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GOVERNMENT OF INDIA
BHABHA ATOMIC RESEARCH CENTRE
Chemical Engineering Division

Ref: BARC/ChED/PES/SD/2017/08 **Date: 03/01/2017**

Sub: Invitation to submit your quotation

On behalf of the President of India, Head, Chemical Engineering Division, Bhabha Atomic Research Centre invites lowest quotation in sealed envelope for the work given below as per the technical specifications enclosed herewith.

S. No.	Description of Job	Completion Period
1	Fabrication, supply and installation of "controlled gas flow line up and countercurrent extractors"	60 days

The terms and conditions are given below:

1. **Qualifying criteria for bidders**

1.1 Firms willing to bid for above mentioned job shall have been vetted by Security Section of BARC.

1.2 All the supervisors and workers should have valid Police Verification Certificate (PVC). The list of manpower available with firm shall be submitted along with their details of PVC.

1.3 The past experience of the firm in similar nature in BARC/DAE shall be made available with Work Order copy and satisfactory completion certificate from the user. Also the list on of going jobs inside BARC premises with expected completion period shall be provided.

1.4 Specification of the Jobs are as per annexure-I. Interested bidders shall contact the undersigned on Phone No. 25594192 (Ext. No. 24192) with above mentioned details for getting the Detailed Tender Specification.

2. The quotation envelope shall be superscripted with **Description of the job and the Tender Ref. No.,** mentioned above.

3. The complete quotation shall reach the following address on or before **23/1/2017** by **Registered Post/ Speed post.** The quotations will be opened on the next working day in Chemical Engineering Division, BARC between 1400 to 1600 Hrs.

Head,
Chemical Engineering Division,
Bhabha Atomic Research Centre,
Trombay, Mumbai- 400 085

4. **Printed Letter Head**: Quotation should be printed on the letter head; computer generated quotation is not valid.
5. **Validity of the Offer**: Validity of the offer shall be 90 days from date of opening of quotation.
6. **Guarantee**: Vendor shall have to give guarantee of the quality and workmanship of work done for the period of 12 months from the date of completion of the work.
7. **Offer of Firm:** Offer of those firms, who do not submit their quotation as per the details given in the technical specification and incomplete quotations in any respect shall not be considered.
8. The department reserves right to extend the date of opening the quotations.
9. **Payment Terms:** Accounts Division BARC Mumbai-400085 shall make full and final payment only after submission of the satisfactory work completion certificate issued from the undersigned, bill, guarantee certificate, delivery challan and advanced stamped receipt. No advance is admissible.
10. **Income Tax Recovery Clause:** Income tax @ 2% will be deducted from the bill.
11. If any of the employee, consultant, or partner of the company is an Ex BARC employee, the same must be stated in the quotation clearly.
12. **Penalty:** Any delay which attributable to the contractor is liable for penalty @ 0.5 % per week (max 5 %) to be imposed on contractor.
13. **ST/VAT/PAN Number:** Quotation shall consists of Sales Tax Registration Number registered with local ST authority /CST authority, PAN number of the firm, service tax registration number etc.
14. **Quantity Variation Clause:** Quantity variation of ± 10% is possible during the execution of the job. Actual payment shall be made based on the actual work carried out by the contract or after completion of entire job.
15. **Safety & Security Rule:** The vendor shall follow all the safety procedures as per the normal industrial practice during the execution of the job at site. Any mishap occurring during the work due to unsafe workmanship shall be the vendor's liabilities. Security and transportation rules at BARC, Trombay premises shall be strictly followed.
16. The buy-back arrangement should be followed wherever applicable for the disposal of scrap/garbage, redundant stores and debris etc. The work completion certificate will be issued only after clearing all such materials from the work premises in BARC.

17. Confidential clauses:

1. Confidentiality: No party shall disclose any information to any third party concerning matters under this contract generally. In particular, any information identified as "Proprietary" in nature by the disclosing party shall be kept strictly confidential by the receiving party shall not be disclosed to any third party without the prior written consent of the original disclosing party. This cause shall apply to the sub-contractors, consultants, advisors, or the employees engaged by a party with equal force.
2. All the drawings if supplied along with or in relation with this tender must be returned.
3. "Restricted Information" categories under section 18 of the Atomic Energy Act, 1962 and "Official secrets" under Section 5 of the Official Secret Act, 1923: Any contravention of the above mentioned provisions by any contractor, sub-contractor, consultant, advisor or the employee if a contractor will invite Penal consequences under the aforesaid legislation.
4. Prohibition against use of name of BHABHA ATOMIC RESEARCH CENTRE without permission for any publicity purpose. The contractor or sub-contractor, consultant, advisor or the employees engaged by the contractor shall not be used for any public purposes through any media like press, TV or internet, without the prior written approval of BARC.

18. The quotation also will declare clearly as to whether the bidder has any relation in BARC or the bidder himself is an ex-employee of BARC or the bidder has an ex-employee of DAE on his pay rolls.

(Snehasis Dutta)
Scientific Officer – C
Chemical Engineering Division
Bhabha Atomic Research Centre

Annexure

Fabrication of "Controlled gas flow line up and countercurrent extractors"

The scope of work involves fabrication, supply and installation of the following,

1) Line up for constant and continuous gas flow (2 designs). These will be used to inject gas streams at controlled flow rates in existing packed bed reactor.

2) Plate frame type micro structured (i.e. intensified) contactors (4 designs). These contactors will be used to study feasibility of intensified liquid-liquid and gas-liquid extraction processes.

The detailed technical specifications are listed below.

1) Line up for constant and continuous gas flow

The vendor is required to supply SS 1/8 inch line up which is required to ensure a constant flow of gas to an existing system. Two different setup are required to be supplied which are detailed below.

Setup-1:

This essentially involves a line up (SS 316 1/8 inch tube) which will be used to inject gas at a fixed rate in an existing setup (which is a packed bed reactor). Service gas is oxygen which will be used from cylinders. The schematic diagram of the line up is shown in figure 1. As can be seen the setup involves the following which needs to be supplied by the vendor. All these individual components must be of reputed make.

