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Modeling A Technology Of Ecological Gold Extraction, Case Of A Separating Cyclone

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***Abstract*—Through the major mining operators, mining resources are one of the driving factors for Madagascar. However, for gold small panners, the volatility of their daily income has an influence on their source of income, possibly on their standard of living and by rebound to the development of their respective localities. The methodology adopted is both quantitative and qualitative. Its eventual realization requires a priori passing through the chronological order of the following activities: bibliographic research and webography, field trips to collect data and see firsthand the reality of gold mining technology. The result of this work has led to the development of the new artisanal gold mining technology: the cyclone separator. This article consists of modeling and simulating the geometry and the principle of operation of the separator. The operation is assessed through two main performance indicators, separating efficiency and speed. The geometry, the separation regime and the properties of minerals are the three groups of parameters that affect the performance of the separation device. The variable fluid separation within the separating cyclone was studied by numerical simulation with ANSYS.**

Keywords—Artisanal Gold Mining, Modeling, Extraction Technology, Increased Productiont

I. INTRODUCTION

The pan, which has never gone out of fashion until now, is the artisanal gold mining tool of the artisanal gold miners. In this article, another technology is possible to replace this old method. Beater separation is effective, but has significant drawbacks that could affect their effectiveness. Namely: archaic and unhygienic means of production, low production capacity. These disadvantages and their consequences to push this research. To do this, before the construction of the cyclone separator model it is necessary to model it.

To complete the design of the device, a study of the centrifugal force in the separator cyclone is necessary. This force separates the gold and the other constituents of the gold ore, respectively.

Numerical modeling of separation by cyclone was chosen because this separator device, by its geometry and its construction, is not difficult.

II. SEPARATION PROCEDURES

The product to be separated enters the inlet of the mixture and will be sucked by the first vacuum cleaner and enters the cyclone which will then separate the heavy and light products. Heavy products exit at the bottom towards the exit and light products whose dust will be sucked up by the second vacuum cleaner and rise towards the exit (Fig. 1).

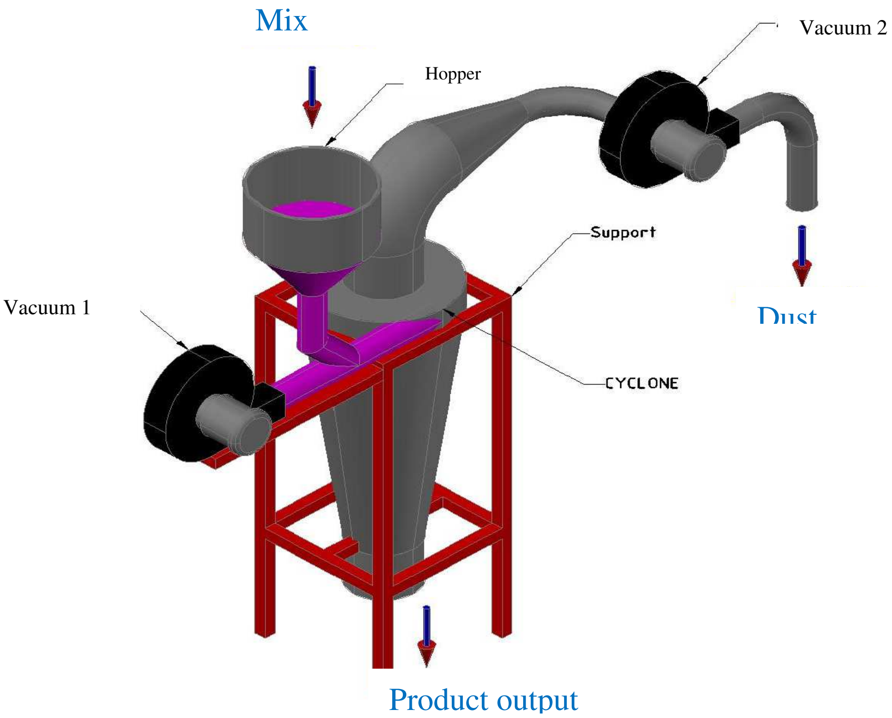

Fig. 1. Representation of the cyclone separator

A. Operation of the separator cyclone

In centrifugal separators, known as cyclone, the vortex field is induced by the spiral pipes and the tangential injection of the mixture to be separated:

