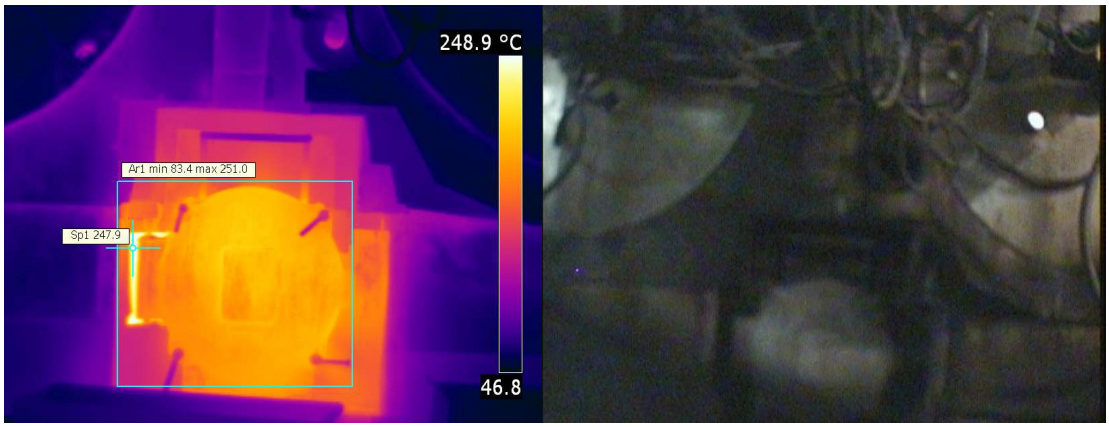
4-1 Calculation

Surface no.1

Area (that area picked up by the thermal camera) =0.785

The average surface temperature (calculated by thermal camera) 175°c



IR IMAGE **NORMAL IMAGE**

Fig 4-1Thermal camera image no.1

Ambient temperature range from 27°c – 32 °c

And the air velocity range from 0.5 m/s – 2.5 m/s

Table 4-1Heat losses by radiation for image no.1

Ambient temperature () °c	Heat losses (Q) (W)
27	1271.8
28	1267.5
29	1263.1
30	1258.8

31	1254.3
32	1250
Average	1261

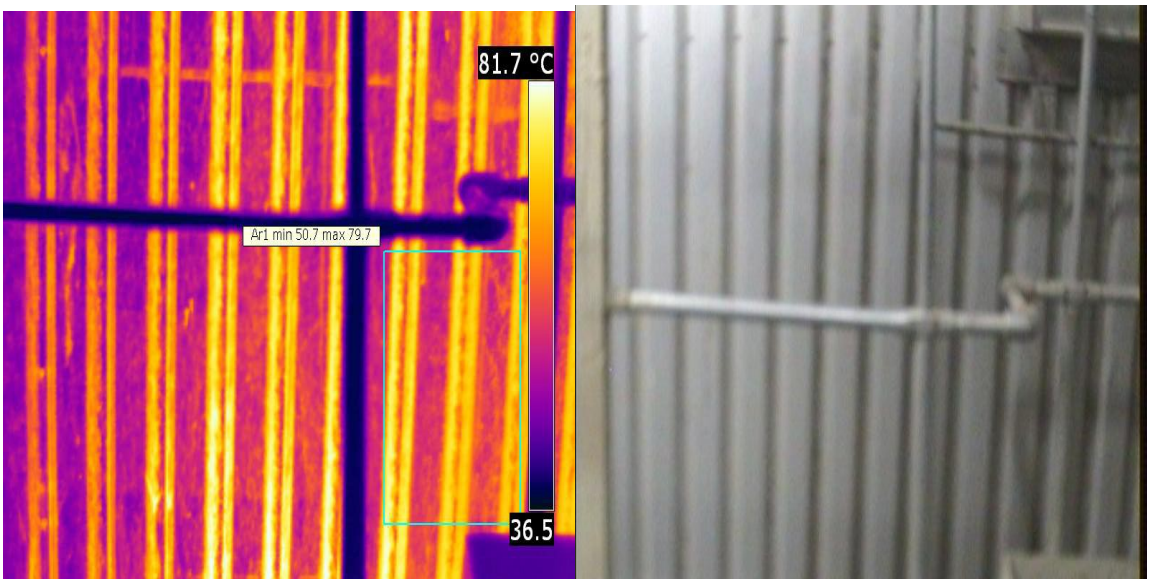
Table 4-2 Heat losses by convectionfor image no.1

