Mixing educator basic principle engineering essay

An educator is a device which mixes two liquids of different flow rates giving a solution of desired flow rate. Educators are made using a venturi design. It enables small pumps to circulate large volumes of tank solution. When pumping is used for solution agitation, the use of an educator will circulate four to five gallons of solution in the tank for every one gallon you pump.

Fig 1. 1: Mixing educator

Basic principle

It operates on the principle of flow dynamics pressurized fluid is accelerated through the nozzle to become a high velocity stream that entrains the tank content and intimately mixes with them. The combined stream exists the educator at a high velocity creating a flow field capable of causing additional agitation and mixing the tank contents.

Tanks have used pumps without educators for solution mixing for years. Now with the usage of educators, the efficiency has been increased. Educators reduce the energy consumption of the pump’s motors and will allow a smaller and less expensive pump to be used to perform the same job.

Tank educator’s motive fluid may come from two sources. The tank liquid may be recirculated through the educator via and external pump or a secondary fluid maybe introduced into the tank. Secondary fluid can be liquid or a gas.

Fig 1. 2: Functioning of the Educator

Usage

Tank mixing educators are widely used in many applications to effectively and efficiently mix tank solutions. They offer many benefits over other approaches and are available in many different types of styles, sizes and materials.

Tank Mixing Educators are used to agitate liquid, dissolve powdered solids in liquid, and to mix two or more liquids intimately within a tank or other vessel without the use of baffles or moving parts inside the tank.

They are used to drain flooded cellars, empty tanks and sumps or bunds.

Also used for pumping and mixing operations in oil treating systems.

De-watering sand and coal barges, Introducing anti-knock fluids and colouring matter into gasoline.

Continuous blending, Acidifying , production of emulsions, Caustic zing of oils, Mixing drilling mud

It can also be used to pump food products, sand and filter clay or activated carbon.

Tank mixing.

Educators are currently installed in the following types of re-circulating process tanks:

Plating tanks

Cleaning tanks

Phosphate tanks

E-coat paint tanks

Sludge tanks

Paint booths

Anodizing tanks

Cooling towers

Fertilizer tanks

Pulp tanks

Decorative fountains

Salt water aquariums – Reef tanks

Features

As there are no moving parts in the educator, it minimizes the maintenance expenses.

Optimum flow field enables more activity within the tank than competitive units without changing pumps.

Compact design and ease of mounting prevents the educator from interfering with other tank equipment.

The educator can be installed in a wide variety of open vessels or closed tanks.

It eliminates stratification and promotes a homogenous tank with relation to pH, temperature, solids or gas dispersion, and distribution of chemicals.

As the educator can generate a directed flow field within the fluid being mixed including viscous fluids, slurries, and suspension , it produces a unique agitation not available with other types of mixers.

Liquids of different specific gravity can be mixed easily.

It is excellent for scrubbing application.

“ In-tank” mounting eliminates the need for costly, complex mounting structures above tanks.

Benefits

Ensures homogeneous fluid mix throughout the tank.

More thorough mixing results in solution uniformity such as temperature, pH level, solids/gas dispersion and chemical distribution which helps in ensuring product and process quality.

Eliminates sludge build-up and reduces the tank cleaning time.

Enables the usage of small pumps to circulate large volumes of tank solution.

Smaller pumps are less costly to purchase- Units are small in relation to the work they do and cost is correspondingly low.

Smaller pumps are less expensive to operate.

Simplifies operation and maintenance – as there are no moving parts it eliminates the need for compressed or blower air and the resulting oil contamination and/or ventilation problems.

Self-Priming – Educators are self-priming. They operate equally well in continuous or intermittent service.

No Moving Parts – Educators have a very simple design and are reliable. There are no moving parts to wear or break in a basic educator. Even when equipped with accessories such as regulating spindles, snap valves, float mechanisms only a little maintenance is required.

Corrosion and Erosion Resistant – Because they can be made of practically any workable material, or coated with corrosion-resistant materials, educators can be made highly resistant to the actions of the liquids handled or the environment in which located.

Educators can be used in hazardous locations where electrically operated alternates would require explosion proofing at considerable cost . Hence they are very safe.

Automatically Controlled – Units can be adapted for automatic control by means of a pressure liquid regulating spindle or a snap-valve and float arrangement.

Easy to Install – Connections can be made to suit your piping requirements. Little space is required to accommodate units and they are normally so light in weight they can be supported by the piping to which they are attached.