- Through guide valves: the mixture is directed axially to guide valves, all of which resemble a Francis turbine. These separators are called axial cyclones;
- Through a tangential inlet pipe: the gyratory movement is obtained by making the fluid enter tangentially to the circumference, in the vicinity of the wall. These separators are called cyclones. There are two (02) types of this type of cyclone:
  - The “reverse types”: the two (02) phases to be separated take different ways. The light phase is collected from above and the heavy phase from below ;
  - The "straight through": the two (02) phases are removed from the same side, generally from the bottom: the light phase in the center and the heavy phase near the walls.

B. Geometry and parameters of the separating cyclone

Table I and Figure 2 represent the sizing of the inlet tube and the thermodynamic conditions of the slurry used.

Table I. Sizing Of The Inlet Tube

	Settings	Values
Mud	Particle diameter	6 à 10µm
	Viscosity	36 cp
	Density	1.05 Kg/m^3
Technical characteristics	Power	650W
	Production	50 à 60Kg par jour
	Entry speed	35.4 m/s
Dimension	Length	1540mm
	Height	962mm
	Width	350mm
	Inlet diameter	60.96 mm
	Outlet diameter	80 mm

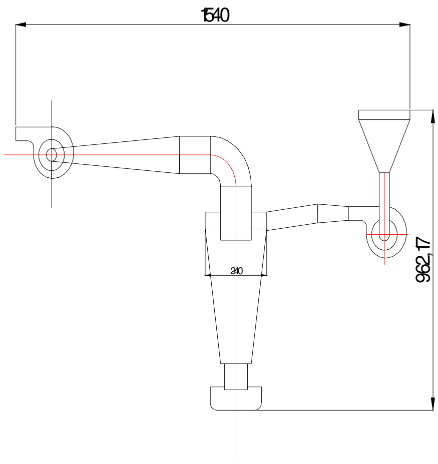

Fig. 2. Sizing of the studied structure

III. MODELING

A. Mathematical formulation

The number of grid points required for fully resolved Direct Numerical Simulation (DNS) is enormously large, especially for high Reynolds number streams, and therefore DNS is limited to relatively low Reynolds number streams [3]. DNS is generally used as a research tool to analyze the mechanics of turbulence, such as turbulence generation, energy cascade, energy dissipation, noise generation, drag reduction.

1) Reynolds Navier Stokes Average (RNSA)

When the flow is turbulent, it is convenient to analyze the flow into two parts, an average component (time averaged) and a fluctuating component.

$$\begin{cases} U_i = \bar{U}_l + u'_i \\ P = \bar{P} + p' \\ T_{i,j} = T_{l,m} + \tau'_{i,j} \end{cases} \quad (1)$$

Over line is a shorthand for the time average and in the case of RNSA $\overline{\overline{U_l}} \equiv \bar{U}_l$ and $u'_i = 0$ The above decomposition technique is called Reynolds Decompositions. The insertion of this decomposition in the instantaneous equations and the temporal average lead to the Navier-Stokes equations of Reynolds (RNSA).

$$\frac{\partial \bar{U}_l}{\partial x_l} = 0 \quad (2)$$

$$\frac{\partial \bar{U}_l}{\partial t} + \bar{U}_m \frac{\partial U_l}{\partial x_i} = -\frac{1}{\rho}\frac{\partial \bar{P}}{\partial x_i} + \frac{\partial^2 \bar{U}_l}{\partial x_l \partial x_m} - \frac{\partial}{\partial x_l}\left(\overline{u'_l u'_m}\right) \quad (3)$$

$\overline{u'_l u'_m}$ in the end of the equation. Equation 3 represents the correlation between the fluctuation rates and is called the Reynolds stress tensor. All the effects of the movement of turbulent fluids on the average flow are grouped together in this single term by the process of middle ages. This will lead to great savings in terms of computational requirements. In another case, the averaging process generates six new unknown variables. This is called the closure problem. Based on how we close the Reynolds tensor, there are two main categories, namely the turbulent viscosity models and the Reynolds stress model [4].

