Journal of International Scientific Publications:
Materials, Methods & Technologies, Volume 7, Part 2
ISSN 1313-2539, Published at: http://www.scientific-publications.net

STUDY OF LIQUID DISTRIBUTORS FOR SOILED AND THICK LIQUIDS

Simeon R. Darakchiev, Svetoslav Tz. Nakov
Bulgarian Academy of Sciences, Institute of chemical engineering
Bulgaria, Sofia 1113, Acad. G. Bonchev Str., bl. 103
e-mail: s_darakchiev@abv.bg

Abstract

Two types of overflowing liquid distributors for soiled and thick liquids are investigated. Experiments are performed in a device for packed column apparatuses with a diameter of 426 mm. The relationship between the flow rates of distributors with beveled pipes and with triangular slits is determined as well as the height of liquid column above the lower end of the slots. Also is investigated the uniformity of the distributing jets depending on the flow rate, as is recommended this to be done with standard deviation not exceeding 0.03. With this precision, the distributor with beveled pipes operates in the range between 2.0 and 8.0 m^3/h, as its maximum capacity is 8.5 m^3/h. The distributor with triangular slits has maximum output of 6.3 m^3/h. Therefore it is not recommended.

Key words: *Packed columns, distillation columns, liquid distributors, soiled and thick liquids, uniformity of the liquid jets.*

1. INTRODUCTION

Uniform distribution of liquid on the column cross section is necessary for their normal operation. It is particularly important the initial flow distribution, which is provided by the liquid distributor. There is a great diversity of distributors for uncontaminated liquids. Sometimes a problem is the distributors for viscous and soiled liquids. Such for example are the distributors for fermented mixtures of ground corn in water with alcoholic content up to 12 %. They are used in distillation columns of rectification plants for ethanol production. Experience shows that for soiled and viscous liquids like those, application can find overflow distributors with slots (Golovachevski, 1967, Sulzer Brochures 2003, Kolev 2006). Unfortunately there are no accurate data on their characteristics in the literature.

Overflow distributors with slots are composed of a cylindrical vessel with evenly spaced pipes in it with different in shape slots. They can be unilaterally beveled pipes with an angle of 45^0 (Fig. 1) or with triangular slots – one or two pieces (Fig.2) or. Their situation in the cylindrical part is such that the slots are radially directed to the outer part. Impurities in the liquid are able to settle in the zone under the slots. Mainly are used pipes ∅53x1.5; 60.3x2 and 70x2. The number of pipes and their location must provide the required number of dripping points and large enough free section in the area of the distributor location. Usually for the widespread range of diameters from 273 to 800 mm, the free section is within 52 and 60 % of the column cross-section. The free section is formed by the ring between the cylindrical part of the distributor and the column wall and the section of the pipes. In the mentioned range of diameters of column apparatuses, the number of pipes is 8 to 33 as for the smaller the pipe diameter is ∅53x1.5 and for the larger - ∅70x2.

2. EXPERIMENTAL

Interesting are the possibilities of these distributors in terms of flow capacity and hence the irrigation density. This study should be related to the determination of uniformity of individual liquid jets.

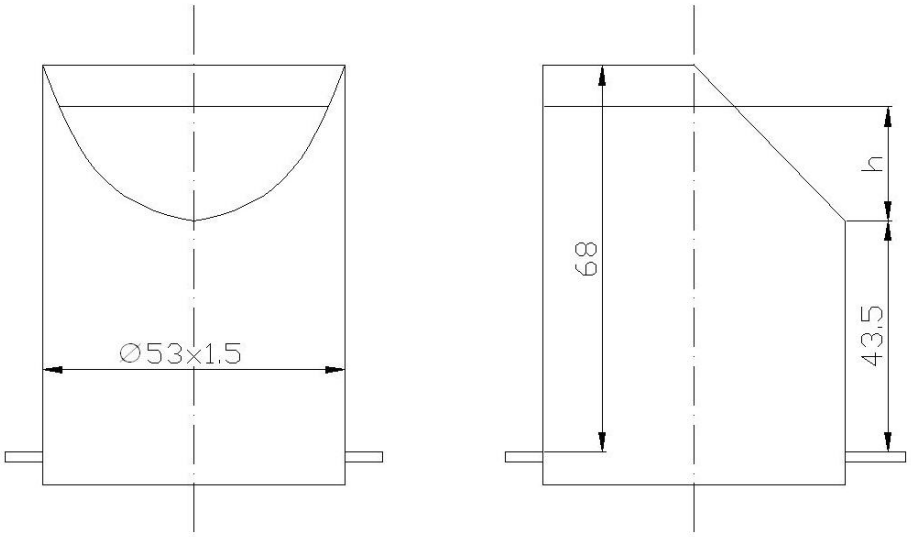


Fig. 1. Overflow pipe with beveled slots.

