Assignment - 3

Question1:-A power plant for generating electricity has been given as a plant design proposal. Two alternative power plants with the necessary capacity have been suggested. One uses a boiler and steam turbine while the other uses a gas turbine. Boiler and steam turbine costs Rs.6,00,000,it has an expected life of 20 years, salvage value zero and needs Rs.12000 as annual operating cost. However, the gas turbine costs Rs.4,00,000 with an expected life span of 10 years, salvage value zero and needs Rs.15,000 as an annual operating cost. A 10% attractive rate of return is required on any investment. If one of these power plants is to be accepted then based on the above information, what is the total present worth of the better option?

[3 marks]

a) Rs. 492,168.51
b) Rs. 209,994.25
c) Rs. 702,162.76
d) **None of these.**

Solution:

Present worth of the steam turbine power plant= Rs.6,00,000

Present worth of the operating cost, for the total life span of steam turbine power plant,i.e.20 years is:

= (annual operating cost)*$[1-(1+i)^{-n}]/i$

= (12000)*$[1-(1+0.1)^{-20}]/0.1$= Rs. 102162.76

Total present worth of the steam turbine power plant = (600000+102162.76) =**Rs. 702162.76**

Present worth of the gas turbine power plant= Rs.400000

Present worth of the operating cost for the total life span of the gas turbine power plant i.e. 10 years

= 15000*$[1-(1+0.1)^{-10}]/0.1$ = Rs. 92168.51

Total present worth of the gas turbine power plant = (400000+92168.51) =**Rs. 492168.51**

As the present worth of the gas turbine power plant is Rs. 209994.25 (=702162.76-492168.51) less than that of steam turbine and it should be recommended.

Question 2:-Two design options for a distillation system are being compared based on the total annual cost. Information available is as follows:

	Option P	Option Q
Installed cost of the system (Rs. In lakhs)	150	120
Cost of cooling water for Condenser (Rs. In lakhs/year)	6	8
Cost of steam for Reboiler (Rs. In lakhs/year)	16	20
Useful life (years)	20	20
Annual interest rate (%)	10	10

Based on the above information, what is the total annual cost (Rs. in lakhs/year) of the better option?

[3 marks]

a) 39.6
b) 42
c) 92.2
d) 128

Solution:

By annual cost method:

For Option P:

Installed cost of the system (in lakhs) = Rs. 150

Annual Capital Recovery of initial installation cost (in lakhs) = $150*i/[1-(1+i)^{-20}]$
$=150*0.1174=$ Rs. 17.61

Annual cost of cooling water for condenser (in lakhs) = Rs.6

Annual cost of steam for reboilers (in lakhs) = Rs.16

Total annual cost for Option P (in lakhs) =Rs. (17.61+6+16) = Rs.39.61

For Option Q:

Installed cost of the system (in lakhs) = Rs. 120

Annual Capital Recovery of initial installation cost (in lakhs) = $120*i/[1-(1+i)^{-20}]$
$=120*0.1174=$ Rs. 14.09

Annual cost of cooling water for condenser (in lakhs) = Rs.8

Annual cost of steam for Reboiler (in lakhs) = Rs.20

Total annual cost for Option Q (in lakhs) =Rs. (14.09+8+20) = Rs.42.09

As the total annual cost of Option P is Rs. 39.61 lakhs which is less than that of Option Q (Rs. 42.09 lakhs), so it would be the better choice.

Question 3:-A boiler needs to be lined with a corrosion resistant lining. Initial cost of one type of lining is Rs. 5,00,000 and annual maintenance cost of this lining is Rs.70,000. Further it will have one time major repair work of Rs.1,00,000 at the end of 15 year. Another type of lining has initial cost as Rs. 'C2'and annual maintenance cost as Rs.80,000. It involves periodic expenditure of Rs. 12000 in every 10 year. If both choices have to be equally economical (based on capitalized cost) for the effective interest rate of 18%, compounded annually, how much initial amount one should pay for second type of lining?

