

Research of Innovative Energy-Drying Technology with the Use of a Spiral Heat Exchanger Filled with Thermal Factor in Simulated Conditions

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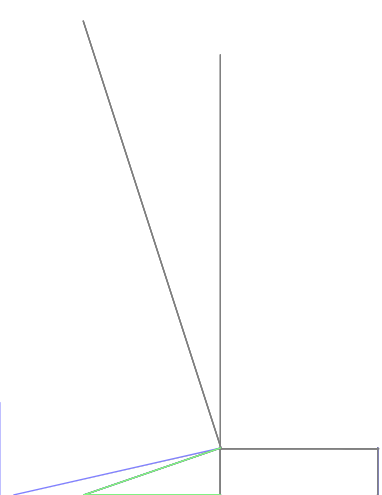
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WbbYMXVrij Ybh'Ujcb'Xi Mg Vrk Yb'k\JW'Ub'Uf'\YUf'k]h'Ub
U]U'Zb'kUg'd'UWZk\JW'dfcXi WX'UgfYUa'cZ\YU]b]'Uf'dUgg]b]
VrkYb'Vch'YiWUb]Yfg'0&Q' 'df]bVd'YcZcdYU]cb'cZHYhg
gUbXWbgdYXcZ'gla i'U]b]'hYdfcWgg'cZUf'\YU]b]'j'Ybh'Ujcb
Xi Mg]a]U]b]'hY]bhf]cf'cZHYXf'nf'UbX'hY\YU' s' Vrk Yb'hY
hgX\YU'Y'WUb]Yfg' '\chUf'Wa]b]'ci hcZHY\YUf'gla i'Uhg
\YU'X'Uf'Wa]b]'ci hcZHYXf'nf'0%Q'DUgg]b]'h'fci]\ 'hY\YU
YiWUb]Yfz]h'fYU'Yg' dUfh'cZ'hY\YU'ic' hY'h'Yfa U' a'YXi a
W'W'U]b]'j'hY]bgU'U]cbzk\JW]g'ZfVX'lc'hY\YU'YiWUb]Yf'j'b
hY'd'UW'cZ'g'W]b]'j'b'W'X'Ua'V]bh'Uf'0%Q'-b'h]g'\YU'YiWUb]Yfz
hY\YU]g'h'f'U'bg'ZffYX'lc'hY'Uf'g'WYX]b'Zca'hY'Yj'f'cba'Ybh'UbX
]b'h]g'k'U'U'f]'Yg]b'lc'hY\YU'f'U'U'h'a'd'Y'U'i'f'Y\]]'Y'f'h'U'b'hY
Ua'V]bh'h'a'd'Y'U'i'f'Y' 'j]Yk'cZHYhg]VbW'Xi'f]b]'hY'hgg]g'
g'ckb]b':]i'fY'0%Q'2%Q

W]g' ppr' hY]bg]XY'cZHY\YU'YiWUb]Yfg]fY'WbbYMX'Vm
a'Y'bg'cZ'h'Yfa'U'm]bg'U'X'W'dd'f' d]d'Y]b'Yg'0%Q'5' V'g'X
W'W'U]cb'cZHY'h'Yfa'U'a'YXi a'k'U'g'U'd']YX'lc'hY\YU'YiWUb]Yf'
g'g'h'a'"7]f'W'U]cb'cZHY'W'W'U]b]'lei]X'hY'h'Yfa'U'Z'W'c'f'k'U'g'
Z'f'VX'V'm'hY'W'W'U]b]'di a'd']bg'U'YX']b'hY'g'g'h'a'k]h'hY
d'c'g]V]h'nc'Z'f'Y'i'U]b]'hY' s'j'Y'c'W'h'i'-'b'U'X]h'cbz'hY'YiWUb]Yf'
]bg'U'U]cb]b'W'X'g'U'V'c'g'X'h'd'Y'Y'Y]b]'j'Y'g'Z'i'g'X'lc'g'U]]h'Y'hY
d'f'Y'g'f'Y'cZHY'lei]X]b'hY'g'g'h'a'z'g'f]J'W]Uj'V'g'UbX'hY'j'Ybh'Uj'Y
Z'f'hY]bg'U'U]cb'0%Q

h'g]g'UbX\U'g'V'Yb'Ye'i]dd'YX'k]h'W'bf'c''UbX'a'Y'U'g'f'Y'a'Ybh
Ye'i]da'Ybh'5'\YU'i'a'Y'h'f']bg'U'YX']b'hY'h'Yfa'U'a'YXi a