The Reynolds stress tensor resulting from the time average of the Navier-Stokes equations is closed by replacing it with a turbulent viscosity multiplied by speed gradients. This is called the Boussinesq hypothesis

$$\overline{u'_l u'_m} = -v_t \left(\frac{\partial \bar{U}_l}{\partial x_m} - \frac{\partial \bar{U}_l}{\partial x_i}\right) \quad (4)$$

v_t is the turbulent kinematic viscosity (turbulent). In order to make (4) valid on contraction because of (02).

2) **Equations governing particles**

Based partly on the physical properties of dust particles and partly on the mathematical modeling effort required, there are some reasonable assumptions to describe the transport of particles in a fluid medium [5]. The main simplifying assumptions are as follows:

- The particles are assumed to be spherical ;
- The ratio between the density of particles and that of fluids is very important: the density of the dust particle is much higher than that of the fluid which is air;
- The drag force is the dominant force: it is the direct result of the previous hypothesis. Since the density of the particles is much higher than the density of the fluid, several forces such as lift force, Basset force and buoyancy force can be easily eliminated as they have negligible effect on particle transport.

By incorporating all of the above assumptions, the Lagrangian equations governing the motion of particles can be written as follows:

$$\frac{dx_p}{dt} = u_p \quad (5)$$

$$\frac{du_p}{dt} = F_d(u - u_p) + g_x\left(\frac{\rho_p - \rho}{\rho_p}\right) \quad (6)$$

x_p is the position of particles, g_x is gravitational force, ρ et ρ_p are the density of the fluid and the particle respectively. Usually, the particle moves with a speed different from that of the fluid at any given point. The difference in fluid velocity (u) and particle velocity (u_p), called slip velocity ($u - u_p$), result in an unbalanced pressure distribution as well as viscous stresses on the surface of the particle. In (6), $F_d\left(u - u_p\right)$ is the drag per unit mass of particles. F_d is given by [6]:

$$F_d = \frac{1}{\tau_p}\left(\frac{C_d R_{ep}}{24}\right) \quad (7)$$

τ_p is the relaxation time of the particles given by:

$$\tau_p = \frac{\rho_P d_p^2}{18\mu} \quad (8)$$

B. Resolution Technique

Parametric numerical simulation studies, using the Fluent code [7], were conducted to characterize the effects of parameters affecting the operation of this device through their performance indicators. The RNSA turbulence model and the multiphase model of the mixture were combined to illustrate the behavior of the components of the mixtures in the separators (fig. 3, fig.4).