[4 marks]

a) Rs. 8,97,239.89
b) Rs. 4,49,962.45
c) Rs. 5,49,962.50
d) None of these

Solution:

By using capitalized cost method,

"**Type 1 lining"**

The capitalized cost of the "Type 1 lining" is equal to sum of the initial cost, present worth of one time major repair cost and capitalized cost of the annual maintenance cost.

The total capitalized cost of the "Type 1 lining" is given by;

Capitalized cost= 5,00,000+1,00,000/ $(1+0.18)^{15}$ +70,000/0.18

Capitalized cost= 5,00,000+1,00,000*0.0835+3,88,888.89

Capitalized cost = Rs. 8,97,238.89…… (i)

"**Type 2 lining"**

Initial investment = C2

One time capital expenditure in every 10 years perpetually

= (annuity of 12000 taking n to be 10)/i = 12000*i/{i[$(1+i)^n$-1]}

= 12000*0.18/{0.18[(1.18)^{10}-1]} = 12000*0.236=Rs. 2832

One time capital required for paying Rs. annually perpetually= 80000/0.18 =Rs. 444444.44

Thus total capital requirement for the "Type 2 lining" to run perpetually
= C2+2832+444444.44 = **C2+447276.44** ……. (ii)

By Equating equation (i) and (ii)-

C2+447276.44 = Rs. 897238.89

Thus, initial amount one should pay for second type of lining (C2) is = Rs. 4, 49,962.45.

Question 4:-A company must purchase one heat exchanger to be used in an operation. Two heat exchangers are designed, all of which are equally capable of giving the required service. The following data apply to these two designs:

	Design 1	**Design 2**
Fixed capital investment(Rs.)	10,000	12,000
Estimated useful life (years)	15	10
Salvage value (Rs.)	500	400
Sum of operating cost and other costs per year (Rs.)	3,000	2,800

By computing the variation in the Net present worth for both designs with minimum acceptable rate of return (MARR) from 5% to 20%.Determine the interest rate (approx.) at which both heat exchangers will have equal net present worth?

[8 marks]

a) 9.5 %
b) 10.2 %
c) 12.3 %
d) 6.7 %

Solution:

Computation of Net Present worth for each design for a given value of MARR is carried out as given below. For different values of MARR from 5% to 20% the process is repeated and the Results are tabulated.

Analysis:

In this problem salvage values of the heat exchangers are positive. It should be noted that salvage values should be deducted from the present worth of the heat exchangers to find net

present worth. Further, as the estimated service life of both heat exchangers are different, the net present worth method can't be applied as it needs equal time window for comparison, To circumvent this problem, in such cases a common time window which is the least common multiple of service lives is taken. In the present case least common multiple of 15 and 10 is 30 years of useful life is considered for the above problem.

In the time window of 30 years,design1 requires only first renewal, whereasdesign2whoseservice life is 10 years requires two renewals within 30 years. At the end of 30 years no machine requires renewal as there is no need for the heat exchangers after 30 years, at least in the present scenario of comparison.

Given:

i =0.05, Cost for design 1= Rs.10000; Cost for design2= Rs.12000; Salvage value of design 1= Rs.500; Salvage value of design 2= Rs.400; Operating cost per year for design 1= Rs.3000; Operating cost per year for design 2 = Rs.2800;

Design "1"

Present worth of design "1"= Rs.10000 (as it is paid at t=0 to purchase the machine)

Present worth of salvage values (one received at the end of 15^{th} year and the second at the end of 30^{th} year) = $500/(1+i)^{15} + 500/(1+i)^{30}$
= Rs.204.51 + Rs.115.69 = Rs.320.20

Present worth of operating cost paid per year for 30 years
= $3000*[1-(1+i)^{-30}]/i$= Rs. 46117.35

Thus net present worth for design "1"= (10000-320.20+46117.35) = **Rs.55797.15**

Design "2"

Present worth of design "2"= Rs.12000 (as it is paid at t=0 to purchase the machine)

Present worth of salvage values (one received at the end of 10th year and the second at the end of 20th year and the third at 30^{th} year) = $400/(1+i)^{10} + 400/(1+i)^{20} + 400/(1+i)^{30}$
= Rs.245.56 + Rs. 150.76+ Rs.92.55 = Rs.488.87