1) Gas regulator (1 No, dual gauge, SS 3.16, maximum pressure rating of 150 bar, temperature rating 50 ^{0}C)

2) Needle valves (3 No., SS 316, maximum pressure of 100 bar, temperature 50 ^{0}C)

3) Non return valve (1 No., SS 316, maximum pressure of 100 bar, temperature 50 ^{0}C)

4) Filter (1 No., SS 316, Maximum pressure of 100 bar, temperature 50 ^{0}C)

5) Mass flow controller along with transmitter/indicator (O_2 gas, 0-200 mL/min, 100 bar, room temperature)

All fittings used in the line up must be ferrule type and the vendor must ensure that the lineup is leak tight. The vendor must provide all the associated fittings of reputed make. The maximum working pressure of the system is 100 bar and the maximum operational temperature will be 50 ^{0}C. MoC of all components should be SS 316.
The entire setup is to be mounted on a table/stand which also needs to be supplied by the vendor. All the components must be properly fastened to the table provided.

Setup-2:

This is also similar to setup 1 except that two such line ups are envisaged-one for oxygen and other for hydrogen. SS 316 1/8 inch tubes which will be used to inject gases (H2 and O2) at controlled rates which will be mixed in a T junction (SS 316, 1 mm characteristic dimension). The gases will be supplied from respective cylinders. The schematic diagram of the line up is shown in Fig. 2. As can be seen the setup involves the following which needs to be supplied by the vendor. These components must be of reputed.

1) Gas regulator (2 No., dual gauge, SS 3.16, maximum pressure rating of 150 bar, temperature rating 50 ^{0}C)
2) Needle valves (6 No., SS 316, maximum pressure of 20 bar, temperature 50 ^{0}C)
3) Non return valve (2 No., SS 316, maximum pressure of 20 bar, temperature 50 ^{0}C)
4) Filter (2 No., SS 316, maximum pressure of 20 bar, temperature 50 ^{0}C)
5) 1 mm SS 316 T junction

The mass flow controllers shown in figure 2 need not be supplied by the vendor. All fittings used in the line up must be ferrule type and the vendor must ensure that the line up is leak tight. The vendor must provide all the associated fittings of reputed make. The maximum working pressure of the system is 20 bar and the maximum operational temperature will be 50 degree C. MoC of all components should be SS 316. The entire setup is to be mounted on a platform which can be placed on a table top. All the components must be properly fastened to the platform provided.

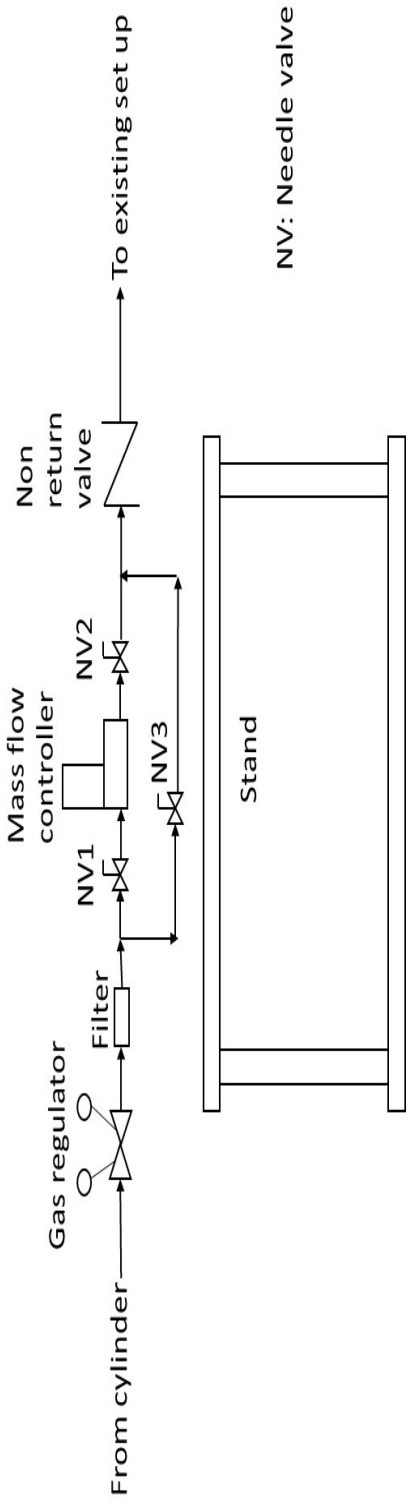


Figure 1: Schematic drawing ofsetup 1.