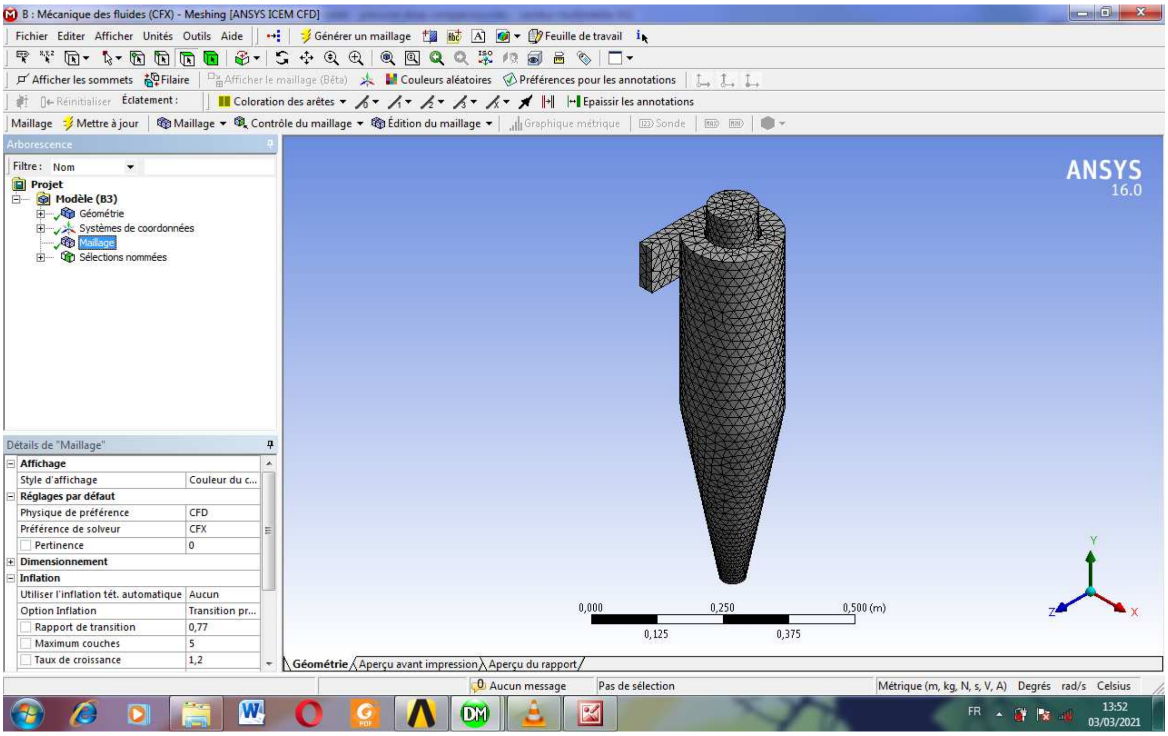

Fig. 3. Mesh of the geometry

The Fluent repeats a modeling program that has among these capabilities:

- 2D Plan, 2D Axisymmetric, 3D;
- Structured and unstructured meshing;
- Permanent or unsteady flow;
- All speed regimes (subsonic, supersonic and hypersonic);
- Not viscous laminar or turbulent ;
- Newtonian or not Newtonian fluid;

- Formulation RNSA: K-ε, K-ω, RSM ;
- Formulation LES;
- Natural, forced and mixed convection;
- Conjugate heat transfer;
- Combustion (reaction and chemical species);
- Multiphase flows;
- Phase change (solidification / fusion).

