Filtration Services Ltd
Unit 5, Sutton Mill
Byrons Lane
Macclesfield
Cheshire. SK11 7JL
United Kingdom

Tel: 01625 616109
Fax: 01625 434678
info@filtrationservices.co.uk
www.filtrationservices.co.uk

White Paper [Ref. WP20170913]

Data Requirement for a Rotary Drum Vacuum Filter

Author: Dr Andrew Walker
First Publication Date: 13th September 2017
Revision: 000
Revision Date: 13/09/2017

Abstract

The purpose of this *White Paper* is to explain the basic data requirement for a rotary drum vacuum filter (RDVF).

It is important to provide accurate and, in particular, applicable data in order to be able to calculate the required filtration area for an RDVF. Whilst the basics of filtration are covered in, for example, Chemical Engineering courses, the applicability of filtration theory to real-life applications is limited. The conventional filter models offer a simplistic approach to filtration which is difficult to align with actual processes and equipment. Furthermore, the reliance on filtration theory creates a flawed understanding by engineers, such that wrong or inapplicable data is often cited when requesting filter manufacturers to size and quote for process equipment.

This *White Paper* has been produced to highlight the most appropriate data for RDVF sizing, and to explain the limited applicability of additional data such as particle size distribution.

Figure 1. *The Rotavac* scraper discharge rotary drum vacuum filter.

Discussion

There are only two data sets required for the sizing of a rotary drum vacuum filter. The first data set is the mass balance around the filter itself. This comprises of input and output data in the form of solid, liquid or solid-liquid mass flows. The second data set is the filtration flux rate, which is the mass flow rate of, for example, the filtrate per unit filtration area.

The Mass Balance:

The mass balance for the RDVF is a critical piece of information because it defines the filtration duty and can be used to specify ancillary equipment pre- and post- filtration. The mass balance is also a method to examine the upper and lower limits of solid / liquid flow conditions.

An example of a simple mass balance sheet is given below:

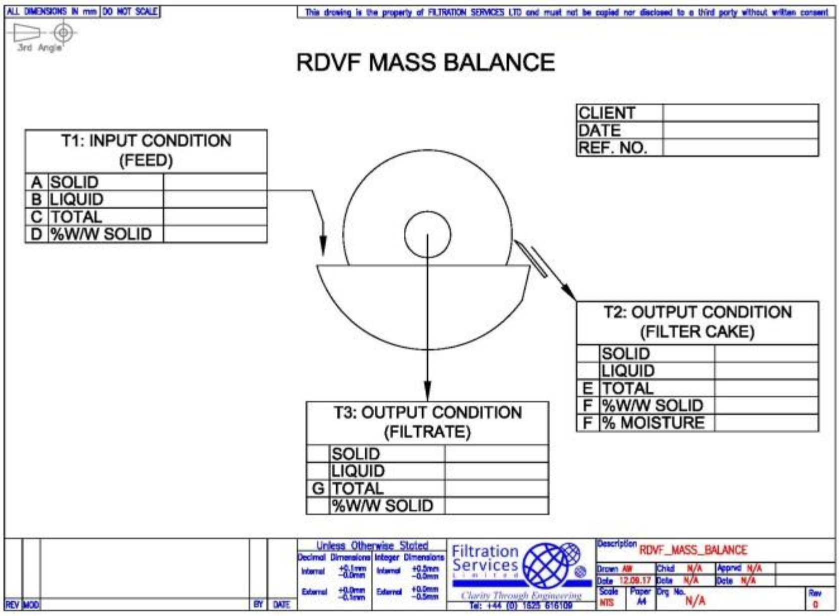

Figure 2. Mass Balance Sheet for an RDVF

If the mass balance cannot be completed then it is impossible to determine the required size of the rotary drum vacuum filter.

The basic information usually consists of the following:

- Total input feed rate and solids concentration;
- Total liquid (filtrate) flow from the filter;
- Total solids (wet cake) discharge from the filter;
- Filter cake moisture content.

