds to an angle of 0°.

3. RESULTS AND DISCUSSION

3.1 Results

The results we obtained relate to:

3.1.1. Configuration studied

- Horizontal spiral (0°);

- Spiral inclined at 15°;

- Spiral inclined at 30°;

- Spiral inclined 45°;

- Spiral inclined 60°;

- Spiral inclined at 75°;

- 90° vertical spiral.

The results obtained are analyzed and compared in order to identify the angle of inclination offering the best compromise between efficiency, regularity of flow and industrial adaptability.

The presentation of the results is divided into three stages:

Starting data;

Calculates theoretical flow rates and actual flow rates for different inclinations;

Interpretation of the results.

3.1.2. Starting data

Spiral diameter (D) = 0.315 m

Inner diameter (d) = 0.06 m

Screw Pitch(s) = 0.315 m

Screw length = 4 m

Rotation speed (n) = 85 rpm (1.5 rpm)

∅: angle of inclination of the screw

Ammonium density (ρ) =800 kg/m³ k = approximate filling coefficient

3.1.3. Calculation of theoretical and actual flow rates for different inclinations of the conveyor screw

1° Horizontal spiral

The horizontal spiral transports the ammonium nitrate without constraints linked to inclination. It generally offers the highest efficiency, because the filling rate is optimal.

ISSN 2394-9686

International Journal of Novel Research in Education and Learning
Vol. 13, Issue 1, pp: (12-21), Month: January - February 2026, Available at: www.noveltyjournals.com

Calculation of theoretical flow (kg/h)

$$Qt = A \times s \times n \times 60 \times \rho$$

With :

Qt: theoretical flow (kg/h)

A: section (m²) S: pitch of the screw (m) n: rotation speed (rpm) 60: conversion of minutes into hours p: Density of the product (kg)

With;

$$A = \frac{\pi \times (D^2 - d^2)}{4}$$

The section of an Archimedes screw corresponds to the passage surface (transverse area) of the turn, that is to say the surface that the materials can occupy in a turn.

$A = 3.14 \times (0.3152 - 0.06^2) = 0.075$ m²

4

Qt $= 800 \times 0.075 \times 0.315 \times 85 \times 60 = 96,390$ kg/h

- Calculation of actual flow (kg/h)

$$Qr = Qt \times k \times cos\ (\theta)$$

With;

Qr: actual flow rate in kg/h

K: 1 filling coefficient which takes into account geometric parameters (gravity, slip), but in practice we will use 0.95

Cos (0°) = 1

Qr $= 96\ 390 \times 0, 90 \times 1 = 86\ 751$ kg/h

- Calculation of hourly output

$$\eta = \frac{8651 * 100}{96390} = 90$$

2° Spiral inclined at 15°

The inclined spiral transports the ammonium nitrate with constraints linked to the inclination. The higher the angle, the more gravity reduces the filling rate and the regularity of transport. This results in a reduction in efficiency compared to the horizontal configuration.

- Calculation of the theoretical flow (kg/h)

$$Qr = Qt \times k \times cos\ (\theta)$$

With:

Qr: actual flow rate in kg/h

K: 0, 85

Cos (15°) = 0, 9659

$$Qr = 96\,390 \times 0,85 \times 0,96 = 78\,654,24 \; kg/h$$

- Calculation of hourly output

$$\eta = \frac{78\,654,24 \times 100}{96\,390} = 82\%$$

3• *Spirale inclinée à 30•*

- **Calcul du débit théorique (kg/h)**

Qt= A × s× n ×60 × ρ

$$Qt = 800 \times 0,075 \times 0,315 \times 85 \times 60 = 96\,390 \; kg/h$$

- **Calcul du débit réel (kg/h)**

$$Qr = Qt \times k \times cos\,(\theta)$$

 Avec;

Qr: débit réel en kg/h

K: 0, 85

Cos (30°) = 0, 866

Qr = 96 390× 0, 75 × 0, 86 = 62 171, 55 kg/h

- **Calcul du rendement horaire**

$$\eta = \frac{62\,171,55 \times 100}{96\,390} = 64\%$$

4° *Spirale inclinée à 45•*

- **Calcul du débit théorique (kg/h)**

$$Qt = A \times s \times n \times 60 \times \rho$$

Qt = 96 390 kg/h

- **Calcul du débit réel (kg/h)**

$$Qr = Qt \times k \times cos\,(\theta)$$

Avec;