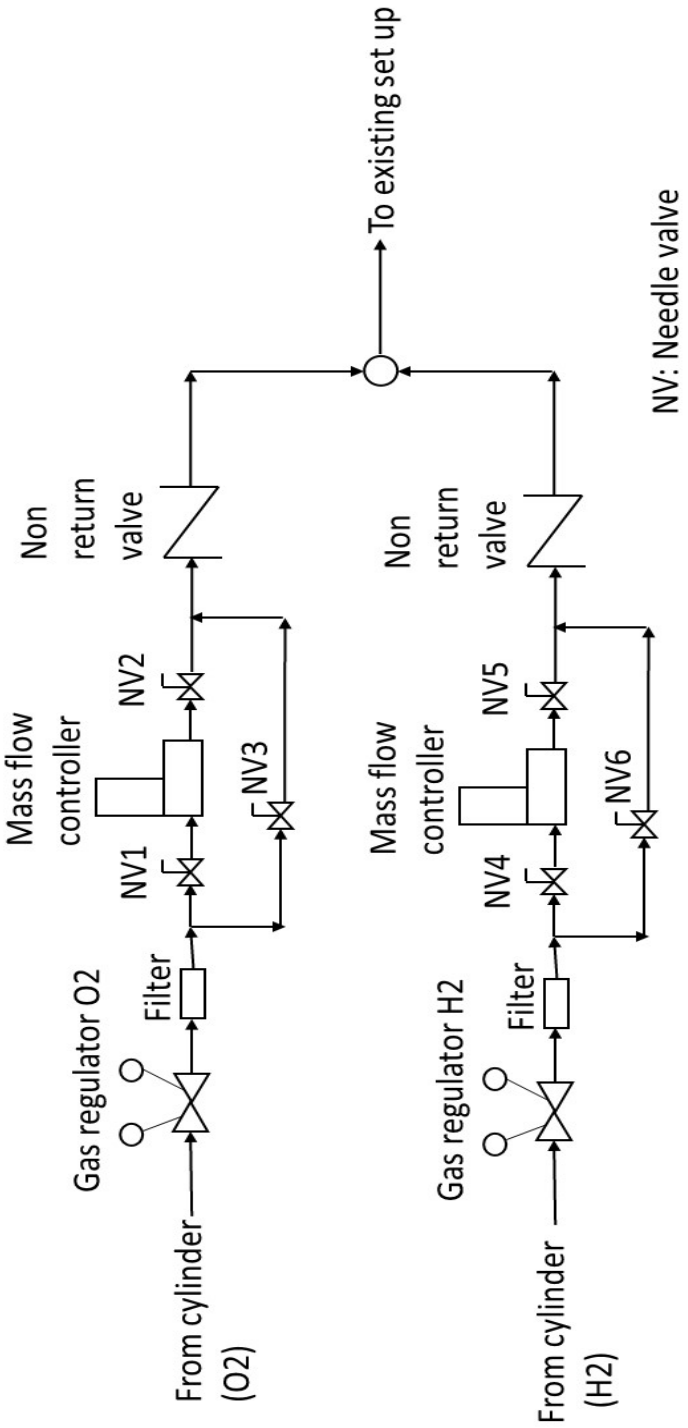


Figure 2: Schematic drawing of setup 2

2) Counter current extractor

This part of the supply essentially involves fabrication, supply and installation of plate and frame based micro contactors. The details are mentioned below.

2.1) Counter current liquid-liquid/ gas-liquid extractor

This design allows counter current movement of a heavy (continuous) phase from top to bottom and a lighter (dispersed) phase from bottom to the top. The cavities through which this counter current movement is attained is in the form of a slit with metal plates on either side. The characteristic gap between these plates is maintained as 0.8 mm and 1 mm. This gap is maintained at a specific value using spacers (frame) of specific thickness. When the plates and frames are pressed against each other (using end plates on either side), a device is obtained having one of its dimensions in micron range. The overall design of the device is shown in Figure 3. The mechanism which allows the countercurrent flow to occur is the design of the dispersed phase distributor, which alternately feeds the dispersed (lighter) phase while there exists provision for outflow of the continuous phase in between two consecutive feed sections. There is also a provision for distribution of the continuous (heavier) phase. Thus, the overall device comprises of three parts-plate frame section, dispersed phase distributor and continuous phase distributor.

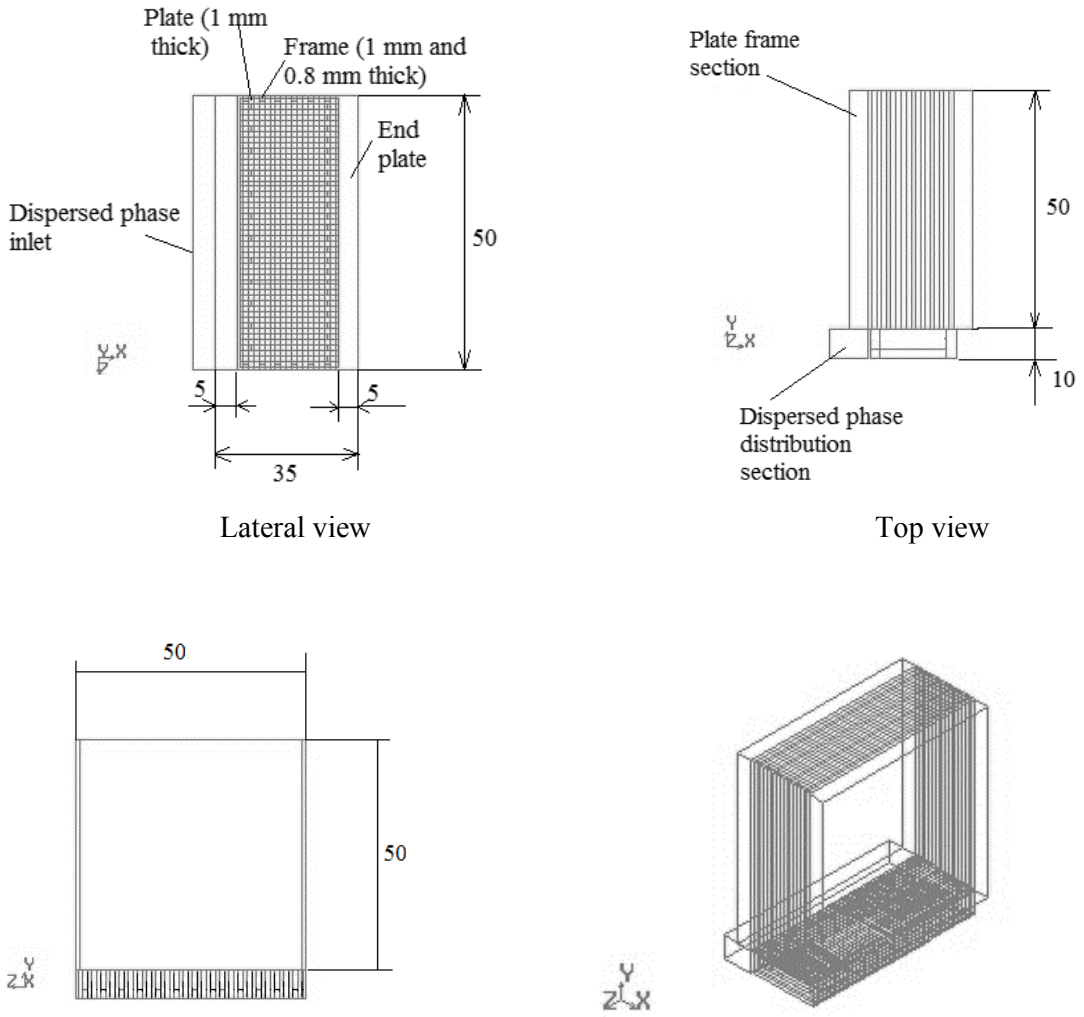
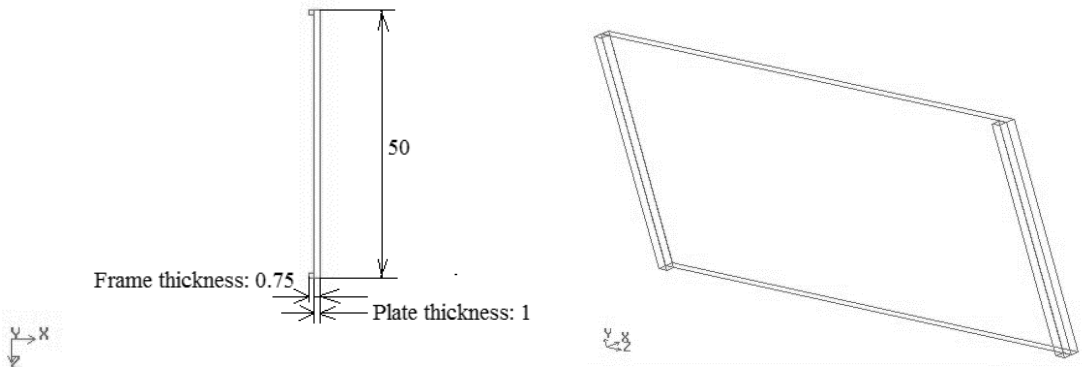