Present worth of operating cost paid per year for 30 years
= $2800*[1-(1+i)^{-30}]/i$ = Rs. 43042.86

Thus net present worth for machine "B" = (12000+43042.86-488.87)= **Rs.54553.99**

MARR	**Net Present Worth for Design-1(Rs)**	**Net Present Worth for Design-2 (Rs)**
0.05	55797.15	54553.99

0.1	38132.39	38270.95
0.2	24902.25	25912.95

The present worth of design "2" becomes higher than design"1" after 5% MARR. Thus both the heat exchangers will have same annual cost between 5% and 10% MARR

Δ1= Annual cost of "1" for 5% MARR –Annual cost of "2" for 5% MARR

= (55797.15 -54553.99) = 1243.16

Δ2 =Annual cost of "1" for 10% MARR –Annual cost of "2" for 10% MARR

= (38132.39-38270.95) = -138.56

Let at MARR value "x" the cost of both heat exchangers are same, thus at x, Δ3=0

Δ3 =Annual cost of "1" for MARR value "x" –Annual cost of "2" for MARR value "x"

= 0

Two heat exchangers will have equal annual cost at the interest rate of =

(x -0.05)/(0.1-0.05) = (Δ3-Δ1)/(Δ2-Δ1)

Or x =0.05+[(Δ3-Δ1)/(Δ2-Δ1)]*0.05 = 0.05+[0-1243.16/(-138.56-1243.16)]*0.05= **0.09499**

i.e. Two heat exchangers will have equal annual cost at the interest rate of = 9.499%

Question 5:-There are three furnace design plans (1, 2 & 3) before an engineer. The details of the financial out lay for these furnaces are given below. The engineer is asked to select a plan based on incremental rate of return. If the minimum acceptable rate of return is 5%. Presume that estimated life of the furnaces for all the plans is 20 years.

Design	1	2	3
Total initial installation cost(Rs.)	10,000	16,000	20,000
Operating cost per year(Rs.)	100	100	100
Fixed charges (% of initial installation cost) (Rs.)	200	200	200
Value of heat saving per year(Rs.)	4100	7000	8500

Select the correct statement for the given information?

[8 marks]

a) Incremental rate of return is 4.476 % for design-2 and 8.087% for design-3.
b) Incremental rate of return shows maximum return for Design-2 which is 5.94%.
c) Incremental rate of return is 8.087% for design-2 and 4.476% for design-3.
d) None of these.

Solution:

Design-"1"

Annual Capital Recovery of initial installation cost for Design-1 = $10000*i/[1-(1+i)^{-20}]$

$=10000*0.08024=$ Rs. 802.40

Annual operating cost for Design-1 = Rs. 100

Fixed charge for Design-1=2*10000 = Rs. 20000

Annual fixed charge for Design-1= $20000*i/ [1-(1+i)^{-20}]$ = Rs. 1604.8

Total annual cost for Design-1 = (802.40+100+1604.8) = Rs. 2507.20

Annual heat saving for Design-1 =Rs. 4100

Annual profit for Design-1= (4100-2507.20) = Rs.1592.80

Total investment for Design-1= 10000+2*10000= Rs.30000

Rate of return Design-1= (1592.80/30000) = 5.31%

Design-"2"

Annual Capital Recovery of initial installation cost for Design-2 = $16000*i/ [1-(1+i)^{-20}]$

$=16000*0.08024=$ Rs. 1283.84

Annual operating cost for Design-2 = Rs. 100

Fixed charge for Design-2=2*16000 = Rs.32000

Annual fixed charge for Design-2= $32000*i/ [1-(1+i)^{-20}]$ = Rs. 2567.68

Total annual cost for Design-2 = (1283.84+100+2567.68) = Rs. 3951.52

Annual heat saving for Design-2 =Rs. 7000

Annual profit for Design-2= (7000-3951.52) = Rs.3048.48

Total investment for Design-2= 16000+2*16000= Rs.48000

Rate of return Design-2= (3048.48/48000) = 6.351%

Design-"3"