Qr: débit réel en kg/h

K: 0, 60

Cos (30°) = 0, 707

Qr = 96 390 × 0, 60 × 0, 707 = 40 888, 63 kg/h

- **Calcul du rendement horaire**

$$\eta = \frac{40\,888,63 \times 100}{96\,390} = 42\%$$

ISSN 2394-9686

International Journal of Novel Research in Education and Learning
Vol. 13, Issue 1, pp: (12-21), Month: January - February 2026, Available at: www.noveltyjournals.com

5° *Spirale inclinée à 60°*

- **Calcul du débit théorique (kg/h)**

$$Qt = A \times s \times n \times 60 \times \rho$$

Qt = 96 390 kg/h

- **Calcul du débit réel (kg/h)**

$$Qr = Qt \times k \times cos(\theta)$$

 Avec;

Qr: débit réel en kg/h

K: 0, 40

Cos (60°) = 0, 5

Qr = 96 390 × 0, 40 × 0,5 = 19278 kg/h

- **Calcul du rendement horaire**

$$\eta = \frac{219\ 278 \times 100}{96\ 390} = 20\%$$

6° *Spirale inclinée à 75°*

- **Calcul du débit théorique (kg/h)**

$$Qt = A \times s \times n \times 60 \times \rho$$

Qt = 96 390 kg/h

- **Calcul du débit réel (kg/h)**

$$Qr = Qt \times k \times cos(\theta)$$

Avec;

K: 0, 15

Cos (75°) = 0, 25

Qr = 96 390 × 0, 15 × 0, 25 = 3 614, 62 kg/h

- **Calcul du rendement horaire**

$$\eta = \frac{3\ 614,62 \times 100}{96\ 390} = 3,7\ 42\%$$

7°Vertical spiral (90°)

In a vertical configuration, transportation becomes less efficient. Filling is severely limited due to the almost constant sliding of the product downwards.

- Calculation of the theoretical flow (kg/h)