CHAPTER 2

TYPES OF EDUCATORS

Water jet educators

The Water Jet Educator is a type of ejector which utilizes the kinetic energy of a pressurized liquid to entrain another liquid, mix the two, and discharge the mixture against a counter pressure. These types of ejectors are used throughout industry for pumping, mixing and various other operations.

During the operation, the pressure liquid enters the educator through the pressure nozzle producing a high velocity jet. This jet action creates a vacuum in the line which causes the suction liquid to flow up into the body of the educator where it is entrained by the pressure liquid. Both liquids are discharged against back pressure after being thoroughly mixed in the throat of the educator . The body with no pockets permits the pressure liquid to move straight through the educator and reduces the possibility of solids in the suction material collecting and clogging. In the suction chamber the pressure drop held to a minimum.

Advantages:

Low initial cost.

Self-priming

Easy to install

Little or no maintenance required

No moving parts

No electrical connections required

Fig 2. 1: Water Jet Educators

Automatic educators

Automatic Water Jet Educators are used to pump out sumps where liquid accumulates slowly but must be evacuated when it has reached a predetermined level. As the liquid in the sump (basin, tank, cellar, bilge, etc.) is accumulated, it raises the ball float until the upward action of the float opens the snap-acting valve, admitting motive fluid into the pressure connection of the educator.

The jet action of the motive fluid creates a vacuum in the educator and entrains the suction fluid, discharging both the fluids then. The sump level drops to a point where the snap acting valve shuts off , as the suction fluid is pumped out. Pumping action does not take place until the sump again fills to the operating level.

Advantages:

Automatic operation.

No electrical connection required.

Only 2 moving parts- snap-acting valve and ball float.

The full assembly is so compact it can be installed in tanks as small as 13 1/2″ diameter.

Condensate and mixing educator

Fig 2. 3: Condensate Educator These educators are designed to mix two liquids in various proportions in operations where the pressure liquid is the greater proportion of the mixture.

In operation, the pressure liquid issues from the nozzle at high velocity and entrains the suction liquid. The high turbulence in the throat of the educator mixes the two liquids, blending and emulsifying thoroughly and completely. Colloidal suspensions are produced.. The pressure drop between the pressure liquid and the discharge should be at least 10 psi for adequate mixing, and the difference between the discharge pressure and the suction pressure should not exceed 75% of the difference between the operating pressure and the suction pressure.

Applications:

Removal of condensate

Mixing gasoline

Diluting acids and alkali

Blending and proportionating chemical solutions

Tank mixing educator

It is done by mechanical agitation. They are used to agitate liquid, dissolve powdered solids in liquid, and to mix two or more liquids intimately within a tank without using baffles or moving parts inside the tank.

Normally, the tank is filled by means of the educators. Mixing occurs as soon as

the level of liquid in the tank covers the suction of the educator. In addition to the

mixing obtained between the fluids in the educator, the jet action

of the discharge from the educator serves to agitate the tank thus preventing stratification.

Hopper equipped educator

Hopper-Type Educators are made for handling slurries or dry solids in granular form and are used for ejecting sludge's from tank bottoms, for pumping sand from filter beds and for washing and conveying granular materials.

Typical materials handled include: borax, charcoal, diatomaceous earth, lime, mash, fly ash, rosin, rock and granulated salt, sand, dry sawdust, light soda ash, dry sodium nitrate, powdered sulphur, wheat and many others.

Fig 2. 5: Hopper Equipped Educator

Advantages:

no moving parts

easy design (made from machine able or cast able materials)

no maintenance required

Water jet sand educator

Water Jet Sand and Mud Educators are used in pumping out wells, pits, tanks, or sumps where there is an accumulation of sand, mud, or other material not easily handled by the standard educator. Heavy sludge residue can be handled easily from refining operations. They have an open suction and are designed to be submerged in the material being handled. The pressure liquid, passing through the nozzle, produces a high velocity jet which entrains the sludge or mud. Discharge then takes place through a vertical pipe or hose.

Annular Multi-Nozzle Water Jet Educator

Annular Multi-Nozzle Water Jet Educators are designed to handle solids and semi-solids. Water is introduced though the nozzles on the periphery. The pressure water creates a vacuum which draws in and entrains the material being handled.

Fig 2. 7: Multi -nozzle Water Jet Educator.

Advantages:

Highest efficiency

Low discharge

High air handling capacities.

Plastic tank educators

There are 2 types: PPL (Glass Reinforced Polypropylene) and PVDF (KYNAR®). Educator circulation ratio of supply to discharge is1: 5

Polypropylene (PPL)

It is a polymer prepared catalytically from propylene which differs from HDPE by having an isotactic replacement of a hydrogen atom by a methyl group on alternate carbon atoms in the main chain. Although largely unreactive chemically the presence of the methyl groups makes Polypropylene slightly more susceptible to attack by strong oxidizing agents than HDPE.