Annual Capital Recovery of initial installation cost for Design-3 = $20000*i/ [1-(1+i)^{-20}]$

=20000*0.08024= Rs. 1604.80

Annual operating cost for Design-3 = Rs. 100

Fixed charge for Design-3=2*20000 = Rs. 40000

Annual fixed charge for Design-3= $40000*i/ [1-(1+i)^{-20}]$ = Rs. 3209.6

Total annual cost for Design-3 = (1604.80+100+3209.6) = Rs. 4914.4

Annual heat saving for Design-3 =Rs. 8500

Annual profit for Design-3= (8500-4914.4) = Rs.3585.6

Total investment for Design-3= 20000+2*20000= Rs.60000

Rate of return Design-3= (3585.6/60000) = 5.976%

As minimum acceptable rate of return is 5%, all Designs (1,2 & 3) are offering rate of return more than 5% and hence can be accepted. However, for incremental rate of return further study is required as given below.

Incremental Rate of Return computation:

Design	**1**	**2**	**3**
Annual Profit	1592.80	3048.48	3585.6
Total investment	30000	48000	60000
Rate of intern on investment	5.31%	6.351%	5.976 %
Extra investment above next lower investment	-	18000	12000
Extra income in comparison to next lower	-	1455.68	537.12
Return on Extra investment	-	**8.087%**	**4.476%**

As incremental rate of return shows maximum return for Design-2 it should be selected.

Question 6:- Find out the total annual cost (AW) of both the equipments on the basis of the Annual cost method, at the interest rate of 9.5% per year.

Equipment-1

Cash flow details:

Initial purchase cost = Rs.50,00,000

Annual operating cost = Rs.60,000 at the end of year '1' which increases by Rs.3000 in the subsequent years till the end of useful life.

Annual income = Rs.700,000

Cost of one time major repair = Rs.200000 at the end of 8^{th} year

Expected salvage value = Rs.140,000

Useful life = 12 years

Equipment-2

Cash flow details:

Initial purchase cost = Rs.46,00,000

Annual operating cost = Rs.70,000 at the end of year '1' which increases by Rs.5000 in the subsequent years till the end of useful life.

Annual income = Rs.650,000

Cost of one time major repair = Rs.230,000 at the end of 6^{th} year

Expected salvage value = Rs.120,000

Useful life = 12 years

Note: The arithmetic gradient factor (A/G) for Annual cost calculations is given by the following formula-

$$\mathbf{A/G = \left(\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right)}$$

[6 marks]

a) **AW1= Rs. 96,366.66; AW2= Rs. 114,240.64**
b) AW1= Rs.120,702.38 ; AW2= Rs. 122,713.46
c) AW1= Rs.96,366.66 ; AW2= Rs. 202,713.46
d) AW1= Rs. 331,349.38 ; AW2= Rs. 224,713.46

Solution:

Since both Equipments have the same life span i.e. 12 years, the annual cost of the Equipments at present will be compared over a period of 12 years.

The annual operating cost is in the form of a positive uniform gradient series. This can be split into the uniform base amount of Rs.60000 and gradient amount in multiples of Rs.3000 starting from end of year '2' till the end of useful life.

Equipment "1"

Initial investment or present worth of Equipment -1= Rs.5000000 (as it is paid at t=0)

Annual cost of capital recovery = Capital investment*i / $[1-(1+i)^{-n}]$

Annual cost of Capital recovery =5000000*0.095/$[1-(1+0.095)^{-12}]$ = **Rs.715938.57**

Annual cost of salvage value to be recovered = (1,40,000/ $(1+i)^{12}$)* i /$[1-(1+i)^{-12}]$
= **Rs. 6746.28**

Annual operating cost = 6000 + 3000*$\left(\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right)$ = 60000+3000*4.4394= **Rs. 73318.34**

Annual income = **Rs.700,000**

Cost of one time major repair = Rs.200000 at the end of year '8'

Annual cost of repair = (200000/ $(1+i)^{8}$)*$[i /[1-(1+i)^{-12}]$
=200000*0.4838*0.1432 = **Rs.13856.032**

