Tshwane University of Technology
We empower people

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT
Department of Chemical, Metallurgical and Materials Engineering
Metallurgical Engineering Technologies: Particle Classification using a Hydrocyclone
Competition Day 2017 – 4 August 2017

1. INTRODUCTION

Metallurgy is a specialised and exciting field of science and engineering that focuses on the extraction of metal elements from their bulk ores, extraction is employed to enhance their value by manipulating their physical and chemical properties. Mineral ores that are abundant in South Africa include hematite (iron rich), chalcopyrite (copper rich), UG2 (platinum, gold and nickel rich) and limestone (calcium rich) — to name a few. Through a sequence of metallurgical technologies, these ores can be treated for a large-scale production of saleable compounds or alloys. Typical applications of these materials range from simple cutlery, jewellery to the intricate vehicle parts, computer chips, electronic wires, machinery and other associated products.

During the extraction of these metals, one of the most important processing stages in metallurgical plants is particle classification (or separation). High classification efficiency is achieved when a considerable difference in the properties such as density, magnetisation and size exists in the mineral ore particles. The most interesting device that skilled Metallurgists use to classify particles through differences in density and size is a hydrocyclone (often referred to as a cyclone) (Figure 1.1a). Cyclones are often used to remove particulates from air, gas, liquid or slurry streams without using any filters. In cases where large volumes of material are processed, cyclones are often arranged in a series of clusters as shown in Figure 1.1b.

Figure 1.1: (a) A sectioned hydrocyclone particle classifier (www.oilfied.gnsolids.com);(b) A cluster of hydrocyclones used in a Metallurgical plant connected in series (**www.flsmidth.com**).

Figure 1.2: Cyclone classifiers: (a) Cross-sectional view (Wills & Finch, 2016); (b) Cyclone particle classifiers in operation (**www.dredgingtoday.com**).

1.1 How Does a Hydrocyclone Work?

During operation, the flow of particles within the cyclone is subjected to two opposing forces:

- An outward centrifugal force, and
- An inwardly acting drag force.

The outward centrifugal force is generated by the feed materials entering the cyclone under pressure and causes the larger and heavier particles to move towards the cone wall thus creating a vortex at the center of the cone. Simultaneously, the finer and lighter materials are kept closer to the center (Figure 1.3). The vortex finder (Figure 1.2a) draws the fluid which comprises of the fine materials to the overflow stream (top) due to the viscous resistance of feed materials moving towards the zone of low pressure. Meanwhile, the coarser materials migrate towards the apex or spigot and constitute most of the splashing underflow stream (bottom) as shown in Figure 1.2b.

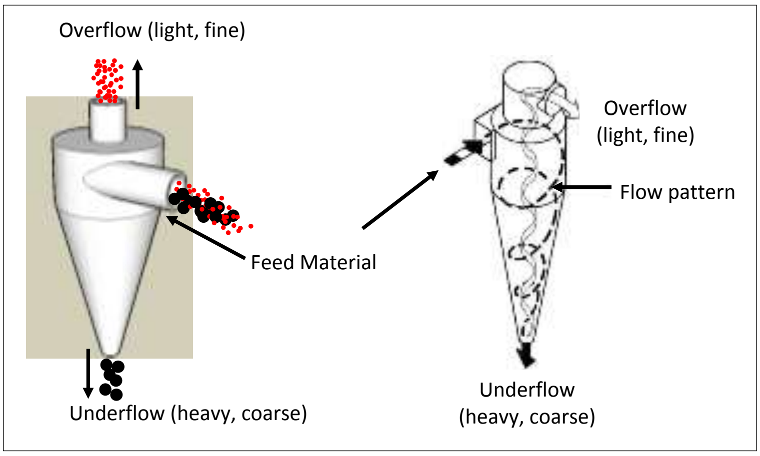

Figure 1.3: Cross-sectional view of the typical cyclone model (www.wikipedia.org).

2. TEAM ASSIGNMENT

Participants are required to design, cost, build, test and present a working prototype of a hydrocyclone. It must produce the underflow and overflow streams as shown in Figure 1.3. This classifier must be able to treat a powdered mixture consisting of materials that vary in size, shape and density. Additional test material will be provided by the TUT competition officials to test the limits of the prototype. During the competition, the participants will be expected to describe the separation dynamics when the prototype is in operation and submit a technical report (refer to Section 4 for additional details).

3. RECOMMENDED BUILDING MATERIALS

Teams can use any materials to construct their hydrocyclone prototype; however, the materials should be transparent. This will allow the audience to observe the physics or flow dynamics corresponding to how the particles respond to the separation forces described in Section 1.1. Outlet or inlet pipes do not have to be transparent. However, any team that will use material that is not transparent for the major vessel (conical shape) will be penalised. Typical materials to use include but not limited to:

- Glue, cans, plastic bottles, buckets, plastic pipes, scissors, razor and other materials of choice.
- The team can use any kind of electrical component that will enable particle separation.
- The team can use any kind of powdered material which can demonstrate the concept of separation.
- VERY IMPORTANT: The hydrocyclone particle classifier should be able to separate the feed material into underflow and overflow streams as illustrated in Figure 1.3.
- NO POWER SUPPLY will be provided by TUT during the competition.

4. RULES, SPECIFICATIONS AND OUTCOMES

The rules for the competition are as follows:

- The partaking teams may consist of a minimum of **three** and maximum of **five** learners.
- Each participating team shall bring a finished prototype of a hydrocyclone to TUT.
- Each school can enter **only one** team into the competition.
- The teams will be expected to present their reports outlining all the ideas, budget, calculations, testing procedures, sketches and designs which were used to create the final model.
- The report must disclose the capacity of the hydrocyclone.
- The report must be typed, not hand written.
- The exhibition stations will be provided at TUT, where the prototype will be displayed during the competition.
- TUT will not provide any electrical components (i.e. should the team need power supply, they must come with their own source.).

5. LEARNING OBJECTIVES

This project will introduce the learners to the following fundamentals of Mineral Processing:

- Metallurgical technology, in this case, a hydrocyclone.
- Design principles and operation of a hydrocyclone or a particle classifier.
- The teams will learn basic calculations or mass balance and procedures that engineers use when designing, starting and running a project.

6. DAY PLAN

This competition day will occur as follows:

- Each team will be given a maximum of 11 minutes for their demonstration.
- If there is a need for the assembling of the model, the team must make sure their prototype is assembled before the completion starts.
- The place to display the prototype will be allocated to each team by competition officials.
- There will be a facilitator or competition official at each station for evaluation.
- The teams will be graded and there will be awards at the end of the competition.

7. EVALUATION

All teams will be judged based on the categories displayed in Table 1.

Table 1: The assessment criteria to be used for all the competing teams

CRITERIA	MAXIMUM POINTS
TEAM	
Theme	5
Teamwork	5
PRESENTATION	
Audibility	5
Content	15
Response to question	10
Report	10
MODEL	
Appearance	10
Capacity	10
Functionality	30
TOTAL	100

8. CONTACT DETAILS

CONTACT PERSON	TELEPHONE	E-MAIL
Ms Innocentia Setlhabi	(012) 382 4244 / 4245	setlhabibi@tut.ac.za