Air velocity(m/s)	0.5	1.0	1.5	2.0	2.5	
Ambient temperature (°c	Q(W)	Q(W)	Q(W)	Q(W)	Q(W)	Q(average) W
27	317	448	549	633	709	531
28	314	445	545	629	704	527
29	312	442	541	625	698	524
30	310	439	537	620	694	520
31	308	436	533	916	689	516
32	308	435	533	615	688	516
Average						522

Surface no.2

Area (that area picked up by the thermal camera) =19.32

The average surface temperature (calculated by thermal camera)is 64.3°c



IR IMAGE **NORMAL IMAGE**

Fig 4-2Thermal camera image no.2

Ambient temperature range from 27°c – 32 °c

And the air velocity range from 0.5 m/s – 2.5 m/s

Table 4-3 Heat losses by radiation for image no.2

Ambient temperature () °c	Heat losses (Q)(W)
27	4714.1
28	4617.5
29	4509.3
30	4401.1
31	4265.5
32	4156
Average	4443.9

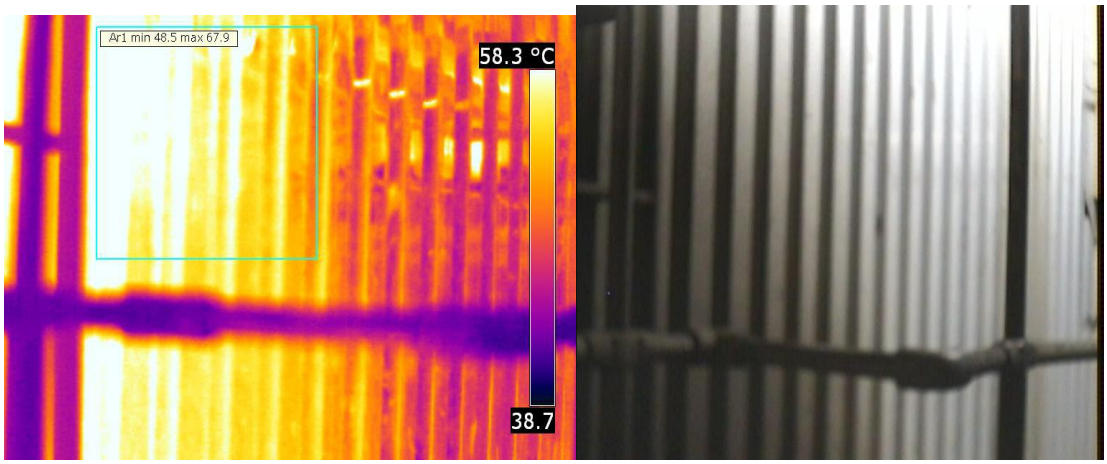
Table 4-4 Heat losses by convectionfor image no.2

Air velocity(m/s)	0.5	1.0	1.5	2.0	2.5	
Ambient temperature (°c	Q(w)	Q(w)	Q(w)	Q(w)	Q(w)	Q average W
27	1185	1676	2053	2371	2651	1987
28	1153	1631	1998	2307	2579	1934
29	1122	1586	1943	2244	2508	1881
30	1090	1541	1887	2179	2436	1827
31	1058	1496	1832	2116	2365	1773
32	1026	1451	1777	2052	2294	1720
Average						1854

Surface no.3

Area (that area picked up by the thermal camera) =19.32

The average surface temperature 57°c



IR IMAGE **NORMAL IMAGE**

Fig 4-3Thermal camera image no.3

Ambient temperature range from 27°c – 32 °c

And the air velocity range from 0.5 m/s – 2.5 m/s

Table 4-5 Heat losses by radiation for image no.3

Ambient temperature () °c	Q(W)
27	3664
28	3559
29	3452
30	3343.7
31	3234.7
32	3124.6
Average	3396.3