Figure 3: Detailed drawing of overall set up

a) Plate and frame section

This section essentially comprises of the plates and the frames that separate the plates from each other and form the slit. The dimension of a typical plate is 50 mm x 50 mm. Thickness of the plates is 1 mm. Frames essentially comprises of two vertical strips (50 mm x 5 mm) (not connected with each other) of two different thickness – 1 mm and 0.75 mm. Thus one plate and two vertical strips (frame in this case) comprise a unit flow cell. This is shown in Figure 4. In all there will be 12 slits i.e. 12 plates and 12 frames (12 each of 1 mm thickness and 0.75 mm thickness). As each frame essentially has two vertical stripes the vendor should supply 24 such strips. MoC of all components should be SS 316. In addition, there will be two end plates (50 mm x 50 mm) made of SS 316 of 5 mm thickness. The plates, vertical strips (frame) and the end plates should have through holes for

accommodating tightening screws (minimum of 5 on each lateral side) which will hold all these components together. Provision of gaskets/seals must also be kept such that there is no leakage through any gap in between the plates and frames. MoC of the gaskets/seals used should be viton.



Top view Isometric view

Figure 4: Detailed drawing of a unit flow cell composed of 1 set of plate and frame

b) Dispersed (lighter) phase distribution section

This section is also composed of plate and frame pressed against each other by tightening screws/bolts. On top of this section the plate and frame section is placed. The alignment of the plates of this section is perpendicular to that of the plate and frame section. This ensures that each slit of the plate and frame section sees a large assortment of plates and frames of the dispersed phase distribution section. This is clearly shown in Figure 3 (top view) which clearly shows the grid like appearance once the plate and frame section is placed on top of the dispersed phase distributor. Figure 5 shows the detailed drawing of the distributor section. It is composed of 0.75 mm thick SS 316 plates and SS 316 frames of thickness 0.75 mm. In this design there are two different types of frames. The first type is a L shaped frame. This when sandwiched in between two plates will form a slit which will be closed at the bottom and one lateral side while it opens at the top and the other lateral side. This slit allows flow of the dispersed phase in the plate and frame section above, the dispersed phase being fed to the open lateral side afforded by the spacer. The second type of spacer which alternates with the first type is simple vertical strips. Thus when sandwiched in between two plates this second type of spacer forms a slit which is opens at the top and the bottom while it is closed on either lateral side. Thus this slit will allow the continuous (heavy) phase to come down. Thus it is alternate arrangement of these two different types of spacers in the distribution section which affords continuous counter current flow of two different phase. The combination of these two spacers and associated plated constitute a unit countercurrent flow cell. This is clearly shown in Figure 5. This design is supposed to handle both liquid-liquid and gas liquid systems. Similar to the plate and frame section 5 mm thick

end plates are also envisaged in this section. 34 number of Type 1, Type 2 frames and 34 number of plates are required in this section.

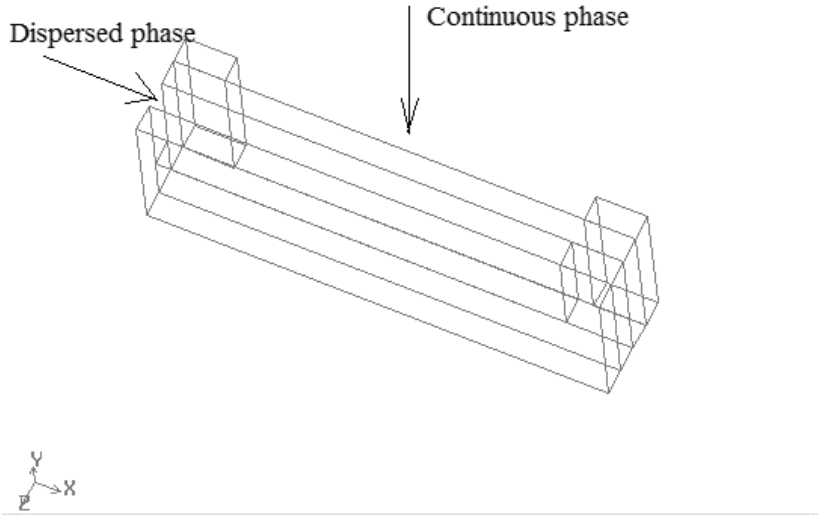


Figure 5: Isometric drawing of unit counter current flow cell of dispersed phase distributor

Figure 6 shows the top view of an unit counter current flow cell of the dispersed phase distributor. The two different types of spacers-Type 1 vertical strips spacers and Type 2 L shaped spacers are clearly shown.