$$Qt = A \times s \times n \times 60 \times \rho$$

Qt = 96 390 kg/h

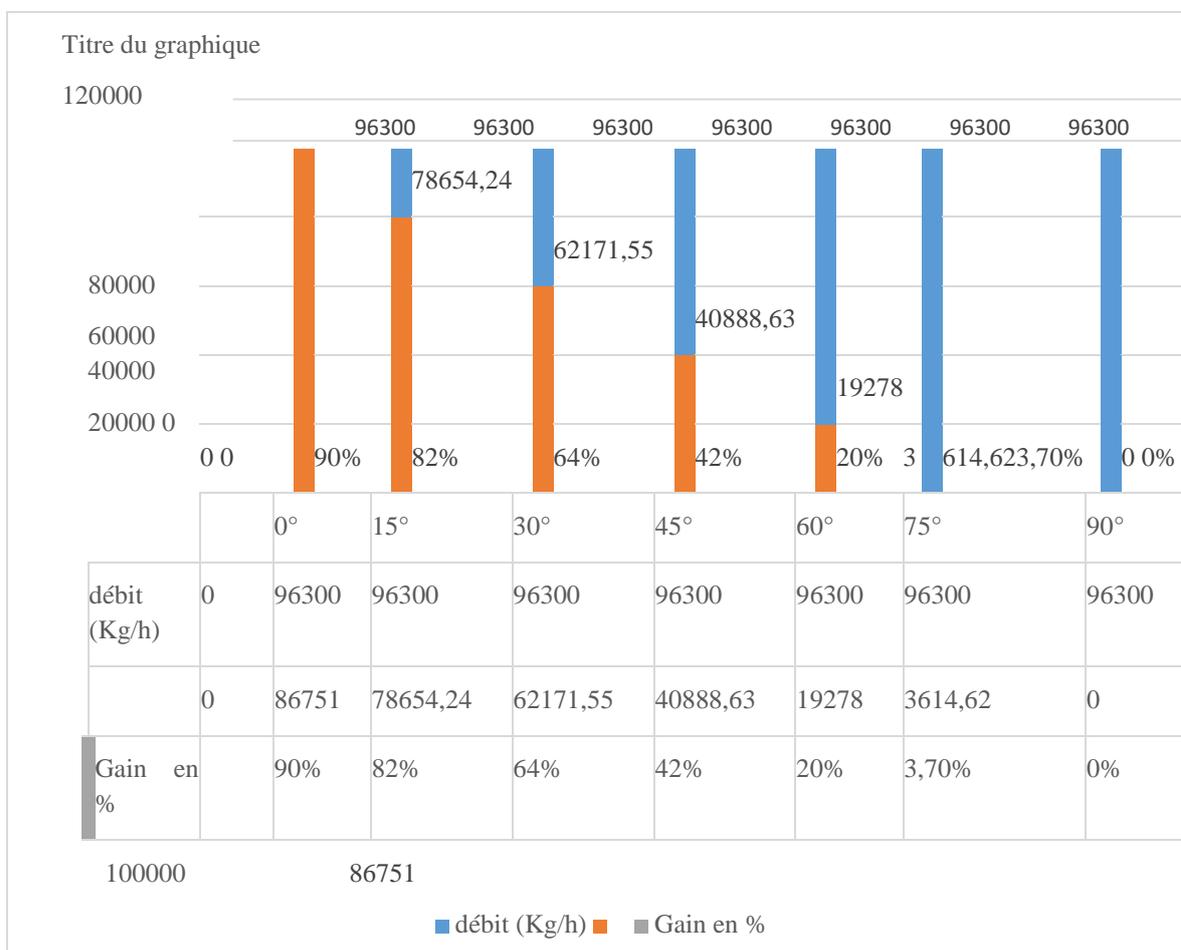- *Calcul du débit réel (kg/h)*
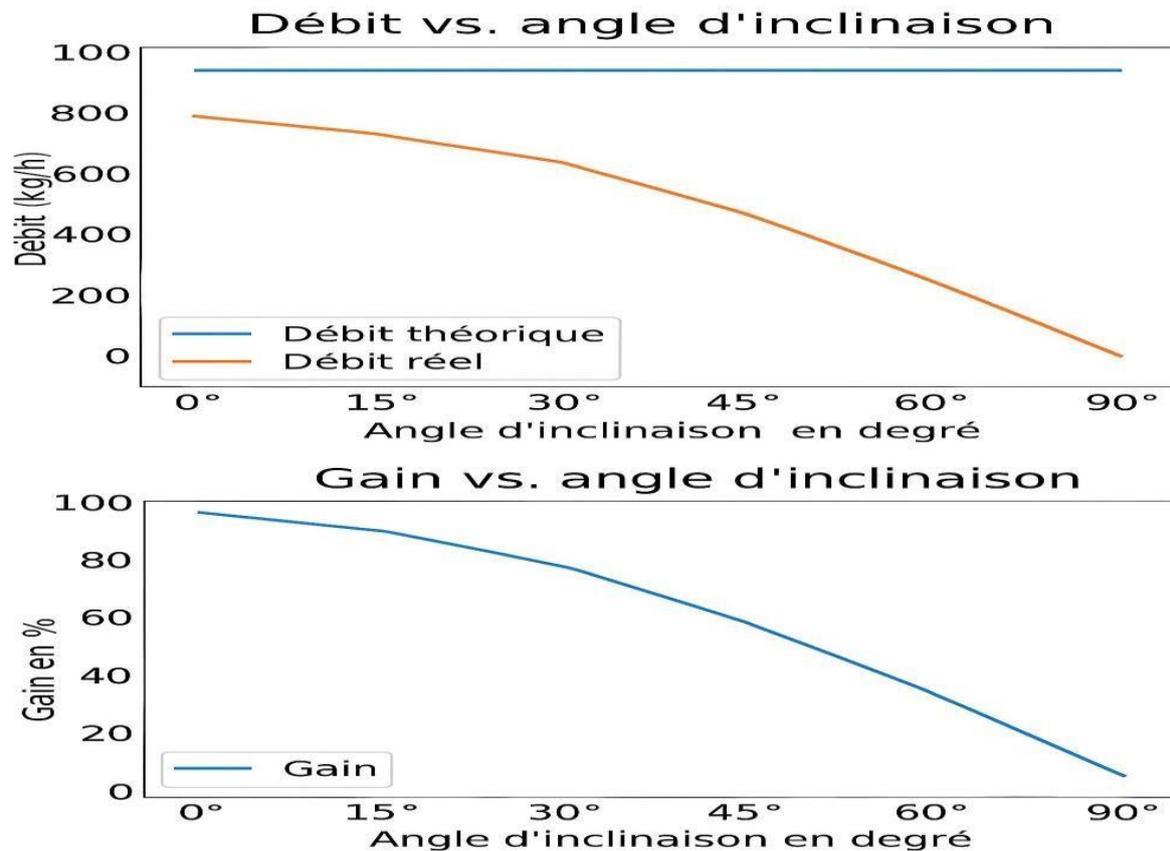
$$Qr = Qt \times k \times cos\ (\theta)$$