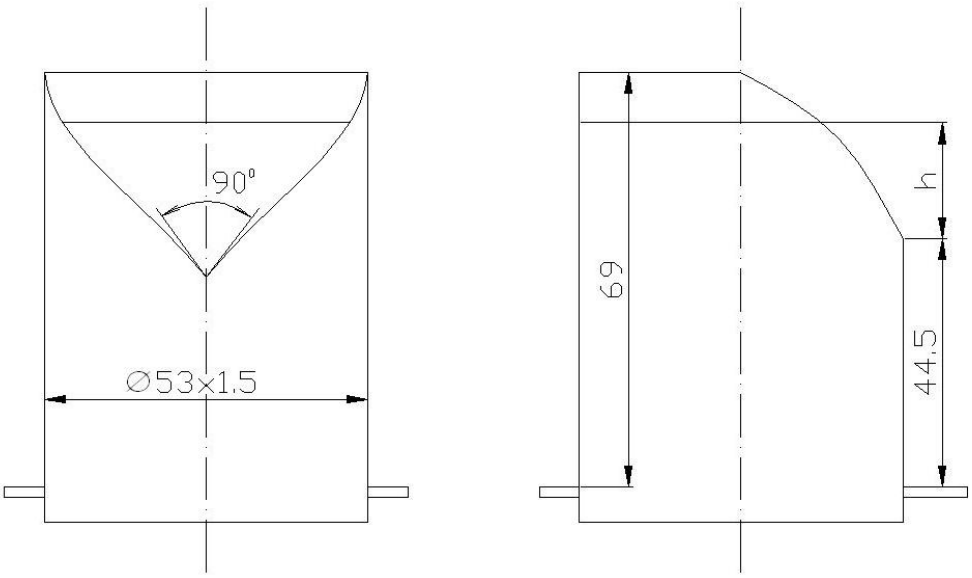


Fig. 2. Overflow pipe with triangular slots.

For this purpose were investigated distributors for a column with a diameter of 426 mm with a number of 12 distributing pipes. The pipes are ∅53x1.5, and the feeding pipe - ∅70x2. Figure 3 shows a scheme of distributor with beveled pipes with angle of 45^0. A picture of this distributor is shown on figure 4. Also was examined distributor with triangular slits with an angle on the top – 90^0 (Fig. 2).

Free section in the area of the distributor was 55 %. Experiments were held with water on experimental plant shown on Fig. 5. Liquid flow was measured with two flow meters with a range from 0 to 6 m^3/h and an accuracy of 0.1 m^3/h. Uniformity of liquid jets was determined by volumetric method with an accuracy of ±10 ml.

For distributor with beveled pipes, the experiment has shown steady operation in the range from 1 to 8 m^3/h (Darakchiev, 2011). These values depend on the height of the hydrostatic column h in the cylindrical part of the distributor above the lower end of the slots (Fig. 1). The relationship between two variables Q = f(h) (Q- flow rate of the distributor) for the most part is straightforward as the lower and upper parts have parabolic deviations (Fig. 6).