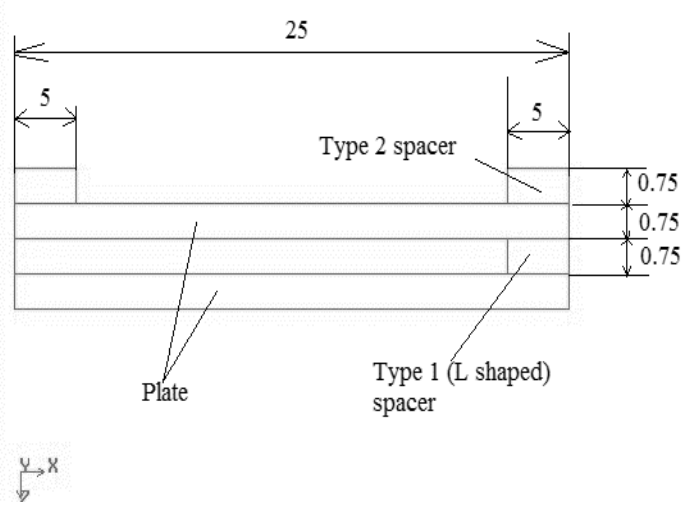
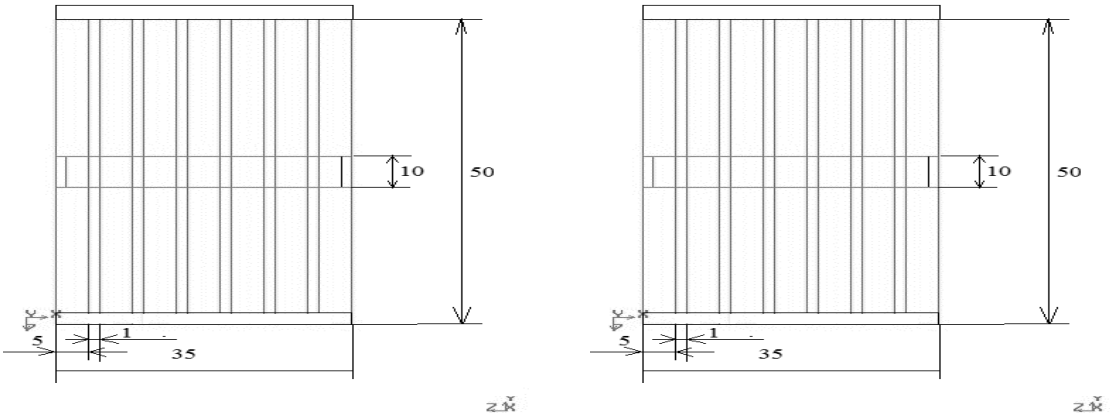


Figure 6: Detailed top view of unit counter current flow cell of dispersed phase distributor

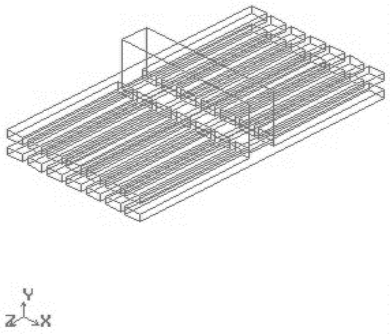
c) Continuous (heavy) phase distributor

This section is designed to ensure proper distribution of the continuous phase onto the plate and frame section. This section will be placed above the plate and frame section. It is essentially composed of distribution slots/channels (50 mm x 10 mm x 5 mm, 7 in number)

arranged parallel to the plates in the plate and frame section stationed below. These slots/channels have a slit of 2 mm thickness through which the liquid will overflow. The slits are located at a height of 5 mm from the base of the distributor channel. The gap (wall to wall distance) between such channels will be maintained at 1 mm. Through these gaps the heavy phase will trickle/fall down uniformly into the plates and frame section below. The distributor channels are being fed by a central feeder channel which opens into each distributor channel by means of a 2 mm square slit/hole located at a height of 5 mm from the base of the feeder channel. The hole/slit is located centrally in each distributor channel. Thus for 7 distributor channel there are 7 slits/holes on either side of the feeder channel. The heavy phase will be injected to this feeder channel. Figure 7 shows detailed drawing of the heavy phase distributor. The dimension of the distributor should be such that it covers the entire plate and frame section.



Top View Lateral view



Isometric view

Figure 7: Detailed drawing of heavy phase distributor

2.2) Direct contact condenser and cooler

This design is also based on an alternate plate and frame arrangement conceptually similar to the counter current extractor detailed above. The design comprises a stagnant liquid phase through which a vapor stream is being bubbled across. The vapor condenses while coming in direct physical contact with the stagnant liquid (of the same species as the vapor) and very high rates of heat transfer can be attained. As the stagnant liquid phase is heated up provision for cooling using a coolant flow is also made. This design is essentially a bubbler with a micro structured arrangement for gas sparing along with provision for sensible heat transfer to a coolant flow. There are two primary components of this design, a plate and frame section and a gas distributor. In the plate and frame section, the rectangular slits formed by sandwiching one frame (columnar) in between two plates holds the stagnant liquid). Just adjacent to the slit holding the stagnant liquid there is another slit where in coolant flow is ensured. This second slit is formed by a second type of frame (L shape). The gas distributor section allows the inlet of the gas/vapor that needs to be bubble through the stagnant columns of liquid held in the gap between two plates. Figure 8 shows the overall drawing of the mentioned device. In addition provision for inserts in form of 0.5 mm SS wires/tubes should also be made.