Quick Facts:

Maximum Temperature: 275°F 135°C

Minimum Temperature: 32°F 0°C

Melting Point: 338°F 170°C

Tensile Strength: 4, 500 psi

Hardness: R95

UV Resistance: Poor

Translucent , Rigid

Specific Gravity: 0. 90

Advantages:

High temperature resistance

Excellent resistance to dilute and concentrated acids, alcohols , mineral oils .

Good resistance to aldehydes, esters, aliphatic hydrocarbons.

Limited resistance to aromatic and halogenated hydrocarbons.

KYNAR (PVDF):

Is a high molecular weight thermoplastic polymer with excellent chemical inertness.

Quick Facts:

Melting point : 352° F

Heat deflection at 66 psi (ASTM D 648) : 300° F

Heat deflection at 264 psi (ASTM D 648) : 235° F

Maximum serving temperature for short term : 340° F

Maximum serving temperature for long term : 285° F

Thermal conductivity (ASTM C 177) : 1. 32 Btu-inch/hr-ft~2- ° F

Specific heat : 0. 23 Btu/lb- ° F

Coefficient of linear thermal expansion (ASTM D 696) : 7. 1×10~5

Applicable temperature range for thermal expansion : 50-300° F

Advantages:

Highly resistant to oxidizing agents and halogens.

Completely resistant to aliphatic aromatics, alcohols, acids and chlorinated solvents.

Resistant to most acids and bases.

Mechanically strong

Thermally stable

Resistant to low temperatures

Self-extinguishing

Non-toxic

High dielectric strength

Stable to ultraviolet and extreme conditions.

CHAPTER 3

CUSTOM TANK EDUCATOR MANIFOLD DESIGN

Manifold designs can be customized for various applications. Shown below is a type of design used by various industries for a number of applications. The main advantage of such a design is that it is highly efficient.

Fig 31: Manifold Design

CHAPTER 4

TYPES OF COATING

4. 1 Fusion Bonded Coating

A single coating offers excellent abrasion resistance that it can withstand the punishment of sand blasting. 5-3 mils thick coating can be applied.

Fig 4. 1

Machine able

Excellent Abrasion Resistance

300° F Continuous Service

Impact Resistant

Withstands Saltwater Environment

Self-Lubrication

Electrical Insulation

4. 2 Edathon Coating

This coating is applied by electrostatic powder spray or fluidized powder bed. Its strength, radiation resistance, wear resistance and creep resistance are greater than those of other fluoropolymers such as PTFF, FEP or PEA.

Excellent Corrosion Resistance

Excellent Abrasion Resistance

300° F Continuous Service

Good Non-Stick Characteristics

Excellent Dielectric Insulation

Resistance to radiation

High chemical and temperature resistant

Fig: 4. 2 Edathon Coating

Edathon Coated Tank Nozzle

CHAPTER 5

DESIGHNING OF AN EDUCATOR

5. 1 Materials of Construction

Carbon steel

316 SS

Bronze

PVC

PPL

PVDF

Titanium

Teflon

Fiberglass

5. 2 Design and Dimensions

As it is one of the most cost-efficient and effective ways for manufacturers to get the best performance from their re-circulating process tanks, it is easy to see why tank mixing educators are the design of choice for all major manufacturers.

To obtain optimal mixing performance, it is important to understand these product differences and how to specify and install educators.

Liquid mixing educators consists of a nozzle, a venture and a body to hold parts in their relative positions and to provide a suction chamber.

Additional accessories such as regulating spindles, snap values and floats for controlled agitation can also be added to the design.

Liquid jet educators are manufactured in a variety of types and sizes as well as materials . The standard type are:

264 type-0. 5 inch to 6 inch

266 type-0. 5 inch to 6 inch

242 type-0. 5 inch to 24 inch

Before determining the correct type and size of the educator certain variables such as pressure, temperature, density required , entrainment rates and operating conditions must all be considered.