Ip.	U_n	S₁	S₂	S₃
	(V)	(m³.h⁻¹)	(m³.h⁻¹)	(m³.h⁻¹)
1	230	471.5	438.6	431.1
2	207	451.6	417.2	413.3
3	184	418.8	387.6	384.0
4	161	390.5	363.2	359.5
5	138	347.9	325.8	325.0
6	115	292.6	270.8	269.8
7	92	259.5	247.5	241.3



UfYU|b[fYg i hcb'cZS%

cZ' , ("S' , +* ' a ' \!% B Y l z U h g h k U g W f f] X c i h z f h Y g a i U h X h a d y U i f y c Z h Y U f W a] b [' c i h c Z h Y X m f U i h Y Y j Y c Z + S 7 U b X h Y s ' f U Y c Z h Y W b j m X U f '] b ' h Y f U b] Y c Z (' % % (' , * ' a ' \!% 8 i f] b [h Y h g z h Y b f] m W b g a d h c b ' W g g f m i c \ U h h Y U f U b X h Y U a c i b h c Z b y f] m f U b g z f f X v m h Y h Y a U ' Z M f c Z h Y \ U h X U f ' k Y Y a Y g f Y X ' C b ' h] g V g g z h Y U a c i b h c Z \ U h f W j Y Y X V m

a Y b g c Z U \ U h Y W U b] Y f Y f U M X Z c a h Y X m f U b X h Y U a c i b h c Z \ U h f U b g z f f X l c ' h Y Y W U b] Y f ' i g X l c \ U h h Y U f ' g W X] b Z c a h Y] b g U U h c b g Y b] f c b a Y b h k U g W W U h X ' ' c V U b Y X h g f Y g] g U Y d f Y g b h X '] b ' H V Y ' z g d d Y a Y b h X U X] h c b U m V m h Y h a d y U i f y g l c ' k \] W h Y U f g a i U] b [' h Y U f W a] b [' c i h c Z h Y X m f k U g \ U h X'

Tube exchanger with sipes					Tube exchanger without sipes			
T	Eel	Ecob	E	temperature obtained	Eel	Ecob	E	temperature obtained
(°C)	(kWh)	(kWh)	(kWh)	(°C)	(kWh)	(kWh)	(kWh)	(°C)
50	3,02	1,20	4,22	48,0	3,67	0,66	4,33	47,2
70	5,10	1,94	7,04	66,9	6,0	0,87	6,87	62,6*

*temperature obtained during continuous operation of the heater

HVY' . 9bYf] mXa UbXZf' cVU]b] U t h a d y U i f y c b h Y h g h V b W k] h j U f] c i g \ U h Y W U b] Y f g'

' c V U] b Y X f Y g] g W U f m] b X] W Y U ' c k Y f ' f i r ' c Z f W j Y f m U b X \ U h f U b g z f ' V n j U f] c i g h Y Y \ U h Y W U b] Y f g Z c a ' h Y h Y a U Z M f ' - b ' h Y W g Y c Z U b ' Y d y] a Y b h k] h ' U h Y Y \ U h Y W U b] Y f ' U i U h a d y U i f y c Z + S 7 z k] h c i h] b g U] b [' U b ' U X] h c b U ' \ U h f z h Y U g j a Y X U f ' h a d y U i f y ' v ' h Y \ U h f ' W i ' X b c h i V Y c V U] b X ' d f Y] a] b U m h g i f Y g] g d f Y g b h X U c j Y a U X] h d c g] V Y l c ' X Y] X Y ' c b Y] a] b U] b [' h Y Z M f g f] g k] h ' U h Y Y \ U h Y W U b] Y f ' k] h c i h g d y g U b X W f f m] b [' c i h U W a d ' Y Y Z M f h g] b h Y W b X] h c b g X g W] V X] b d c] b h ' & ' k \ Y b ' i g X] b ' U W W U h c b ' g g h a ' U g U h Y a U ' k U h f ' Z M f ' U b X h Y b ' & ' c Z U b ' h m b Y] m W # U m ' a] h f Y U b X h i V ' U f ' Y W U b] Y f g k] h g d y z k \] W \ U j Y V Y b ' v ' h U g a c f Y '] b h Y Z b W] c b c Z \ U h f U b g z f V h k Y b U f ! ' j e i] X U f ' V b h f g'