a) Plate and frame section

This design is also based on an alternate plate and frame arrangement conceptually similar to that detailed for counter current extractor. As before sandwiching a frame (unconnected vertical strips) (of thickness 0.75 mm) in between two plates (of 0.75 mm thickness) creates a micro slit which retains a liquid column. In the present design this micro slit containing the stagnant fluid is placed next to another slit through which cooling water can be passed. This essentially helps to maintain the temperature of the stagnant liquid column at a desired value. This second type of micro slit is composed by a second type of frame. This is essentially an L shaped frame (of thickness 0.75 mm). Using this design of frame a slit is formed which is closed at the top and bottom and opens at the lateral surfaces. Thus the coolant fluid in this second slit does not mix with that contained in the first slit. The dimension of a typical plate is 150 mm x 150 mm. In this design two plates, one type 1 spacer (2 unconnected vertical strips) and one type 2 spacer (2 unconnected L shaped) comprise a unit flow cell. In all there will be 35 slits of cooling fluid and 35 strips of cooling fluid (in all 70 slits). This necessitates 70 plates, 35 type 1 frames (i.e. 70 vertical strips) and 35 type 2 frames (70 L shaped strips). MoC of all components should be SS 316. In addition there will be two end plates (150 mm x 150 mm) made of SS 316 of 10 mm thickness.

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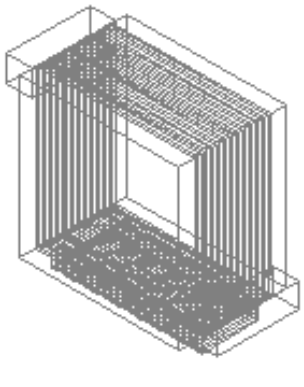
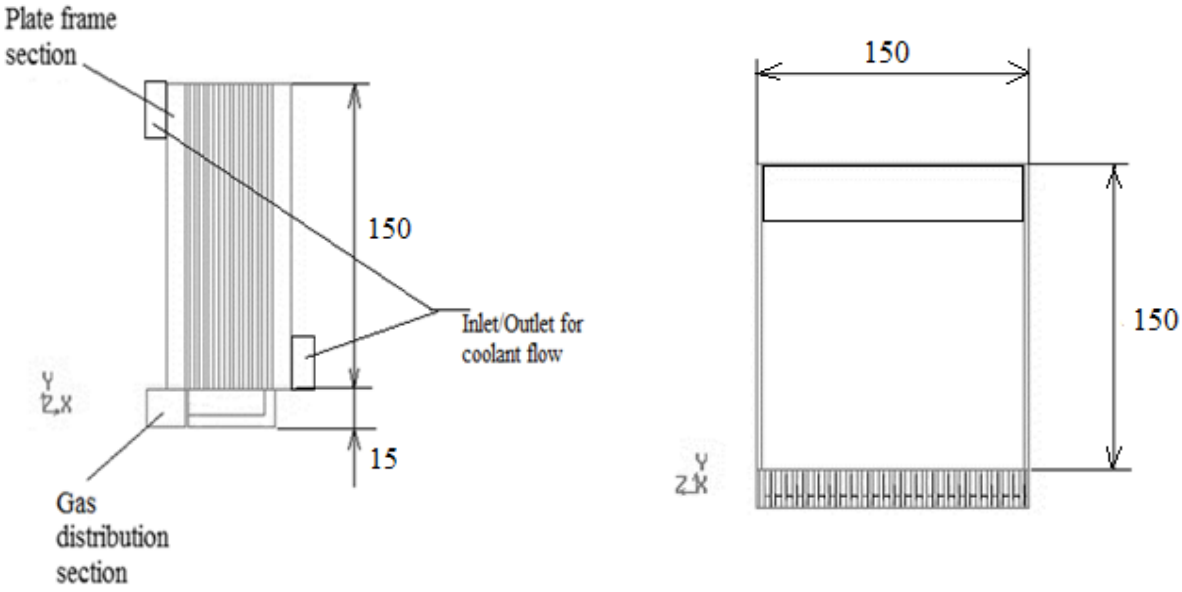


Isometric view



Lateral view

Front view

Figure 8: Overall view of direct contact condenser.

A provision for SS inserts in each slit must also be made. These inserts essentially prevents coalescence of bubbles by physically separating them inside the slit. These will be in form of 0.5 mm SS wires. These tubes will be arranged in form a grid such that they are available in every slit and are spaced 2 mm apart (in each slit). These will be supported from the top. These wires may be supported from an overhead grid arrangement (themselves made of thin tubes). The overhead arrangement can be such that there is a slender rod (of 1 mm) to which these thin wires (0.5 mm) are attached over each slit. All these slender rods are

connected to each other via a central SS rod. The vendor is free to suggest alternative design subject to the approval of the competent authority.