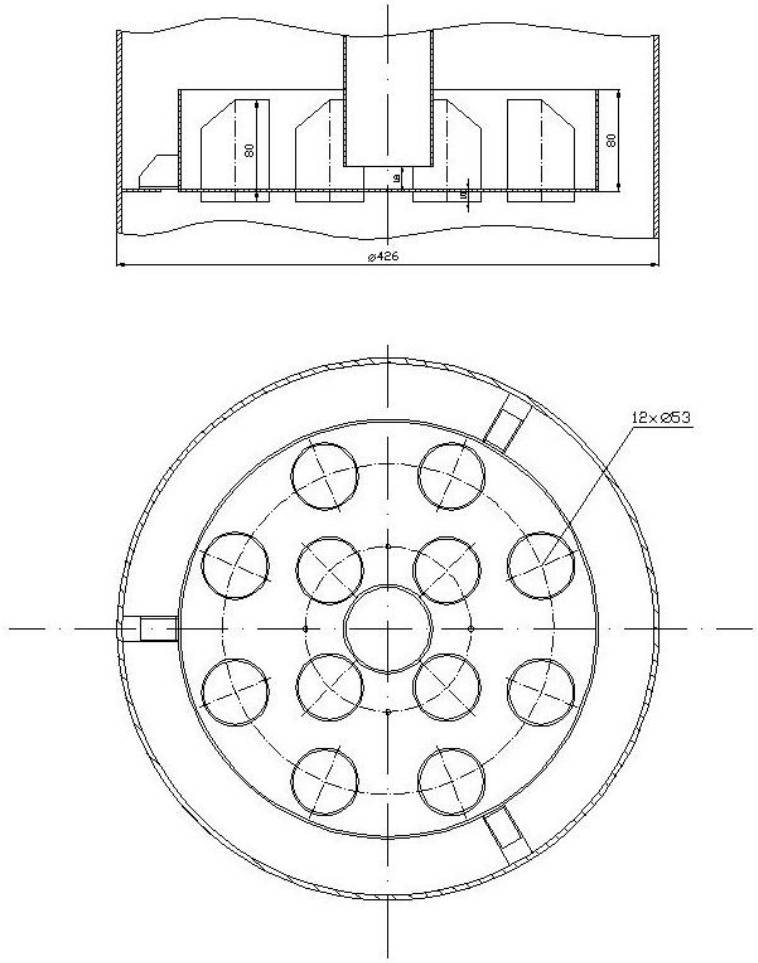


Fig. 3. Scheme of a distributor with beveled pipes with an angle of 45^0.



Fig. 4 Picture of the distributor with beveled pipes

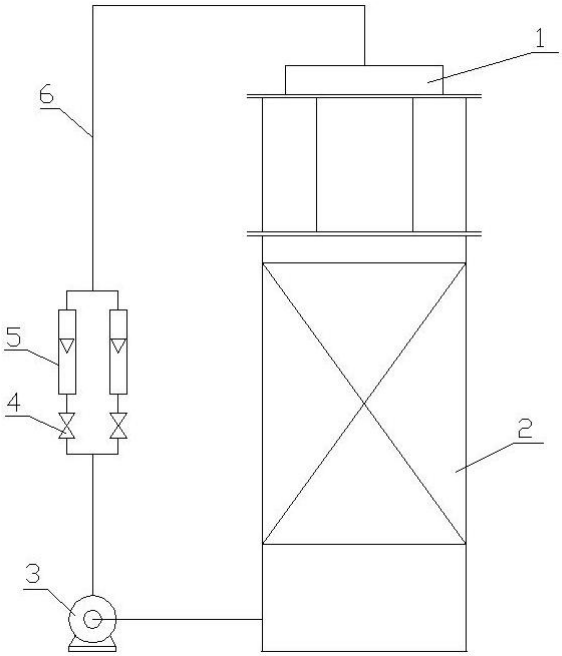


Fig. 5. Scheme of the experimental installation: 1 - liquid distributor; 2 - packed layer; 3 - pump; 4 - valve; 5 - flow meter; 6 - feeding pipe.

Measurements showed some technical irregularities in the welding of the pipes in height to the bottom of the cylindrical part of the distributor. They were within 0 and 1 mm. this showed quite large non-uniformities at low flow rates of about 2 m^3/h.