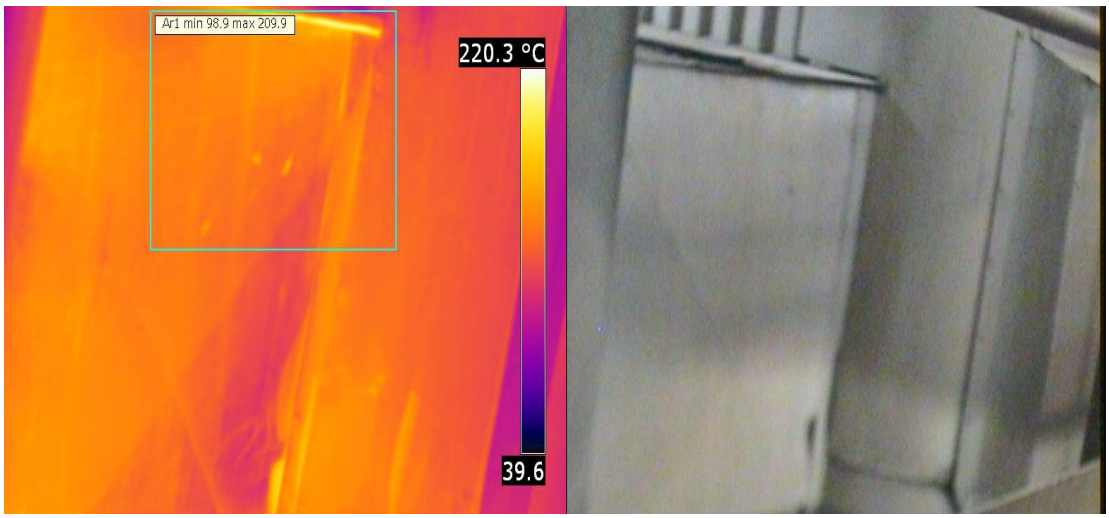
Table 4-6 Heat losses by convectionfor image no.3

Air velocity Ambient temperature (°c	0.5 Q(w)	1.0 Q(w)	1.5 Q(w)	2.0 Q(w)	2.5 Q(w)	m/s Q average W
27	954	1350	1653	1909	2134	1600
28	922	1303	1596	1843	2061	1545
29	887	1255	1537	1774	1984	1487
30	859	1214	1487	1717	1920	1439
31	827	1169	1432	1653	1848	1386
32	795	1124	1377	1589	1777	1332
Average						1465

Surface no.4

A (that area picked up by the thermal camera) =24.84

The average surface temperature 146°c



IR IMAGE **NORMAL IMAGE**

Fig 4-4Thermal camera image no.4

Ambient temperature range from 27°c – 32 °c

And the air velocity range from 0.5 m/s – 2.5 m/s

Table 4-7 Heat losses by radiation for image no.4

Ambient temperature () °c	Q(W)
27	28477
28	28334
29	28203
30	28064
31	27924
32	27783
Average	28131

Table 4-8 Heat losses by convectionfor image no.4

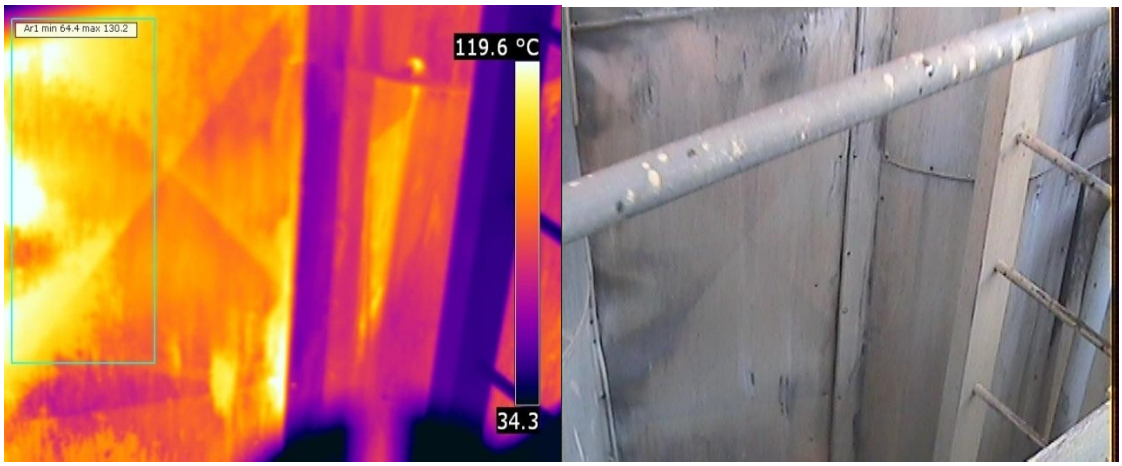
Air velocity(m/s)	0.5	1.0	1.5	2.0	2.5	m/s
Ambient temperature (°c	Q(W)	Q(W)	Q(W)	Q(W)	Q(W)	Q average W
27	6020	8513	10427	12040	13461	10092