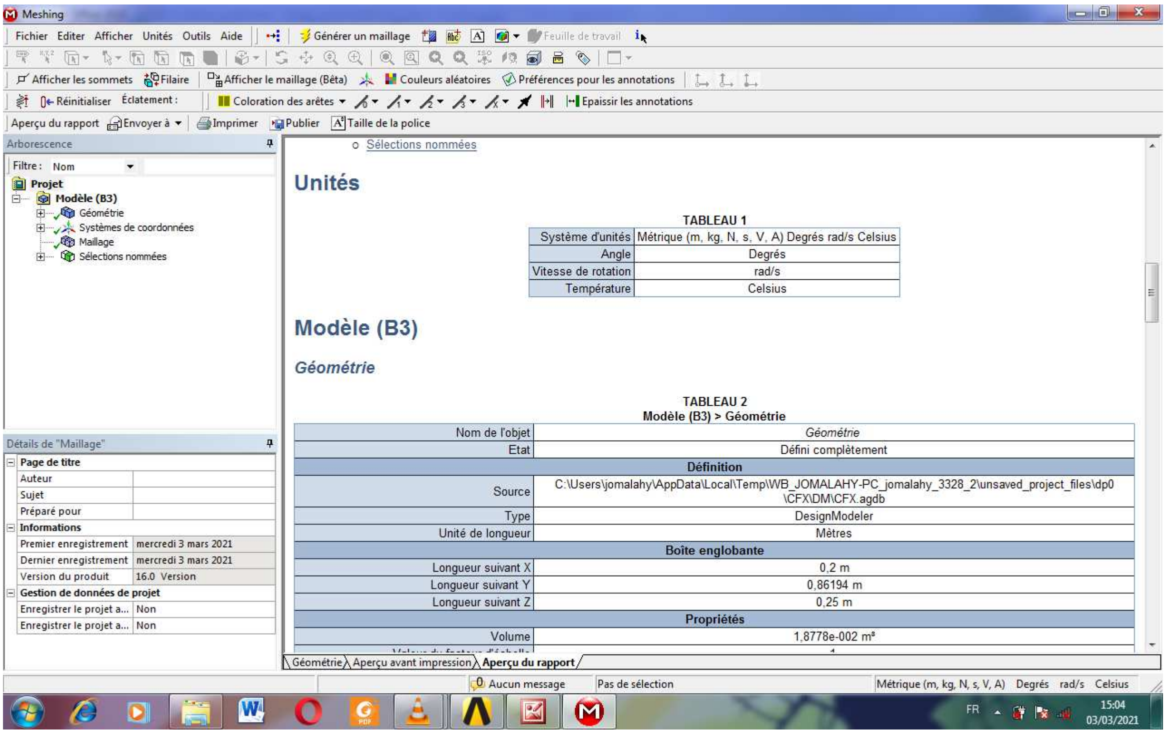

Fig. 4. Entering parameters in ANSYS

The model used in this work and the K- ε formulation with the following specifications:

- Model of K-ε : RNSA
- Option of RNSA : differential viscosity model

IV. Results And Interpretation

Figure 5 and figure 6 represent the results of the cyclone modeling.

C. Result speed

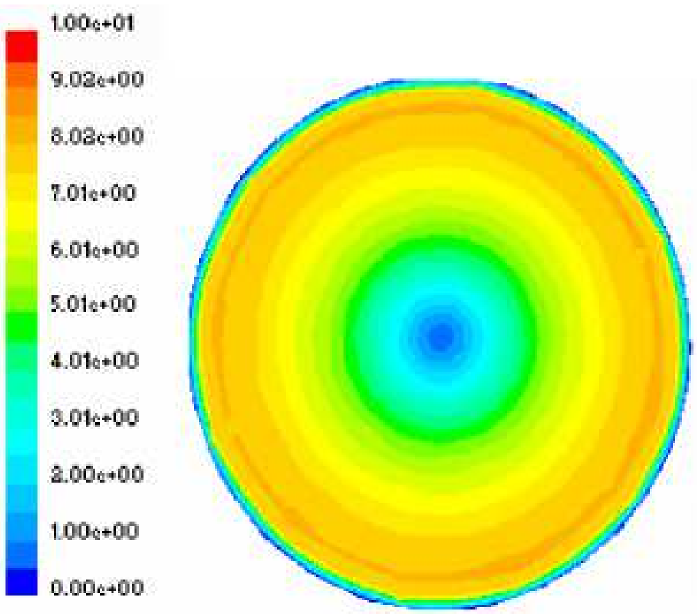

Fig. 5. Representation of remaining speeds

Figure 5 shows contours and streamlines in the plane (x, z) for y=0 and this for the turbulence models RNSA K- ε. There is a tilting of the fluid around the axis of the cyclone. We also notice in this separator that there are two flows, a descending flow illustrated by negative speeds, and an ascending flow.