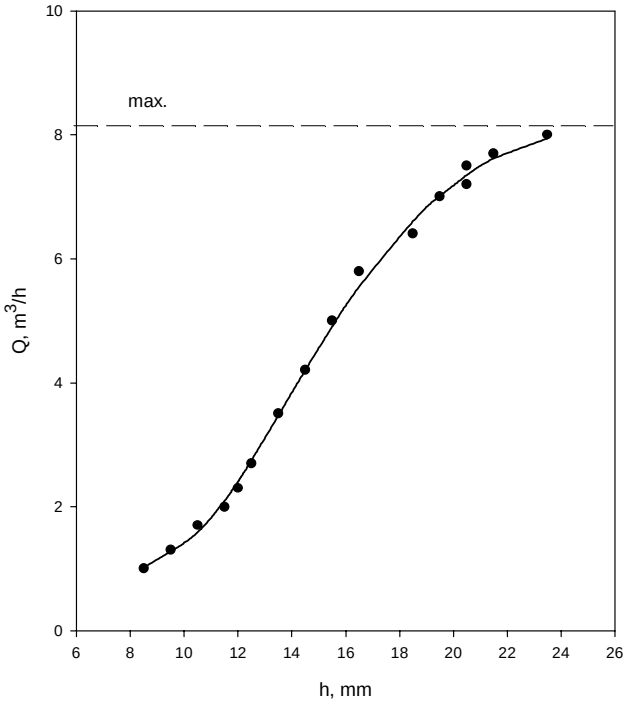


Fig. 6. Dependence of distributor flow rate and height of hydrostatic column above the lower end of the slots in a distributor with beveled pipes.

The non-uniformities are best determined by the standard error:

$$StdErr = \sqrt{\frac{i}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} \qquad (1)$$

where x_i are the measured flow rates of the jets and $\bar{x}$ is their average value and n is the number of measured jets.

Figure 7 (line 1) shows the dependence of standard error from the flow rate of the distributor. It is seen that deviation from uniformity as a result of irregularities in the development are greater for small flow rates. For flow rates greater than 2.0 m^3/h standard error is less than 0.03. Maximum flow rate of this distributor is e 8.5 m^3/h.

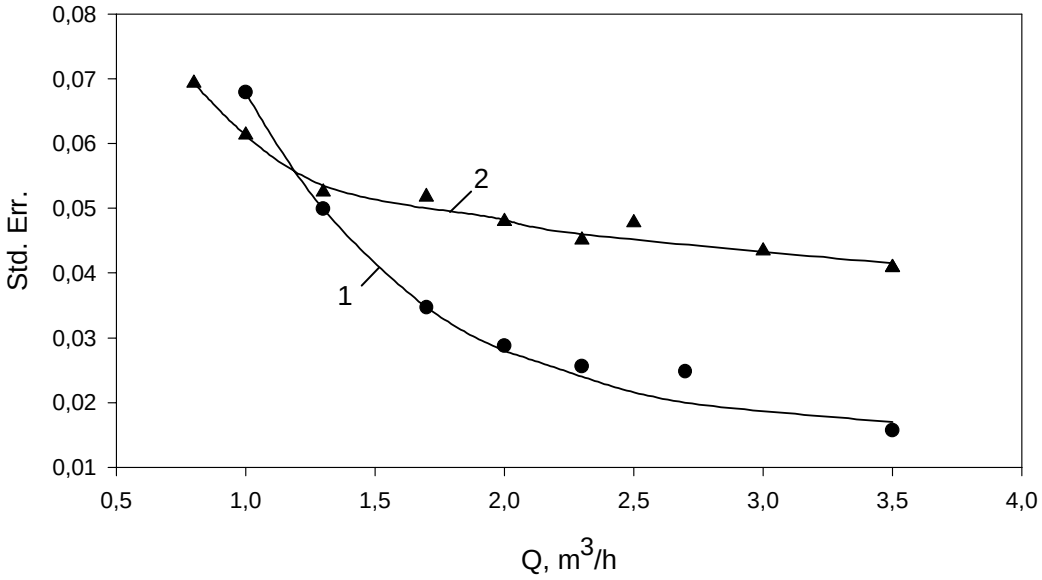


Fig. 7. Dependence of the standard error on jets flow rate of distributor with beveled pipes (line 1) and triangular slots (line 2).

It is supposed that for small sections of jets flowing for this type of distributors may be expected less standard deviation. Therefore, studies were made with distributor with triangular slots with an angle at the bottom of 90^0 (Fig. 2). Measurements here showed again that the difference in height between the bottom edge and the base of the distributor is in the range 0-1 mm.

Studies were performed on the same experimental installation using the same methodology. Figure 8 shows the relationship between the flow rate of a distributor with triangular slots and the height of hydrostatic column above the lower end of the slots (top of the angle). It is seen that this dependence generally has another character, based on the other section of the slots. Maximum flow rate of this distributor is 6.3 m^3/h.

Figure 7 (line 2) shows the standard error of liquid jets and for distributor with triangular slots. Despite the expectations can be seen, that it is bigger and in high flow rates. Therefore we believe that such slots are more inappropriate for overflowing type of distributors.