Avec;

K: 0, 02

Cos (90°) = 0

Qr = 96 390 × 0, 02 × 0 =0 kg/h

Vertically, cos (90°) = 0, but in practice, we consider a very low efficiency: If we want an empirical efficiency, we can also use a reduced k (e.g. k = 0, 2) at 90°

3.1.4. Summary of results

Tilt angle in degrees	Flow rate (kg/h)		Gain en %
	Theoretical	Real	
0°	96 390	86 751	90%
15°	96 390	78 654,24	82%
30°	96 390	62 171,55	64 %
45°	96 390	40 888,63	42%
60°	96 390	19 278	20 %
75°	96 390	3 614,62	3.7 %
90°	96 390	Low	Low

Titre du graphique

		0°	15°	30°	45°	60°	75°	90°
débit (Kg/h)	0	96300	96300	96300	96300	96300	96300	96300
	0	86751	78654,24	62171,55	40888,63	19278	3614,62	0
Gain en %		90%	82%	64%	42%	20%	3,70%	0%

■ débit (Kg/h) ■ Gain en %

3.2 Interpretation of results

The comparative study of the hourly flow rates of the transport spirals according to their inclination highlights the significant influence of the angle on the performance of the screw conveyer. The calculations carried out make it possible to draw several technical and practical lessons.

The results obtained show a significant variation in the actual flow rate depending on the angle of inclination of the transport spiral. Horizontally (0°), the conveyor achieves optimal efficiency with an actual flow rate of 90% of the theoretical flow rate, reflecting almost maximum efficiency. This performance remains acceptable up to 30°, where the gain drops to 64%.

However, beyond this angle, a drastic drop is observed: the gain drops to 42% at 45°, then to only 20% at 60°, reaching almost zero at 90° (0%). This loss is mainly due to the effect of gravity which opposes the movement of the material in the screw. These results demonstrate that the tilt angle has a direct and negative influence on the transport efficiency of ammonium nitrate. It is therefore recommended, for optimal performance, to limit the tilt angle to a maximum of 30° in industrial installations.

3.2.1 Gradual degradation with inclination

As the tilt angle increases, the efficiency drops almost exponentially. This is due to two main phenomena:

A reduction in filling (coefficient k decreases) linked to the sliding of the product inside the spiral.

The effect of gravity, which opposes the advancement of the product.

3.2.2 Parameters influencing transport

1°Gravity

It acts as a force that opposes the movement of the product in the inclined or vertical spiral. It causes a loss of efficiency when the angle of inclination increases, because part of the product tends to slide or fall towards the entrance.

ISSN 2394-9686

International Journal of Novel Research in Education and Learning
Vol. 13, Issue 1, pp: (12-21), Month: January - February 2026, Available at: www.noveltyjournals.com

The hourly output gradually decreases with the angle and this results in a reduction in flow rate, proportional to cos (ɵ).

2°Friction

Friction is present between the nitrate and the walls of the screw.

In an inclined spiral, some friction is helpful because it prevents the product from sliding back too quickly under gravity, but excessive friction reduces flow, especially with sticky or granular products.

The presence of friction explains the differences between the theoretical flow and the actual flow, it requires reducing the filling coefficient in the calculation.

These two parameters help explain the losses observed during the transport of nitrate; they justify the choice of configurations or the need to add speed or diameter.