28	5969	8441	10338	11938	13347	10007
29	5925	8379	10263	11850	13249	9933
30	5867	8297	10162	11734	13119	9836
31	5816	8225	10074	11633	13006	9751
32	5765	8153	9986	11531	12892	9665
Average						9881

Surface no.5

Area (that area picked up by the thermal camera) =24.84

The average surface temperature 101°c



IR IMAGE **NORMAL IMAGE**

Fig 4-5Thermal camera image no.5

Ambient temperature range from 27°c – 32 °c

And the air velocity range from 0.5 m/s – 2.5 m/s

Table 4-9 Heat losses by radiation for image no.5

Ambient temperature ()°c	Q(W)
27	14369
28	14233
29	14096
30	13957
31	13817
32	13675
Average	14025

Table 4-10 Heat losses by convectionfor image no.5

Air velocity(m/s)	0.5	1.0	1.5	2.0	2.5	m/s
Ambient temperature (°c	Q(W)	Q(W)	Q(W)	Q(W)	Q(W)	Q average W
27	3757	5313	6507	7513	8400	6298
28	3705	5240	6468	7411	8286	6222
29	3650	5162	6322	7300	8161	6119
30	3603	5096	6241	7206	8057	6041
31	3552	5023	6152	7104	7942	5955
32	3501	4951	6064	7002	7828	5869
Average						6084

4-2 Total heat losses

Table 4-11 Total heat losses

Surface No.	Heat losses by radiation(W)	Heat losses by convection(W)	Total (W)
1	12609	523	13132
2	4744	1853	6498
3	3396	1465	4861
4	28131	9881	38012
5	14025	6084	20109
Total	62905	19806	82711

4-3 Fuel cost calculation

Assumed the boiler temperature is uniform at boiler surface and estimated boiler and boiler auxiliary heat losses 250kw

Operation time of unit during one year = 365 day – 35 shutdown days

330 days= 7920 hours

Power losses during one year =25036007920=7.13kJ/Year

Fuel unit cost =0.507 SDG/kg

The fuel calorific value is 40000kj/kg

Actual Power losses during one year =Power losses during one year boiler efficiency

=7.13/0.8=8.91 KJ/Year

Fuel cost = (ActualPower losses during one year /CV) x fuel unit cost

8.91/40000=112935 SDG/year

4-4 Insulation thickness calculation

Infrared devise used to measure boiler wall tube temperature and find temperature is 354°c.

Heat losses= = = == = 1522.8 w

Power losses during one year= operation time

Power losses during one year =1522.836007920=4.3 w/year

== 4.3/0.8

=53.75k w/year

Annual Cost=/cv fuel unit cost =195336007920(400001000) =706SDG/year

= Surface temperature

= ambient temperature

=actual Heat losses during one year

=boiler effeceincy

CV=fuel calorific value

The unit cost of insulation is given to be 20 SDG/ per cm thickness, plus 30 SDG/ for labor. Then the total cost of insulation becomes
Insulation Cost = Unit cost Surface area

Cost savings = Energy cost without insulation - Energy cost with insulation

Table 4-12 Optimum insulation thickness

Insulation Thickness(cm)	Rate of heat loss (W)	Cost of heat lost(W)	Cost savings (SDG)	Insulation cost (SDG)
0	1523	688	0	0
1	736.3	333	355	50
2	485.5	220	468	70

5	240.1	109	579	130
10	130.3	59	629	230
15	89.5	41	647	330
20	68.1	31	657	430
25	55	25	663	530
27	51	23	665	570
30	46.1	21	667	630
31	44.6	20	668	650
32	43.3	19	669	670
35	40	18	670	730

Therefore, the thickest insulation that will pay for itself in one year, the thickness is 32 cm.