Thus total annual cost of Equipment "1" at present is (AW1)
= (715938.57-6746.28+73318.34-700000+13856.032) = Rs.96,366.66

Equipment "2"

Initial investment or present worth of Equipment -2= Rs.4600000 (as it is paid at t=0)

Annual cost of capital recovery = Capital investment*i / $[1-(1+i)^{-n}]$

Annual cost of Capital recovery =4600000*0.095/$[1-(1+0.095)^{-12}]$ = **Rs.658720**

Annual cost of salvage value to be recovered = (120,000/ $(1+i)^{n}$)* i /$[1-(1+i)^{-n}]$
= **Rs. 5782.53**

Annual operating cost =70000 + 5000*$\left(\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right)$ = 70000+5000*4.4394= **Rs. 92197**

Annual income = **Rs.650000**

Cost of one time major repair = Rs.230000 at the end of year '6'

Annual cost of repair = (230000/ $(1+i)^{6}$)*$[i /[1-(1+i)^{-12}]$
=230000*0.5801*0.1432 = **Rs.19106.17**

Thus total annual worth of Equipment "2" at present is (AW2) =Rs.114,240.64

Analysis:

From the comparison by annual worth method, it is observed that Equipment-2 exhibits higher annual worth as compared to Equipment-1. Thus the Equipment-1 is the most economical Equipment.

Question 7:-There are three different investment plans under consideration for purchasing a house for a purpose to earn rent. A comparison of these plans to be made at the end of the time window of 5 years at that time it assumes that the resale value is 200% of the original investment. It is estimated that the minimum acceptable rate of return (MARR) as well as interest rate are 10%. The data for the above plan is given in the table shown below:

[8 marks]

	Plan-1	**Plan-2**	**Plan-3**
Original Investment (Rs.)	100,000	200,000	300,000
Annual Rent	25,000	35,000	40,000
Annual maintenance	2000	5000	3000
Taxes(Rs./year)	1000	1500	1800

Using the Minimum return as cost method; determine Annual savings after adding MARR as a cost for all plans?

a) Annual savings after adding MARR as a cost: Plan 1 = Rs. (-)1999.96; Plan 2=Rs.(-)11500 ; Plan 3=Rs. 24800
b) Annual savings after adding MARR as a cost: Plan 1 = Rs. (-)1999.96; Plan 2=Rs.11500 ; Plan 3=Rs. 24800
c) Annual savings after adding MARR as a cost: Plan 1 = Rs. (-)1999.96; Plan 2=Rs.11500 ; Plan 3=Rs. (-)24800
d) None of these

Solution:

As after 5 years the investment will fetch double the amount and will result a profit of 100%. This amount which is a Future worth of profit should be distributed as annuity throughout the 5 years period and should be treated as earnings. Further, the original investment needs to be recovered through an annuity and should be treated as expenditure.

For Plan-1:

Annual profit due to 200% enhancement of cost (For Plan-1)
$= 100{,}000*0.1/ ((1+0.1)^{5}-1)=$ **Rs.16379.75**

Annual cost of capital recovery (For Plan-1) $= 100{,}000*0.1/(1-(1+0.1)^{-5})=$ **Rs. 26379.79**

Annual Rent =Rs. 25000

Annual maintenance =Rs. 2000

Taxes (Rs. /year) = Rs. 1000

Net annual profit for Plan-1 = 16379.75+25000-26379.79-2000-1000 = **Rs. 11999.96**

Annual savings after adding MARR as a cost for Plan-1
= 11999.96-0.10*100000 =Rs. 1999.96

For Plan-2:

Annual profit due to 200% enhancement of cost (For Plan-2)
$= 200{,}000*0.1/ ((1+0.1)^{5}-1)=$ Rs.32759.496

Annual cost of capital recovery (For Plan-2) $= 200{,}000*0.1/(1-(1+0.1)^{-5})=$ Rs. 52759.496