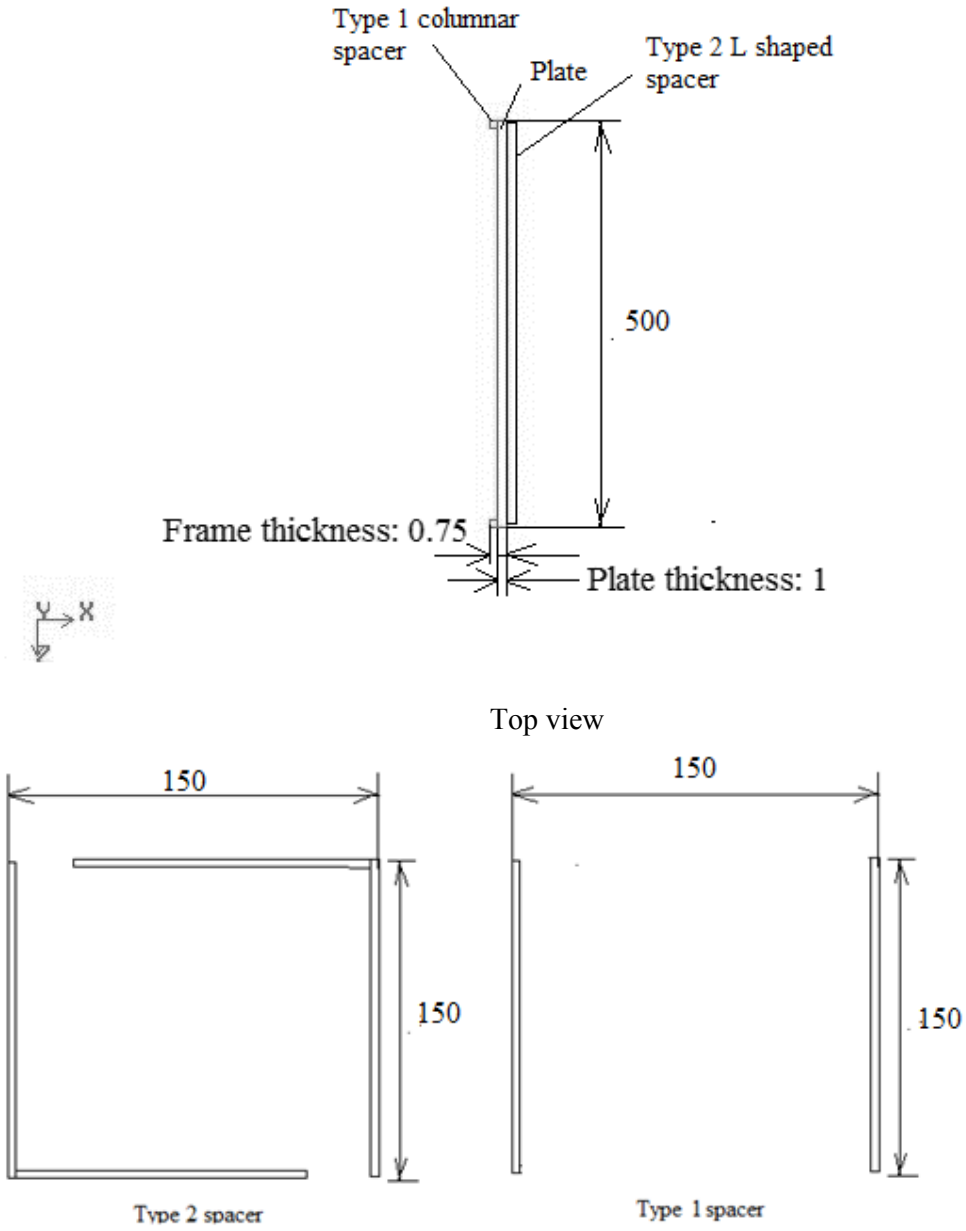
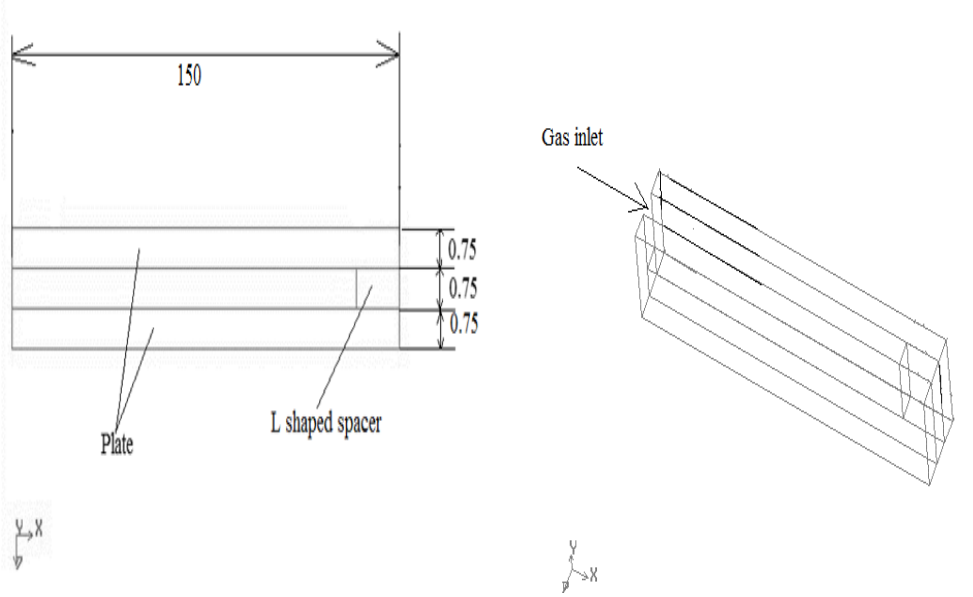


Figure 9: Detailed drawing of a unit flow cell composed of type 1 spacer, plate and type 2 spacer and individual front view of spacers

b) Gas distribution section

The design of this section (Figure 10) is similar to that of the dispersed phase distributor in counter current extractor design mentioned earlier. The only difference is

that there is only one type of spacer-the L type spacer. The single role of this section is to distribute the gas equally across all the slits. This section is also composed of plate and frame pressed against each other by tightening screws/bolts. On top of this section the plate and frame section is placed. The alignment of the plates of this section is perpendicular to that of the plate and frame section. It is composed of 0.75 mm thick SS 316 plates and SS 316 frames of thickness 0.75 mm. The L shaped spacers separate one plate from the other and affords a path for the flow of the gas into the mass of stagnant liquid above. It is imperative that some amount of liquid will fall/drip into the gas inlet section if the gas pressure is low or nil. However at constant gas flow conditions thee gas pressure will support the liquid column and the gas will be sparged though this liquid column.100 such plates and 100 frames (L shaped) are needed.