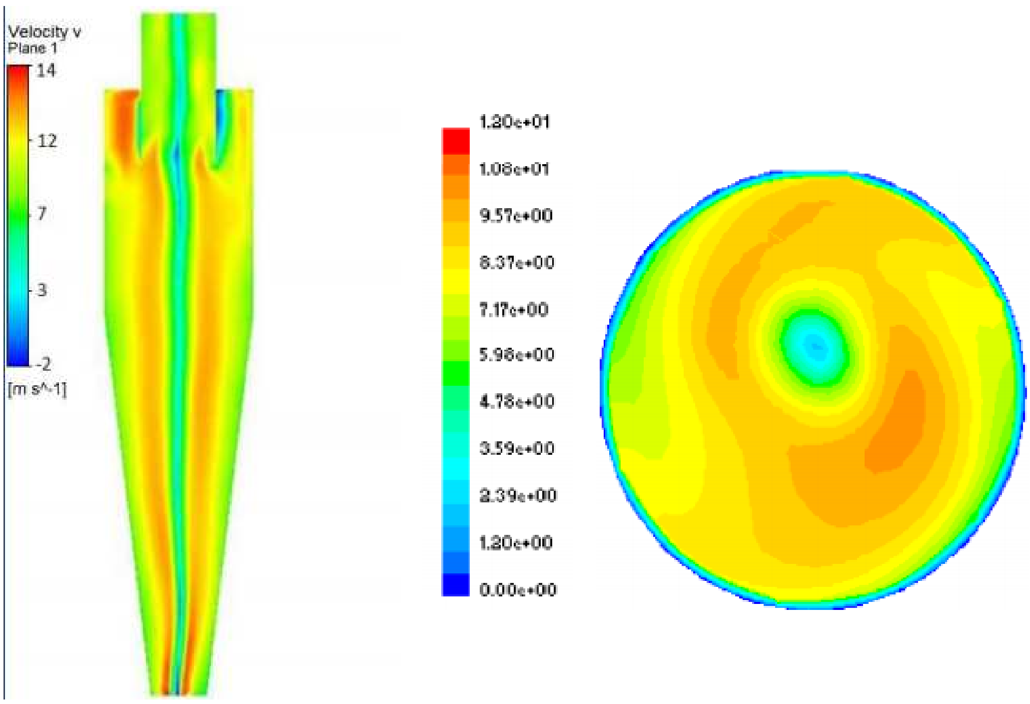

Fig. 6. Representation of Average Velocity Components

In Fig. 6 the axis of the flow is oscillatory with respect to the axis of the cyclone which actually causes a loss of energy which can be seen at very low velocities. Subsequently, the particles close to the wall of the outlet duct internally, the speeds are clearly important.

D. Pression statique

Figures (7) and (8) illustrate the different representation of the static pressure for different inlet velocities, These figures show that the flow crossing the tangential inlet of the geometric configuration of cyclone causes the flow to press against the walls and generates a strong pressure far from the axis of the cyclone, on the other hand at the center of the cyclone, we notice a strong depression felt creating a large flow tube of low pressure oscillating around the cyclone axis.

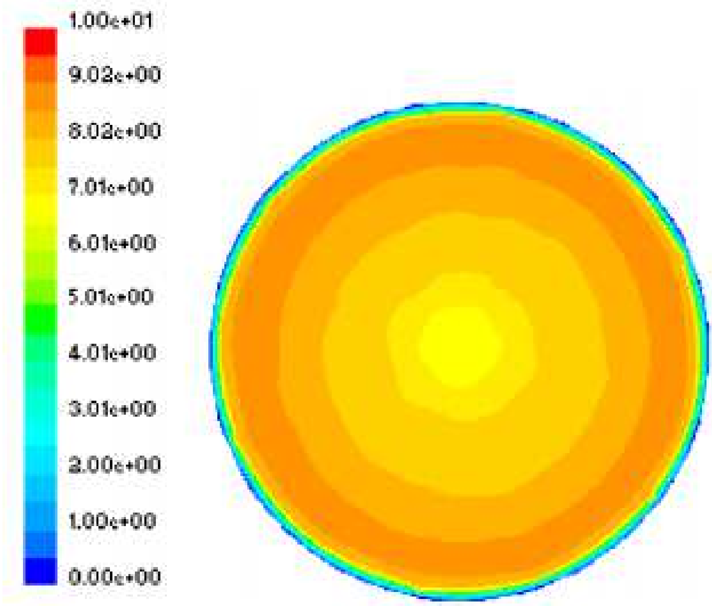

Fig. 7. Representation of static pressure

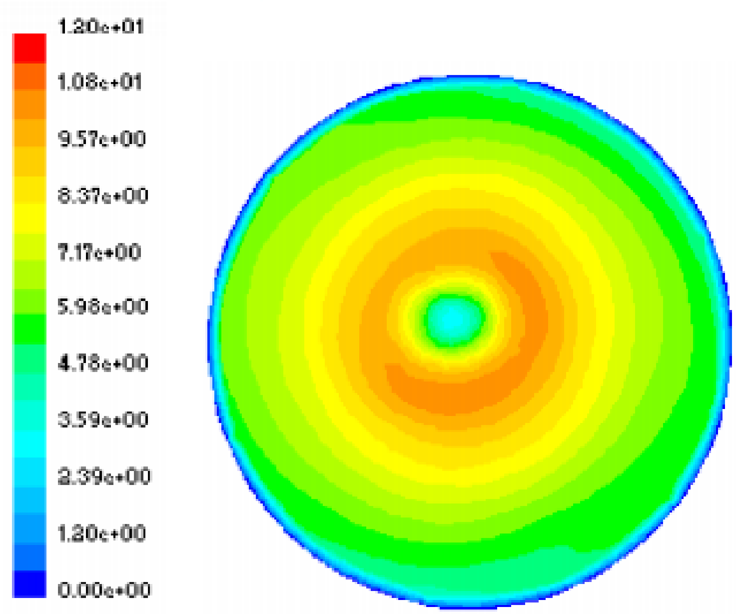

Fig. 8. Pressure drop at constant speed

E. **Kinetic energy**

Figures (9) and (10) show contours of turbulent kinetic energy at different input speeds.

