

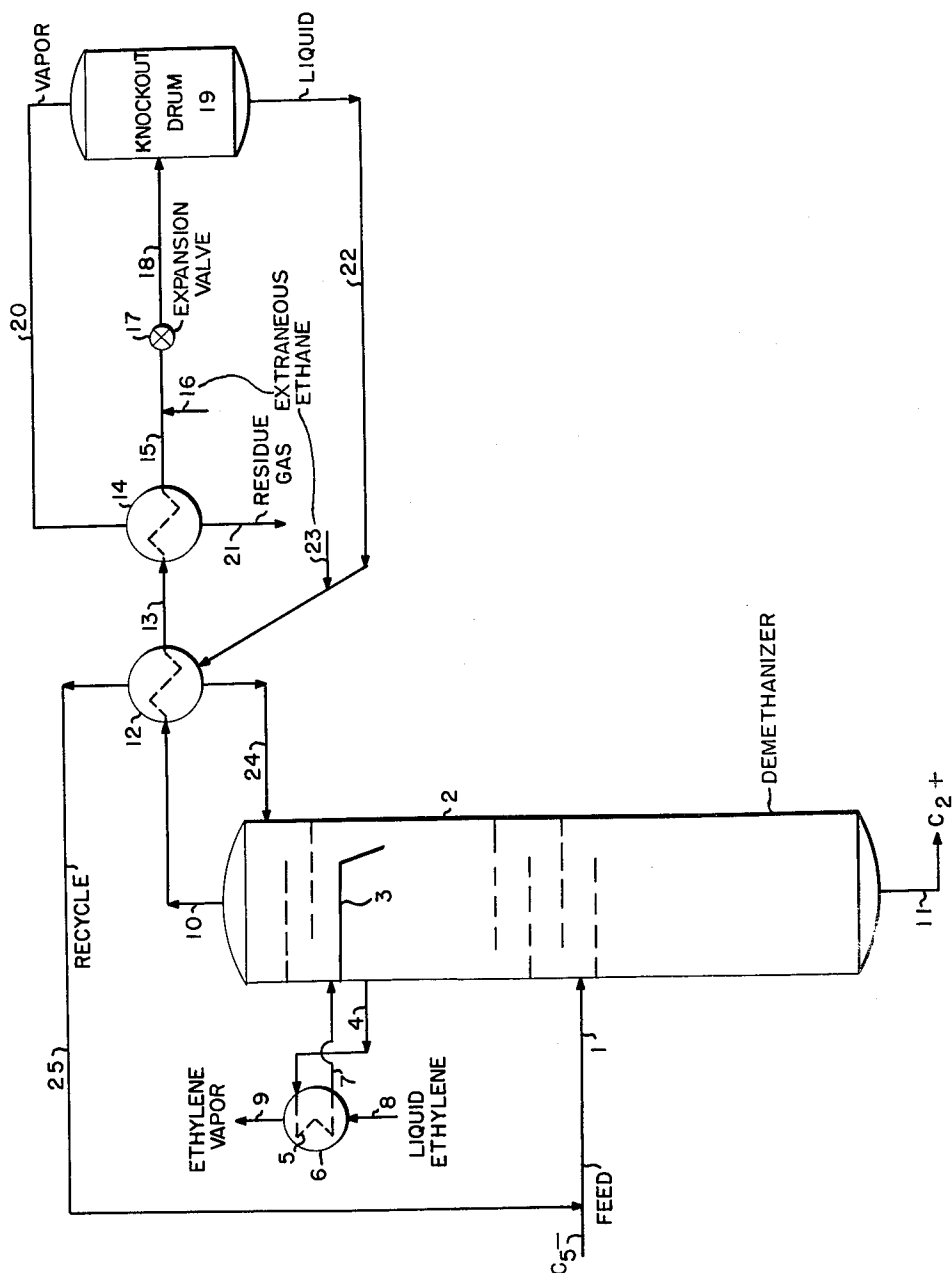
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INCREASED ETHYLENE RECOVERY BY ETHANE ADDITION

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INCREASED ETHYLENE RECOVERY BY ETHANE ADDITION

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The present invention relates to an economic method for recovering additional ethylene from the overhead stream of a low temperature high pressure demethanizer. More particularly, this invention relates to improving the conventional process in which:

(1) A C_5^- stream is fractionated at low temperatures and high pressures in a demethanizer to obtain an overhead stream predominantly consisting of methane, hydrogen and nitrogen and containing small amounts of ethylene and ethane;

(2) The overhead stream (after cooling if necessary) is then expanded at temperatures of below -145° F. isenthalpically through a Joule Thompson valve to obtain condensation of a part of the ethylene and ethane present; and

(3) This liquid condensate is separated and recovered e.g. by recycling to the demethanizer.

It has now been discovered that a large increase in the amount of valuable liquid ethylene separated out (condensed) by expansion is obtained by intentionally adding 3-6 volume percent additional ethane to the stream prior to expansion.