In many instances, the filter cake moisture is an assumed value based on what the engineer *wants* rather than what is *actually achievable*. The moisture content is a function of the physical properties of the solid-liquid suspension and the filtration and dewatering characteristics of the filter cake. **It must not be assumed.** Instead, it must be determined by test work which is applicable to the filter configuration under consideration.

The mass balance should also reflect any variations in mass flow rate, concentration etc., for example:

- Feed rate = 10,500 to 14,500 kg/hr
- Feed concentration = 5 to 7% by weight
- Filter cake moisture = 32 to 36 % by weight

It is reasonable to assume that the solids content in the filtrate is negligible.

The maximum filtrate flow occurs at:

- Feed rate = 14,500 kg/hr (maximum feed rate)
- Feed concentration = 5% by weight (minimum solids concentration)
- Filter cake moisture = 32% by weight (lowest filter cake moisture content)

FEED (INPUT)		
SOLID	725	kg/hr
LIQUID	13,775	kg/hr
TOTAL	**14,500**	kg/hr
% SOLID	**5**	% by weight
FILTER CAKE (OUTPUT)		
SOLID	725	kg/hr
LIQUID	341	kg/hr
TOTAL	1,066	kg/hr
% MOISTURE	**32**	% by weight
FILTRATE (OUTPUT)		
SOLID	**0**	kg/hr
LIQUID	13,434	kg/hr
TOTAL	13,434	kg/hr
% SOLIDS	**0**	% by weight

<u>Filtrate flow rate = 13,434 kg/hr</u>

The minimum filtrate flow occurs at:

- Feed rate = 10,500 kg/hr (minimum feed rate)
- Feed concentration = 7% by weight (maximum solids concentration)
- Filter cake moisture = 36% by weight (highest filter cake moisture content)

FEED (INPUT)		
SOLID	735	kg/hr
LIQUID	9,765	kg/hr
TOTAL	**10,500**	kg/hr
% SOLID	**7**	% by weight
FILTER CAKE (OUTPUT)		
SOLID	735	kg/hr
LIQUID	413	kg/hr
TOTAL	1,148	kg/hr
% MOISTURE	**36**	% by weight
FILTRATE (OUTPUT)		
SOLID	**0**	kg/hr
LIQUID	9,352	kg/hr
TOTAL	9,352	kg/hr
% SOLIDS	**0**	% by weight

Filtrate flow rate = 9,352 kg/hr

Maximum to minimum variation in filtrate flow rate is 13,434 - 9,352 = 4,082 kg/hr

It is important to consider the maximum filtrate flow rate when sizing the rotary drum vacuum filter and any auxiliary equipment.

The Filtration Flux Rate:

Once the basic mass balance has been completed, the next step is to establish the filtration flux rate profile for the suspension. In most cases, this is expressed as the *filtrate flux rate*. The filtration flux rate can also be expressed as the *feed flux rate* and *filter cake flux rate*. For the purpose of this *White Paper*, the filtration flux rate will be based on *filtrate*.

The filtrate flux rate is defined as the rate of flow of filtrate per unit filtration area, for example, $kg/m^2/hr$. The filtrate flux rate is normally determined by test work utilising representative samples of the feed suspension. It is the easiest parameter to measure, and a direct indication of the overall filtration characteristics of the suspension. For a rotary drum vacuum filter, the test apparatus is an *inverted filter leaf* which mimics the operational cycle.

An explanation of the filter leaf test procedure is covered in the Filtration Services Ltd document: *Pocket Guide to Filter Leaf Tests*.

Filter leaf test work is also used to validate or refute any assumption made about the filter cake moisture.

An example of a filtrate flux rate profile as a function of equivalent drum speed is given below.