Top view Isometric view

Figure 10: Detailed drawing of the plate spacer arrangement in the gas distributor

2.3) Wetted wall micro contactor

This design (Figure 11) essentially is a counter current gas liquid contactor. Essentially this is a column (Glass 2 inch column) of length 400 mm. The column will comprise of inserts in form of punched disc and doughnuts plates. There will be 3 sets of disc and doughnuts i.e. 3 disc and 3 doughnut plates. In all there will be 6 plates (combined). The nominal gap between the disc and doughnut plate should be 60 mm. The plates are to be held in position by means of 3 tie rods (120 degree apart). Annular spacers (sliding on the tie rods) will determine the gap between the plates. Provision should be made such that this gap can be varied. Thus all the plates should be detachable and held in plate by bolting from the top. Both disc and doughnut plates will have a wall around the opening i.e. the disc having an opening at annular section will have an enclosure wall (overall enclosure wall) around the edges of the plate while the doughnut plates will have a wall around the central hole. The

punctures in the plates will be in form of nozzle holes. Design of the nozzle hole is shown in Figure 11 below. The outer and inner diameter of the nozzle hole will be 5 and 4 mm respectively while the depth of the nozzle protrusion will be 1 mm. Just along the edge of the outer diameter of the nozzle hole one enclosure wall (hole enclosure wall) is sought. The height of this wall should be 5 mm. This will serve to uniformly distribute the liquid across all the holes. The plates should be 2 mm thick. Slender rods of 3 mm thick will pass through the hole. The rods should be aligned vertically such that they pass through the holes perfectly. The annular gap between the central rods and the inner diameter of the nozzle hole should be 0.5 mm. Arrangements should be made to hold the rods in place at the top and bottom. The rods can be attached firmly (by fastening or welded) to the bottom most place. Suitable supports must also be provided at the top section of the column to fasten the rods properly. One possible way is to fasten (not weld) the rods to a top fastening plate (over and above the disc and doughnut plates mentioned before). Infact the fastening plate can be used to compress all the plates together as well. Thus the entire assembly of 3 set of perforated disc and doughnut plates with enclosure walls, tie rod and spacers holding the plates apart and the slender rods passing through the nozzle holes punched in the plates forms a cartridge that is preset and then pushed in the column from top.

The bottom most plate will be a doughnut will a central hole. The gas will enter the column though a side port below the bottom most plate, move up along a zig zag fashion along the column section and escape from above the top plate (which will be a disc plate). The exit of the gaseous stream will be below the top fastening plate. The liquid stream will be fed to the top most plate through a liquid inlet port. The liquid should be injected through a dip tube. The clearance of the dip tube end form the surface of the top most plate should be less than 5 mm. The bottom most plate (which will be a doughnut plate) is the one where in the slender rods are welded. They should also have the overall enclosure wall like other plates. In addition they should have three openings (orifice holes of 5 mm diameter with their own orifice enclosure wall, spaced 120 degree apart) through which the liquid will come down to the bottom most section of the column. There should be a drain line at the bottom of the column through which the liquid can drained off continuously. It must be kept in mind that the gas inlet section should be below the bottom most plate and above the liquid drain line.

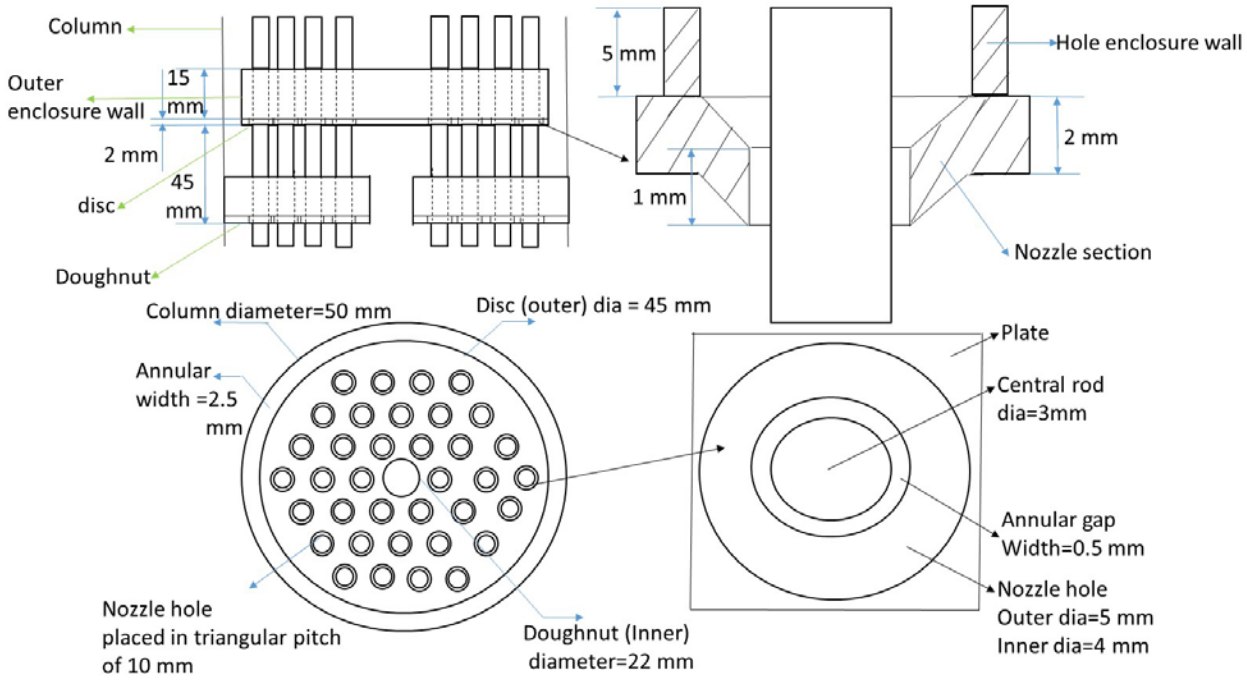


Figure 11: Schematic diagram of wetted wall contactor.

Note:

a. The fabricator should ensure that all the fittings are leak tight and that the fabrication is as per the specification provided.

b. The items will be supplied to Chemical Engineering Division, BARC and the cost of transportation will be borne by the fabricator. Therefore, the cost should be quoted accordingly and transportation clause should be explicitly stated.

c. Guarantee statement should be stated in the quotation.