4-5 Analysis

Heat losses increase when the air velocity increase as show in the figures blow (4-7 & 4-8)

Heat losses decrease when the ambient temperature increase as show in the figures blow (4-7 & 4-8)

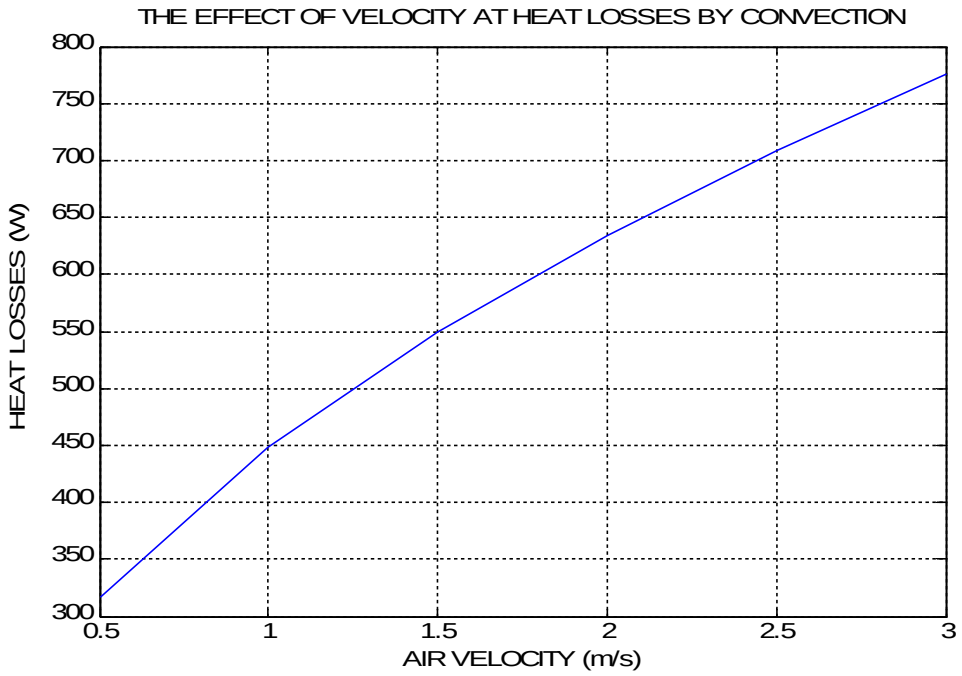


Fig 4-7 Heat losses when the ambient temperature 27

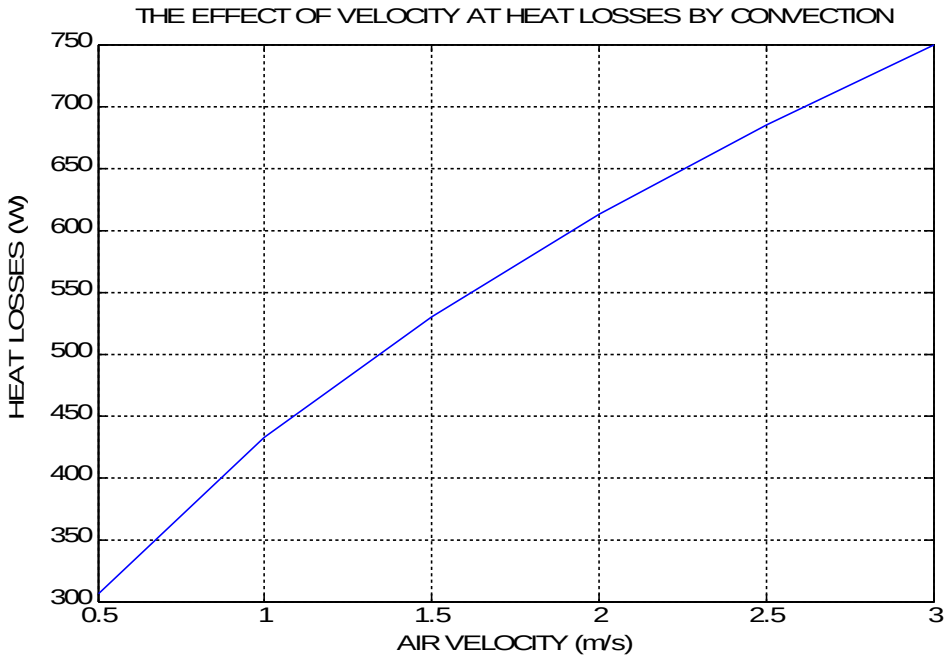


Fig 4-8 Heat losses when the ambient temperature 28

Improper insulation cost the plant money by burning more fuel and this effect directly in plant efficiency (increase input). We find in this case bad insulation cost 112935 SDG every year for one unit and Khartoum north power station has 6 units.

The thickest insulation that will pay for itself in one year, the thickness is 32 cm.