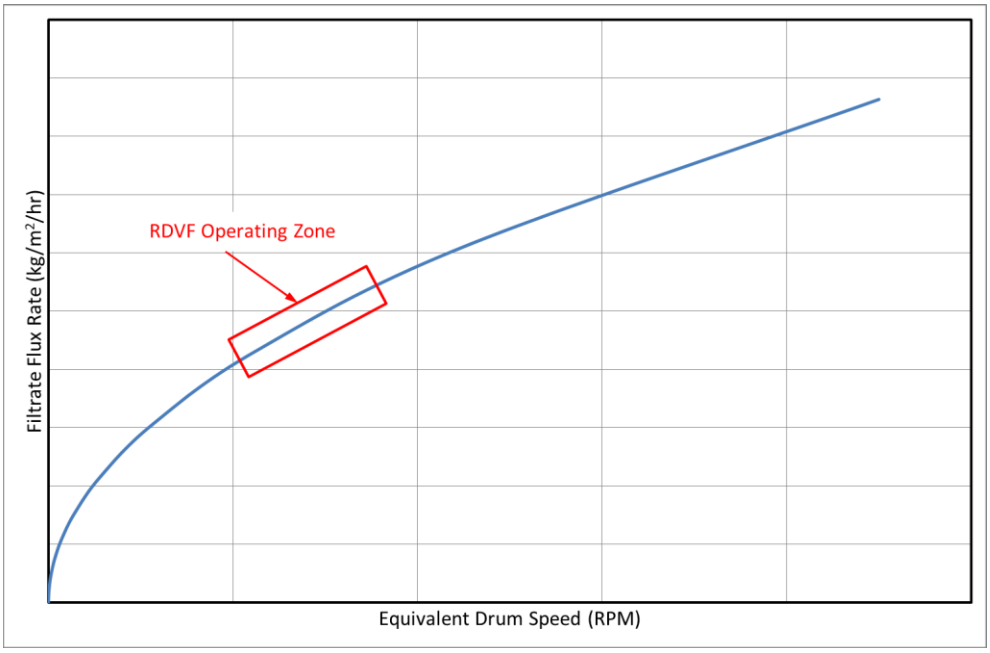

Figure 3. Example of a Filtrate Flux Rate Profile as a Function of Equivalent Drum Speed

The filtrate flux rate profile is used to determine the most appropriate operating zone or 'window' for the RDVF.

As equivalent drum speed increases:-

- overall throughput increases;
- filter cake formation time reduces (producing a thinner filter cake);
- filter cake dewatering time reduces (producing a higher moisture content filter cake);
- filter cake discharge becomes more difficult.

As equivalent drum speed decreases:

- overall throughput decreases;
- filter cake formation time increases (producing a thicker filter cake);
- filter cake dewatering time increases (producing a lower moisture content filter cake);
- filter cake discharge becomes easier.

The filtrate flux data, in conjunction with the mass balance, is used to calculate the required filtration area for an RDVF, for example:

Maximum filtrate rate (from earlier mass balance) = 13,434 kg/hr

If the filtrate flux rate, within the ideal operating zone or 'window', varies between, say, 420 and 510 kg/m^2/hr, then the required filtration area will be:

Maximum filter area = (13,434 / 420) = 32 m^2

Minimum filter area = (13,434 / 510) = 27 m^2

Summary

This *White Paper* demonstrates the basic method for establishing the correct size of a rotary drum vacuum filter. The two important data sets are the mass balance and the filtration flux rates. With these two data sets it is possible to calculate the required filtration area for the system under investigation.

Please note that the data sets for filter sizing **do not** require any of the following:

- Particle size distribution
- Chemical analysis
- Solids composition
- Liquid composition
- pH
- Temperature

Whilst this additional data might be useful in selecting, for example, materials of construction or setting operating conditions, it has no influence on the filter sizing calculations.

Furthermore, this *White Paper* clearly shows that filtration model equations are not required. However, it is acknowledged that filtration model equations form the basis in the methodology for determining the filtrate flux rate.

Filtration Services Ltd

Ref: WP20170913