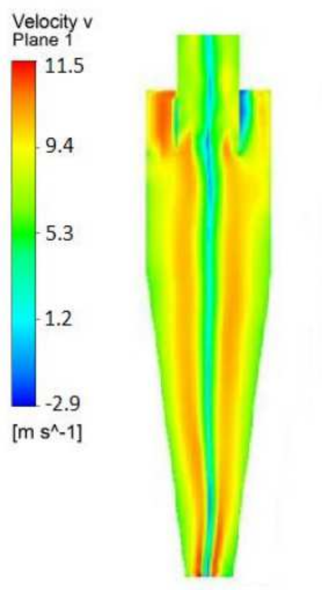

Fig. 9. Turbulent kinetic energy

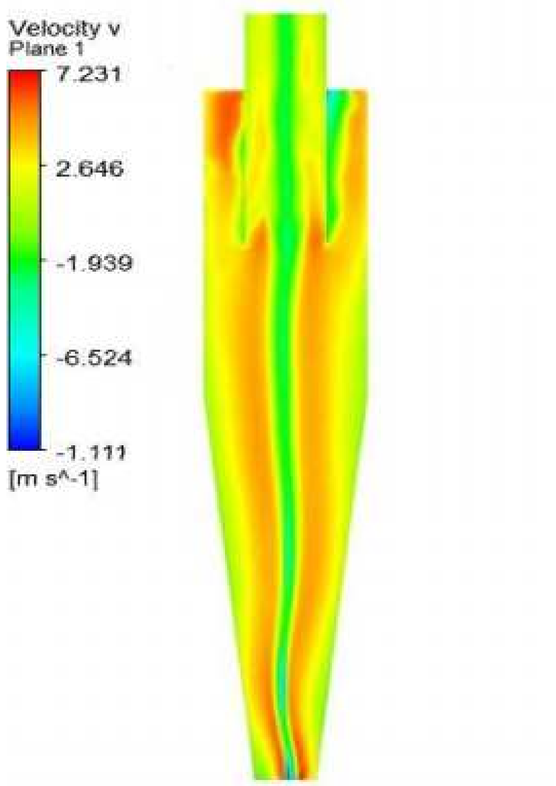

Fig. 10. Flow energies

It is observed that near the outlet duct, a creation of a strong velocity gradient which causes the particles to change direction which in fact generates an increase in the turbulent kinetic energy. Where, the turbulent kinetic energy is maximum in this highly turbulent region. This somewhat original configuration is surely due to the velocity gradient caused by the cone effect which converts other energies of the flow into increases in velocity.

V. DISCUSSION

The shape of the tangential velocity is divided between a forced vortex which has been translated by an almost linear increase from the center, then it falls, it is the free vortex. The tangential speeds simulated by the RNSA k-e model are important under the outlet pipe. The oscillatory motion around the axis of the cyclone gives large radial magnitudes and different signs on either side of the axis. The flow is three-dimensional because of the radial component which is strongly manifested in these regions.

The tilting of the flow on the axis of the cyclone, proves that the RNSA model captures radial velocities well than other models [9]. The maximum turbulent kinetic energy is found in a region of strong velocity gradients, in the area of deviation of the flow from the axis of the cyclone. There is an acceleration of the particles in the bottom zone of the cyclone, which gives a greater exchange between the fluid and the wall due to friction.

VI. CONCLUSION

The study of separator cyclone made it possible to estimate the capacities and limitations of the model under different operating conditions.

The simulation model will be used for the design for accurate results.

The purpose of this research is to improve the means of production of gold miners by providing them with new artisanal gold mining technology, ecological, with high production yield and within reach of their purse. This technology also makes it possible to recover other high value-added minerals that are lost during gold mining.

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