Annual Rent =Rs. 35000

Annual maintenance =Rs. 5000

Taxes (Rs. /year) = Rs. 1500

Net annual profit for Plan-2 = 32759.496+35000-52759.496-5000-1500 = Rs. 8500

Annual savings after adding MARR as a cost for Plan-2
= 8500-0.10*200000 =Rs. (-) 11500

For Plan-3:

Annual profit due to 200% enhancement of cost (For Plan-3)
$= 300{,}000*0.1/ ((1+0.1)^{5}-1)=$ Rs. 49139.24

Annual cost of capital recovery (For Plan-3) $= 300{,}000*0.1/(1-(1+0.1)^{-5})=$ Rs. 79139.24

Annual Rent =Rs. 40000

Annual maintenance =Rs. 3000

Taxes (Rs. /year) = Rs. 1800

Net annual profit for Plan-3 = 49139.24+40000-79139.24-3000-1800= Rs. 5200

Annual savings after adding MARR as a cost for Plan-3
= 5200-0.10*300000 = Rs. (-) 24800

	Plan-1	**Plan-2**	**Plan-3**
Annual profit due to 200% enhancement c initial cost, Rs.	16379.75	32759.496	49139.24
Annual cost of capital recovery , Rs.	26379.79	52759.496	79139.24
Net annual profit, Rs.	11999.96	8500	5200
Return	12%	4.25%	1.733%
Annual savings after adding MARR as a cost	**1999.96**	**-11500**	**-24800**

Conclusion:

As the annual savings after adding MARR as a cost is Maximum for Plan-1.Hence, it is selected for investment. The annual savings after adding MARR as a cost for Plan-2 and Plan-3 shows a negative value indicating that it offers a Return which is lower than MARR and thus in no case it should be accepted.

Question 8:-To improve the public transportation services in a town, two plans have been prepared. Plan-A calls for initial investment of Rs. 60,00,000 and will be requiring expenditure in every 10 years costing Rs.50,000. It also calls for an investment of Rs.10,000 every year. Plan-B calls for an initial investment of costing Rs.50,00,000 followed by an annual investment of Rs.40,000.It also involves periodic expenditure of Rs. 15,000 every 10 years. Considering MARR to be 9% and capitalized cost method to be used. Which one of the following statement correct?

[4 marks]

a) Sum of total capital requirement for the plan-A and B to run perpetually is Rs. 6,47,677.83
b) Difference in total capital requirement for the plan-A and B to run perpetually is Rs. 61,47,677.83
c) Total capital requirement for the plan-A to run perpetually is Rs. 61,47,677.83

d) Total capital requirement for the plan-B to run perpetually is Rs. 61,47,677.83

Solution:

Plan-A

Initial investment = Rs.60, 00,000

One time capital expenditure every 10 years perpetually

= (annuity of 50000 taking n to be 10)/i = $50000*i/\{i[(1+i)^n-1]\}$

= $50000*0.09/\{0.09[(1.09)^{10}-1]\}$ =**Rs. 36566.72**

One time capital required for paying Rs.10000 annually perpetually
= 10000/0.09=**Rs. 111111.11**

Thus total capital requirement for the plan-A to run perpetually = Rs. 61,47,677.83

Plan-B

Initial investment = Rs.50, 00,000

One time capital expenditure every 10 years perpetually

= (annuity of taking n to be 10)/i = $15000*i/\{i[(1+i)^n-1]\}$

= $15000*0.09/\{0.09[(1.09)^{10}-1]\}$ =**Rs. 10970**

One time capital required for paying Rs.40000 annually perpetually

= 40000/0.09=**Rs. 444444.44**

Thus total capital requirement for the plan-B to run perpetually= Rs. 54, 55,414.44

As the Plan-B requires less Capitalized cost than Plan-A, it should be selected.

Common data question (question 9 and 10):-

A heat exchanger has been designed and needs thermal insulation on its outer surface to save heat loss. The insulation can be obtained in thickness of 1, 2, 3 or 4 inch. The following pertinent data have been provided for the different insulation thicknesses.