Fig 5. 2 Design

Fig 5. 3: Dimensions of an Educator

Table 1: Types of educators

Dimension A

Dimension B

Dimension C

Dimension D

Size

Max Free Passage

IN

(mm)

IN

(mm)

IPS

(mm)

IN

(mm)

3/8″

0. 2656

5. 00

(127)

2. 50

(64)

3/8 MNPT

(10)

. 50

(12)

3/4″

0. 4062

7. 25

(184)

3. 69

(94)

3/4 MNPT

(20)

. 81

(20)

1-1/2″

0. 5625

10. 88

(276)

5. 50

(140)

1-1/2 FNPT

(40)

1. 12

(28)

2″

0. 8125

14. 50

(368)

7. 69

(195)

2 FNPT

(50)

1. 62

(41)

3″

1. 1875

22. 00

(559)

11. 75

(298)

3 FNPT

(80)

2. 50

(63)

4″

consult

25. 00

(635)

12. 00

(305)

4 FNPT

(100)

3. 00

(76)

6″

consult

35. 00

(889)

25. 00

(635)

6 FNPT

(150)

4. 50

(114)

CHAPTER 6

WORKING

As the motive liquid enters the tank contents into the suction openings , a thorough mixing takes place within the unit before being discharged. Further mixing and agitation is provided by the discharge flow within the tank. The motive fluid is drawn from the tank.

Requirements for Mixing:

Minimum inlet pressure – 10 PSIG

Maximum inlet pressure – 100 PSIG

For efficient operation the inlet pressure should be within the range of 20 to 70 PSIG.

As the solution is pumped through an educator's orifice, a low pressure area is created that acts to pull solution from behind the bell shape of the educator and direct the solution out of the bell end. For each gallon of solution that is pumped through the educator, five gallons of additional solution is circulated within the tank.

Fig 6. 1: Working

CHAPTER 7

GUIDELINES FOR SPECIFYING MIXING EDUCATORS

Step 1: Determine the needed turnover rate:

How many times per hour does the tank solution need to circulate through the educators? The answer is application dependent and based on solution viscosity and the number of particulates. A general rule of thumb is 20 turnovers per hour.

Some typical guidelines are given below:

- Plating and rinsing tanks: 10 to 20 turnovers per hour although (some plating tanks may require more than 30 turnovers per hour).

- Cleaning tanks: at least 10 turnovers per hour

- Heavily soiled tanks: up to 20 turnovers per hour

- Critical cleaning tanks: more than 20 turnovers per hour.

Step 2: Calculate the needed flow rate:

Multiply the turnover rate by the tank volume and then divide by 60.

Example:

Let, turnover rate/hr. = 10;

Tank volume= 800 gallons

Then 10 x 800= 800 gph

Now 8000 ÷ 60 = 133. 3 gpm

Step 3: Determine the needed inlet flow rate:

As educators mix at a 5: 1 ratio, take the gallons (litters) per minute and divide by 5.

Example:

133. 3 ÷ 5 = 26. 7 gpm

Step 4: Determine the educator size required with the help of the performance table.

Step 5: Determine how many educators you need:

Multiple educators may be used to obtain the needed flow rate or to prevent stagnation which is a common problem in square and rectangular tanks. In general, using multiple educators in larger tanks will provide more effective mixing than one centrally located educator.

Step6: Determine the educator placement:

As little agitation occurs below the level of the educator, in order to obtain maximum liquid turnover, the educators should be positioned as close as possible to the bottom of the tank.

If settling cannot be tolerated, install the educators 1′ (. 3 m) above the bottom of the tank.

Educators should be placed so the flow field will reach the farthest and highest liquid level at the opposite side of the tank.

Mounting adapters are available to direct flow as needed.

The educators should be placed 12″ (. 3 m) apart for uniform and even agitation.

CHAPTER 8

OBSERVATIONS AND CALCULATIONS

Mathematical Model

The educator designed here is made up of fiberglass and is based on the operating data for type 264. For the test the eductant used is water and the suction fluid used is blue ink. Eductant pressure, suction head and discharge pressure were varied and the eductant and suction flows were measured. For example: The following table shows the values calculate when using a . 48″ educator, with 15 PSI pressure available. The flow rate through the nozzle will be 25 GPM-The total amount circulated will be 125 GPM.

Table 2: Observations

Size – orifice and NPT connection

Pressure (PSI)

8

10

15

20

25

30

35

40

Nozzle Flow (USGPM)

. 20

1/4 NPT

3. 2

3. 5

4. 3

5. 0

5. 5

6. 1

6. 6

7. 0

. 30″

3/8″

6. 2

7. 5

9. 2

10. 7

11. 9

13. 1

14. 1

15

. 37″

3/4″

11. 8

13. 5

17

19

21

23

25

27

. 48″

1″

18. 7

21

25

29

33

36

39

42

. 62″

1 1/2″

—

33

41

47

53

58

63

67

8. 2 Graphical Analysis

The graph for flow vs. pressure drop was calculated for different diameters is show below:

Fig 8. 2 : Graphical Analysis (Flow Vs Pressure Drop)

8. 3 Performance Table

Table 3: Performance and observation

The values for the designed educator we measured and tabulated below:

Size IPS

Pressure Difference, PSI

10

20

30

40

50

60

70

80

90

100

120

140

Motive Flow (GPM)

7. 1

10. 0

12. 3

14. 2

15. 8

17. 4

18. 7

20. 1

21. 3

22. 4

24. 6

26. 5

3/8″ MNPT

Outlet Flow (GPM)

35

50

61

71

79

87

88

90

91

92

94

96

Max. Plume Length

4

8

12

16

22

29

36

43

50

58

72

86

Table 4: Performance Study

The estimated values for the educators of various other sizes are tabulated below:

3/4″ MNPT

Motive Flow (GPM)

15. 4

21. 8

26. 7

30. 8

34. 5

37. 8

40. 8

43. 6

46. 3

48. 8

53. 4

57. 7

Outlet Flow (GPM)

77

109

134

154

172

189

192

195

197

200

204

209

Max. Plume Length (FT)

5

11

17

24

33

42

53

64

74

85

106

127

Motive Flow (GPM)

30. 8

43. 6

53. 4

61. 6

68. 9

75. 5

81. 5

87. 2

92. 5

97. 5

107

115

1-1/2″ FNPT

Outlet Flow (GPM)

154

218

267

306

345

378

384

389

395

400

409

417

Max. Plume Length (FT)

7. 5

16

24

34

46

60

75

90

105

120

150

180

2″ FNPT

Motive Flow (GPM)

61. 6

87. 2

107

123

138

151

163

174

185

195

214

231

Outlet Flow (GPM)

308

436

534

616

689

755

767

778

789

799

818

835

Max. Plume Length (FT)

11

23

34

48

65

85

106

12

148

170

212

255

Motive Flow (GPM)

142

201

246

283

317

347

375

401

426

449

491

531

3″ FNPT

Outlet Flow (GPM)

708

1, 003

1, 228

1, 417

1, 585

1, 737

1, 764

1, 790

1, 815

1, 836

1, 880

1, 920

Max. Plume Length (FT)

16

34

51

73

99

129

161

193

225

257

322

386

4″ Flanged

Motive Flow (GPM)

246

349

427

493

551

604

652

698

740

780

856

920

Outlet Flow (GPM)

1, 232

1, 744

2, 136

2, 448

2, 760

3, 024

3, 072

3, 112

3, 160

3, 200

3, 272

3, 336

Max. Plume Length (FT)

22

41

60

95

132

164

196

228

260

295

360

424

6″ Flanged

Motive Flow (GPM)

493

698

854

986

1, 102

1, 208

1, 304

1, 395

1, 480

1, 560

1, 712

1, 840

Outlet Flow (GPM)

2, 464

3, 488

4, 272

4, 896

5, 520

6, 048

6, 144

6, 224

6, 320

6, 400

6, 544

6, 672

8″ Flanged

Motive Flow (GPM)

986

1, 395

1, 709

1, 971

2, 205

2, 416

2, 608

2, 790

2, 960

3, 120

3, 424

3, 680

Outlet Flow (GPM) (FT)

4, 928

6, 976

8, 544

9, 792

11, 040

12, 096

12, 384

12, 448

12, 640

12, 800

13, 088

13, 344

10″ Flanged

Motive Flow (GPM)

1, 971

2, 790

3, 418

3, 942

4, 410

4, 832

5, 216

5, 581

5, 920

6, 240

6, 848

7, 360

Outlet Flow (GPM)

9, 856

13, 952

17, 088

19, 584

22, 080

24, 192

24, 576

24, 896

25, 344

25, 600

26, 176

26, 688

CHAPTER 9

CONCLUSION

This report consists of the basic principle, the design and a performance study of the mixing educator. Chapter 1 is basically an introduction to the topic and summarizes the principle, applications, features and advantages of the educator. Chapter 2 summarizes the different types of educators used in the industries today. Chapter 3 shows the different custom made designs. Chapter 4 shows the types of coatings used on the educators and its advantages. Chapter 5 summarizes the designing of the educator. Its consists of the educators of different dimensions and their construction. Chapter 7 summarizes the guidelines for specifying the educator. Chapter 8 consists the mathematical model and the performance study.

Tanks have used pumps without educators for solution mixing for years . Now with the usage of educators , the efficiency has been increased . Educators reduce the energy consumption of the pump's motors and will allow a smaller and less expensive pump to be used to perform the same job

CHAPTER 10

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