The present invention will be more clearly understood from a consideration of the accompanying drawing describing the demethanizer section of a preferred low temperature light ends recovery system. A C_5^- stream or a selected cut therefrom is supplied through line 1 to demethanizer column 2 at temperatures in the range of -70° F. to -90° F., preferably -80° F. to -90° F., e.g. -80° F. and pressures in the range of 400 to 600 p.s.i.a., preferably 470 to 480 p.s.i.a., e.g. 470 p.s.i.a. Cooling is provided to the upper section of the demethanizer column by indirect heat exchange with liquid ethylene, preferably by directing all of the gases collected beneath impervious plate 3 through line 4 and coils 5 of exchanger 6 back to the column above the impervious plate through line 7. Liquid ethylene is supplied to the exchanger 6 through line 8 and ethylene vapor is withdrawn through line 9. Methane and lighter materials are taken overhead and are removed from the column at a temperature of -120 to -150° F., preferably -140 to -150° F., e.g. -140° F. through line 10. From the bottom of the column C_2^+ material is taken off through line 11 at a temperature of 50 to 100° F., preferably 60 to 70° F., e.g. 60° F. The overhead stream passes from line 10 through heat exchanger 12 (where it is cooled) through lines 13 and heat exchanger 14 (where it is further cooled) to line 15. Extraneous ethane (supplied e.g. from the ethane ethylene splitter of the light ends system to which the C_2^+ material is sent) is added through line 16. The amount of ethane addition is 1 to 5 volume percent, preferably 2 to 3 volume percent, e.g. 2 volume percent based on total gas. It may alternatively and less preferably be added at other locations as will be described, the only requirement being that it increase the concentra-

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tion of ethane in the gas supplied to the expander. The combined stream at a temperature of -140 to -165° F., preferably -160 to -165° F., e.g. -160° F. and a pressure of 450 to 600 p.s.i.a., preferably 470-480 p.s.i.a., is expanded through Joule Thompson valve 17 and passed through line 18 to knock-out drum 19. It is noted that temperature must be below about -140° F. to obtain any appreciable beneficial effect by the present addition of ethane. From knock-out drum 19 vapor, now at a temperature of -170 to -200° F., preferably -190 to -200° F., e.g. -195° F. and a pressure of 50 to 200 p.s.i.a., preferably 140 to 160 p.s.i.a., is passed overhead through line 20 to heat exchanger 14 where it is used to provide cooling and thence out from the system through line 21 (ordinarily burned for its heat value only). From the bottom of the knock-out drum liquid ethane and ethylene are passed through line 22 to heat exchanger 12. Alternatively, as previously mentioned the extraneous ethane supplied through line 16 may be supplied to line 22 through line 23. From the heat exchanger 12 liquid is refluxed and forced back in to the tower through line 24 and gases are passed overhead and recycled through line 25 to the feed line 1.

Having described the present invention its utility may be clearly seen from the following. Any ethylene lost in the off gas of the demethanizer is ordinarily burned as fuel as compared to its relatively high value as a chemical. The initial fractionation in the high pressure, low temperature demethanizer reduces the level of ethylene in the overhead to 3 to 6 volume percent. Reduction in level beyond this is in general not economic due to tower structural and process refrigeration limitations. The pressure level of 500 p.s.i.a. dictates the use of ethylene as a refrigerant in cooler 6. Further recovery at the high pressure would require a methane refrigerant system and this is not economically justified. Ethylene is a common refrigerant since it is available from the ethane ethylene splitter.

A part of the ethylene and ethane present in the demethanizer overhead is recoverable by a sudden reduction in the pressure, e.g. from 450 to 600 p.s.i.a. to 100 to 150 p.s.i.a. In general, this pressure drop is taken isenthalpically across a control valve. The present inventors have discovered that if small amounts of ethane, above the levels normally present, are added to the gas mixture prior to expansion the recovery of ethylene is greatly increased. The normal composition of a typical demethanizer overhead consists of 30 to 40 volume percent hydrogen, 10 to 12 volume percent nitrogen, 50 to 55 volume percent methane, 2 to 5 volume percent ethylene and 0.2 to 0.5 volume percent ethane. By the addition of 1 to 5 volume percent ethane the equilibrium and Joule Thompson coefficients can surprisingly be modified to favor the liquification of ethylene at the expense of ethane. The present invention provides a highly desirable improvement since ethylene is exchanged for ethane at a 2:1 ratio i.e. for each mole of ethane added 2 moles of ethylene are recovered and additionally the ethane is of considerably less value since it would have to be thermally cracked (at considerable cost) to produce the desired end product ethylene with only 70% selectivity.

The present invention will be more clearly understood from a consideration of the following data obtained in a commercial operation.

Example 1

Presented below is a comparison of the results obtained in the prior art system and that of the present invention. Conditions were as described in the description of the drawing (i.e. the e.g. values).