Insulation thicknesses→	**1 inch**	**2 inch**	**3 inch**	**4 inch**
Investment on heat exchanger with insulation, Rs.	1,10,000	1,35,000	1,65,000	2,53,000
Cost for installation insulation (Rs.)	1,08,000	1,04,000	1,17,000	1,21,550

Taxes, insurance, inspection, etc. Rs. Per year	20000	25000	30000	32000
Maintenance of pipeline, Rs. per year	50,000	60,000	30,000	18000
Heat saving, (kJ/hr)	2000	2500	2700	2800

The value of the heat is Rs. 30,000 /1000,000 kJ. If the service life of heat exchangers with insulation is 15 years with zero salvage value and minimum acceptable rate of return (MARR) is 10%.The interest rate is also 10%. The exchanger operates 100 days per year.

[12 marks]

Question 9:- Using Incremental rate of return method, select the correct statement about the insulation thickness?

a) Return on extra investment will be minimum for 4-inch insulation thickness which is 3.1%
b) 2-inch insulation thickness is selected as it has 78.48% Return on extra investment w.r.t 1-inch insulation.
c) 2-inch insulation thickness is selected as it has 86.85% Return on extra investment w.r.t 1-inch insulation.
d) 3-inch insulation thickness is selected as it has 78.48% Return on extra investment w.r.t 2-inch insulation.

Question 10:- Using Minimum Acceptable Rate of Return (MARR) as a cost method, select the correct statement about the insulation thickness?

a) 2-inch insulation thickness is selected because annual savings after considering MARR as a cost is maximum for it, which is Rs.69117
b) 3-inch insulation thickness is selected because annual savings after considering MARR as a cost is maximum for it, which is Rs.64892
c) 3-inch insulation thickness is selected because annual savings after considering MARR as a cost is maximum for it, which is Rs.39672
d) None of these

Solution:

Given:

	1 inch	2 inch	3 inch	4 inch
Investment on heat exchanger with insulation, Rs.	1,10,000	1,35,000	1,65,000	2,53,000
Cost for installation insulation (Rs.)	1,08,000	1,04,000	1,17,000	1,21,550
Total fixed investment,(Rs.)	**2,18,000**	**2,39,000**	**2,82,000**	**3,74,550**
Taxes, insurance, inspection, etc. Rs. Per year	20,000	25,000	30,000	32,000
Maintenance of pipeline, Rs. per year	50,000	60,000	30,000	18,000
Total annual operating cost, Rs.	**70,000**	**85,000**	**60,000**	**50,000**
Heat saving,(kJ /hr)	2000	2500	2700	2800
Annual heat saving, (Rs./yr)	**1,44,000**	**1,80,000**	**1,94,400**	**2,01,600**

Question 9:-Solution:

Incremental rate of return Method:

"1-inch" insulation

Annual Capital Recovery of fixed investment= 2, 18,000*i/ $[1-(1+i)^{-15}]$

=2, 18,000*0.1315= Rs.28667

Total annual operating cost = Rs. 70000

Total annual cost = (28667+70000) = Rs. 98667

Annual heat saving = (2000*24*100*(30,000/1000000)) = Rs. 1,44,000

Annual profit = (144000-98667) = Rs.45333

Total fixed investment = 2, 18,000

Rate of return = (45333/218000) = 20.79%

"2-inch" insulation

Annual Capital Recovery of fixed investment = 2, 39,000*i/ $[1-(1+i)^{-15}]$

=2, 39,000*0.1315= Rs.31428.5

Total annual operating cost = Rs. 85000

Total annual cost = (31428.5+85000) = Rs. 116428.5

Annual heat saving = (2500*24*100*(30,000/1000000)) = Rs. 1,80,000

Annual profit = (180000-116428.5) = Rs.63571.5

Total fixed investment = 2, 39,000

Rate of return = (63571.5/2, 39,000) = 26.6%

“3 inch” insulation

Annual Capital Recovery of fixed investment = 2, 82,000*i/ $[1-(1+i)^{-15}]$

=2, 82,000*0.1315= Rs.37083

Total annual operating cost = Rs. 60000

Total annual cost = (37083+60000) = Rs. 97083

Annual heat saving = (2700*24*100*(30,000/1000000)) = Rs. 1,94,400

Annual profit = (194400-97083) = Rs.97317

Total fixed investment = 2, 82,000

Rate of return = (97317/282000) = 34.51%

“4-inch” insulation

Annual Capital Recovery of fixed investment = 3, 74,550*i/ $[1-(1+i)^{-15}]$

=3, 74,550*0.1315= Rs.49253.32

Total annual operating cost = Rs. 50000

Total annual cost = (49253.32+50000) = Rs.99253.32

Annual heat saving = (2800*24*100*(30,000/1000000)) = Rs. 2,01,600

Annual profit = (2, 01,600-99253.32) = Rs.102346.68

Total fixed investment = 3, 74,550

Rate of return = (102346.68/374550) = 27.33%

As minimum acceptable rate of return is 10%, and for all insulation thickness (1, 2,3& 4) rate of return more than 10% thus any insulation thickness can be selected. Further, the 3” insulation is giving maximum return of 34.51%. However, selecting the best option incremental rate of return study is required further as given below.

Incremental Rate of Return computation:

	1 inch	2 inch	3 inch	4 inch
Annual Profit	45333	63571.5	97317	102346.68
Total investment	2,18,000	2,39,000	2,82,000	3,74,550
Rate of return on investment	20.79%	26.6%	34.51%	27.33%
Extra investment above next lower investment	-	21000	43000	92550
Extra income in comparison to next lower	-	18238.5	33745.5	5029.68
Return on Extra investment	-	**86.85%**	**78.48%**	**5.43%**

Conclusion: 2-inch insulation thickness is selected as it has 86.85% Return on extra investment w.r.t. 1-inch insulation.

Question 10:- Solution:

Minimum Acceptable Rate of Return (MARR) as a cost method

The annual cost of capital recovery for 1 inch to 4-inch insulation:

Annual cost of capital recovery (For 1-inch) = 2, 18,000*0.1/(1-(1+0.1)$^{-15}$ = Rs. 28667

Annual cost of capital recovery (for 2-inch) = Rs. 31428.5

Annual cost of capital recovery (For 3-inch) = Rs. 37083

Annual cost of capital recovery (For 4-inch) = Rs. 49253.32

For '1-inch' insulation thickness:

Net annual profit = (annual heat saving-annual capital recovery-annual operating cost)
= (144000-28667-70000) = Rs.45333

Annual savings after adding MARR as a cost = 45333-0.10*218000 =Rs. 23533

For '2-inch' insulation thickness:

Net annual profit= (annual heat saving-annual capital recovery-annual operating cost)
= (180000-31428.5-85000) = Rs. 63571.5

Annual savings after adding MARR as a cost = 63571.5-0.10*239000=Rs. 39671.5

For '3-inch' insulation thickness:

Net annual profit= (annual heat saving-annual capital recovery-annual operating cost)
= (194400-37083-60000) = Rs. 97317

Annual savings after adding MARR as a cost = 97317-0.10*282000 =Rs. 69117

For '4-inch' insulation thickness:

Net annual profit= (annual heat saving-annual capital recovery-annual operating cost)
= (201600-49253.32-50000) = Rs. 102346.68

Annual savings after adding MARR as a cost = 102346.68-0.10*374550 =Rs. 64891.68

	1 inch	2 inch	3 inch	4 inch
Annual heat saving, (Rs./yr)	1,44,000	1,80,000	1,94,400	2,01,600
Annual cost of capital recovery , Rs.	28667	31428.5	37083	49253.32
Total annual operating cost, Rs.	70,000	85,000	60,000	50,000
Net annual profit, Rs.	45333	63571.5	97317	102346.68
Total investment	2,18,000	2,39,000	2,82,000	3,74,550
Return	20.79%	26.6%	34.51%	27.33%
Annual savings after adding MARR as a cost (Rs.)	**23,533**	**39,671.5**	**69,117**	**64,891.68**

Conclusion: **3-inch insulation thickness is selected because annual savings after considering MARR as a cost is maximum for it, which is Rs.69,117**