Gravity force: $F_{grav} = m \times g \times \sin(\alpha)$

Friction force: $F_{frott} = \mu \times m \times g \times \cos(\alpha)$

With: μ=friction coefficient

4. RECOMMENDATIONS AND CHOICE OF EQUIPMENT

4.1 Preference for the horizontal spiral

When space constraints allow, the horizontal spiral is the best option to maximize hourly output. This configuration minimizes the effect of gravity opposing the movement of the product, thus ensuring more efficient transport with reduced energy consumption. It is particularly suitable for long conveying distances where there is sufficient floor space.

4.2 Limited use of inclined spirals

In installations where floor space is limited, the inclined spiral may be an acceptable compromise. However, it is recommended to limit the tilt angle to around 15°, because beyond that, efficiency losses increase quickly, which can lead to a significant drop in capacity and an increase in energy consumption. This configuration also requires adjustment of the rotation speed to maintain a stable flow and avoid jams.

4.3 Vertical spiral in case of absolute necessity

Vertical transport should be reserved for cases where no other solution is possible. It requires special attention, because the efficiency drops sharply due to gravity and internal friction. It is advisable to equip these conveyors with more powerful motors in order to compensate for these losses. Additionally, wear-resistant materials and non-stick coatings should be used to facilitate the movement of ammonium nitrate, which is susceptible to agglomeration.

5. CONCLUSION

The comparative analysis of the different arrangements of the ammonium nitrate transport spiral indicated that:

The best hourly output is obtained for the horizontal spiral, with good filling and movement efficiency.

The maximum theoretical flow rate is obtained with a spiral inclined at 15–30°, due to its larger dimensions, but at the expense of actual efficiency.

From 45°, the negative effects of inclination become dominant: drop in yield, product reflux, loss of performance.

The vertical spiral, although used in certain specific cases, has limited effectiveness and should only be used when space or height constraints require it.

REFERENCES

[1] BERNARD, A, Introduction to industrial processes and logistics, 1997.

[2] CCOPER. B, Modern Methods for Handling and Transporting Materials, London: Routledge, 2012.

[3] DE LAPLACE, M, Largonii etloucherbem au siècle de lorédan larchey, Paris Editions Linguistica, 2019.

[4] DIXON, J and ISSA, K, Design and analysis of industrial transport systems, London: Springer, 2000.

[5]   SICODEX DOCUMENTS, Technical report on the handling and transport of chemicals.

[6]   DUPON, R, Modern materials handling techniques, 2018.

[7]   HERAGU, S, Design of industrial installations, 3rd ed. Boca Raton, FL: CRC Press, 2008.

[8]   HOUNSLL, G, Engineering Approaches for Bulk Transportation, 2017.

[9]   TRAMPKIS, P, Mechanical conveyor systems, 2010.

[10] DEHOMBREUX P., Description of machine III; mechanical transmission, polytechnic faculty of Mons, 2006, Paris.

[11] VALEMBOIS G, Engineering technique, covers Mechanical Engineering, University of Paul Sabatier of Toulouse, edition, 2012.

[12] OHNET M, Encyclopedia of industrial chemistry, edition, 2003.

[13] HUTTE Engineer's manual, volumes 1 and 2, Polytechnique library, 1942, Paris.

[14] Basquin, R, Mechanics 1 kinematic, static and dynamic, LOUIS PASTAURIAUX collection, Delagrave edition.

[15] NACHTERGAL Material resistance aide-memoire, Volume 1, 10th edition, A de Boeck, 1969, Paris.

[16] BERNARD DIONNE, Methodological guide for study and research, 3rd edition 1998, Montreal.

[17] P. AGETI, N. MATTERA, Applied Mechanics, 1996, Paris.

[18] HEL MUT Ernest, Lifting devices, volume 2, Eyrolles edition, 1984, Paris.

[19] EL BAR, Thesis doctorate in science in industrial chemistry, Mohamed Khider University, 2016.

[20] Industrial technical center for metal construction, CM 66 calculation rule and Addendum 80, 1992.

[21] MOREL. Design and calculation of metallic structures, Eyrolles edition, 1975.

[22] L.PIOVRET, Mechanical construction and power transmission, 2005.

[23] FRANCIS ESNAUT, Mechanical construction – power transmission, volume 3, 2000, Dunod Paris.

[24] NICOLET. G and TROTTET, Elements of machines, 1971, Brussels.