	No Ethane Injection	Ethane Injection
Ethane added (Lb./hr.)		500
Analysis of Demethanizer Overhead:		
Hydrogen (Vol. percent)	10.8	10.7
Nitrogen (Vol. percent)	30.6	30.2
Methane (Vol. percent)	52.0	51.5
Ethylene (Vol. percent)	6.0	6.2
Ethane (Vol. percent)	0.6	1.4
Analysis of Residue Gas:		
Hydrogen (Vol. percent)	33.2	33.3
Nitrogen (Vol. percent)	12.0	12.0
Methane (Vol. percent)	51.0	51.5
Ethylene (Vol. percent)	3.5	2.35
Ethane (Vol. percent)	0.3	0.85
Residue Gas Flow (Mol./hr.)	1,950	1,930
Equivalent Ethylene Loss:		
As Ethylene (Lb./hr.)	1,911	1,270
As Ethane ¹ (Lb./hr.)	133	344
Total (Lb./hr.)	2,044	1,614
Equivalent Ethylene Recovered (Lb./hr.)		430

¹ Ethylene yield from ethane 70 weight percent.

It can be seen from the above that losses of ethylene are reduced by approximately 2 to 3% or looking at it from the standpoint of the ethylene production rate from the light ends unit this is increased by 2 to 3%, i.e. 430 lb./hr. increase in ethylene production divided by 16,000 to 20,000 lb./hr. ethylene present in demethanizer bottoms.

What is claimed is:

1. In a process for recovering ethylene from a gaseous stream containing 3 to 6 volume percent ethylene, 0.1 to 1.0 volume percent ethane, and the remainder being lighter gases, by expanding the said gaseous stream from a temperature of -140 to -165° F. and a pressure of 400 to 600 p.s.i.a. to a temperature of -170 to -200° F. and a pressure of 50 to 200 p.s.i.a. to thereby obtain condensation and separation of a part of the ethane and ethylene from the lighter gases, the improvement which comprises adding 1 to 5 volume percent of additional ethane (based on total gas) to the gas prior to expansion thereby increasing the amount of ethylene condensed.

2. In a process for recovering ethylene from a gaseous stream containing 3 to 6 volume percent ethylene, 0.3 to 0.6 volume percent ethane, and the remainder being lighter gases, by expanding the said gaseous stream from a temperature of -160 to -165° F. and a pressure of 410 to 480 p.s.i.a. to a temperature of -190 to -200° F. and a pressure of 140 to 160 p.s.i.a. to thereby obtain condensation and separation of a part of the ethane and ethylene from the lighter gases, the improvement which comprises adding 1 to 3 volume percent of additional ethane (based on total gas) to the gas prior to expansion thereby increasing the amount of ethylene condensed.

3. In a process for recovering ethylene from the gaseous overhead stream of a demethanizer operated at pressures of 400 to 600 p.s.i.a., the said gaseous overhead stream containing 3 to 6 volume percent ethylene, 0.1 to 1.0 volume percent ethane and the remainder being lighter gases by expanding the said gaseous overhead stream from a temperature of -140 to -165° F. to a

temperature of -170 to -200° F. and a pressure of 50 to 200 p.s.i.a. to thereby obtain condensation and separation of a part of the ethane and ethylene from the lighter gases, the improvement which comprises adding 1 to 5 volume percent of additional ethane (based on total gas) to the overhead gas prior to the said expansion thereby increasing the amount of ethylene condensed.

4. In a process for recovering ethylene from the gaseous overhead stream of a demethanizer operated at pressures of 400 to 600 p.s.i.a. on a C₅- feed stream, the said gaseous overhead stream containing 3 to 6 volume percent ethylene, 0.1 to 1.0 volume percent ethane and the remainder being lighter gases by expanding the said gaseous overhead stream from a temperature of -140 to -165° F. to a temperature of -170 to -200° F. and a pressure of 50 to 200 p.s.i.a. to thereby obtain condensation and separation of a part of the ethane and ethylene from the lighter gases, the improvement which comprises adding 1 to 3 volume percent of additional ethane (based on total gas) to the overhead gas prior to the said expansion thereby increasing the amount of ethylene condensed.

5. In a process for recovering ethylene from the gaseous overhead stream of a demethanizer operated at pressures of 400 to 600 p.s.i.a., the said gaseous overhead stream containing 3 to 6 volume percent ethylene and 0.1 to 1.0 volume percent ethane and the remainder being lighter gases by expanding the said gaseous overhead stream from a temperature of -140 to -165° F. to a temperature of -170 to -200° F. and a pressure of 50 to 200 p.s.i.a. to thereby obtain condensation and separation of a part of the ethane and ethylene from the lighter gases, the improvement which comprises adding 1 to 5 volume percent of additional ethane (based on total gas) to the feed stream to the demethanizer prior to the said expansion thereby increasing the amount of ethylene condensed.

6. In a process for recovering ethylene from the gaseous overhead stream of a demethanizer operated at pressures of 400 to 600 p.s.i.a. on a C₅- feed stream, the said gaseous overhead stream containing 3 to 6 volume percent ethylene, 0.1 to 1.0 volume percent ethane and the remainder being lighter gases by expanding the said gaseous overhead stream from a temperature of -140 to -165° F. to a temperature of -170 to -200° F. and a pressure of 50 to 200 p.s.i.a. to thereby obtain condensation and separation of a part of the ethane and ethylene from the lighter gases, the improvement which comprises adding 1 to 3 volume percent of additional ethane (based on total gas) to the feed stream to the demethanizer prior to the said expansion thereby increasing the amount of ethylene condensed.

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