In this type of submitting of liquid in the distributor and disposal of the overflowing pipes is not observed influence of the liquid gradient on the uniformity of the jets.

Studies on this uniformity showed that greater distance between the lower end of the distributing pipes and the packing layer may lead to non-uniformity. This is due to change in the trajectory of the flowing jets. Therefore the distance above the packed layer should not exceed 50 mm.

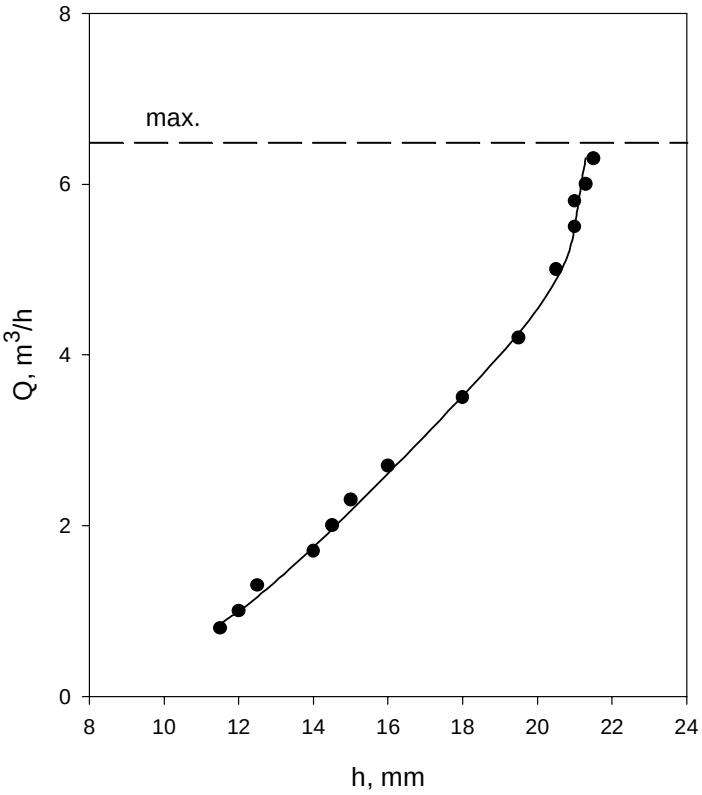


Fig. 8. Dependence of distributor flow rate and height of hydrostatic column above the lower end of the slots in a distributor with triangular slots.

Although studies have been made with one size of distributor, the results apply to other larger or smaller distributors. This relates to columns with larger or smaller diameters. The basic requirement is the characteristic size of the single pipe to be maintained (Fig.1). Hydrodynamic characteristic of one pipe is obtained as the total flow of the pattern Q = f(h) is divided by the number of pipes (in this case 12). For distributors with other sizes it is obtained as it is multiplied by the number of overflowing pipes in them.

3. CONCLUSION

The survey of two typical representatives of the overflow distributor for contaminated and viscous liquids can be made several important conclusions. Experiments were carried out with water in distributors for a column with a diameter of 426 mm. The relationship between the flow rate of the distributors and the height of liquid column above the lower end of the slots is determined. The uniformity of liquid jets is examined depending on the flow rate and is recommended this to be done with standard error below 0.03. With this accuracy the distributor with beveled pipes operates in the range from 2.0 to 8.0 m^3/h, as its maximum flow rate is 8.5 m^3/h. The distributor with triangular slots has maximum flow rate of 6.3 m^3/h, but operates with 2-3 times greater non-uniformity. Because of

this it is not recommended. The distance between the lower end of the distributor and the packing layer must not be greater than 50 mm.

The validity of this study from one size distributor to be transferred to other distributors with more or fewer pipes is justified.

REFERENCES

Darakchiev, S., Sv. Nakov, 2011, Study of overflow liquid distributor with beveled pipes, Proceedings of University of food technologies – Plovdiv, Vol. LVIII, 3, 423 – 428. (in Bulgarian)

Golovachevski, I.A., 1967, Distributors and nozzles for scrubbers for chemical industry, Mashinostroenie, Moscow. (in Russian).

Kolev, N. N., 2006, Packed bed columns for absorption, desorption, rectification and direct heat transfer, Elsevier, Amsterdam.

Sulzer Chemtech Separation Technology Brochures: Internals for packed columns (December 2003)