Simulation tests of the parameters of the exchanger installation on the test bench

' f y g] g c Z W W U h c b g ' c Z h Y U a c i b h c Z h Y a U ' Y b Y f] m h U b g z f f X V h k Y b U f ! ' j e i] X U b X U f ' c b ' U h g h g U b X Y e i] d d Y X k] h h i V ' U f ' \ U h Y W U b] Y f g k] h ' U a Y ' U Y k] h ' h c ' h m Y g c Z h Y a U W W U h c b ' a X j i a ' U f Y g c k b] b H V Y ("

Wbhf'g' 'lg'X'Ylc'h'Y[fYUM' t '\YhcZkUhf'W'a dFYXlc
h'Y'Yh'mBY[nW'a]l'h'fY'='h'fbzh'YU'j'U'h'Y'cZi'g]b['Ua]l'h'fY
cZk'Uhf'UbX'Y'h'mBY[nW']g]lg'ck'Y'Z'Y'rb['dc]bh'='h]g'U'j'lg'UYlc
d'Yd'U'f'Y'Ua]l'h'f'Y'k]h'U'W'W'W'bf'U'j'cb'U'X'i'g'X'lc'h'Y'Y'l'd'Y'W'X'ck'Y'gh
h'a d'Y'U'i'f'Y'g]b'h'Y'g'U'g'b'c'Z'X'f'nb[]'f'U'bg'Z'U']b['Z'f' h'Y'd'Y'c'X'c'Z
G'd'h'a'V'f']B'c'j'Y'a'V'f'z'k'\Y'b']h']g' d'c'g']V'Y'h'U'i'ck' 'U'f' h'a d'Y'U'i'f'Y'g
a'U'rc'W'f'="h]g'U'g' a'Y'X'h'U'h'Y'ck'Y'f'h'Y'W'W'W'bf'U'j'cb'c'Z'U'a]l'h'f'Y'z
h'Y'\]\Y'f']g' t '\Y'U'z'U'X'g'c'U'i'\$'7'Z'f'U'a]l'h'f'Y'c'Z' *1' f'Z'Y'rb[
d'c]bh'U'ci' h')'·7'z' t '\Y'U']g' " %_>f] ['?E'Z'f'U'a]l'h'f'Y'c'Z' *1
f'Z'Y'rb[h'a d'Y'U'i'f'Y'U'ci' h'&\$'7'E' t '\Y'U']g' '(-_>f] ['?E'Z'U'X
Z'f' U'a]l'h'f'Y'k]h' U'W'W'W'bf'U'j'cb' c'Z' &'1' f'Z'Y'rb[h'a d'Y'U'i'f'Y'
U'ci' h'&\$'7'z' t '\Y'U']g'U'ci' h' '*, _>f] ['?E'¹⁰

Acknowledgment

'U'f]W'Y'U'a'g'lc'X'lg'Y'a]b'U'Y'h'Y'f'Y'g']g'c'Z]b'X'i'g'f]U'f'Y'g'U'f'W'c'Z
h'Y' d'f'c'W'W'Y'h]h'Y'X' 'F'Y'g'U'f'W' U'X'X'Y'Y'c'd'a'Y'b'i'c'Z'U'b']b'bc'j'U'j'Y'z
Y'j']f'c'b'a'Y'b'U'nt'Z']Y'b'X'm'g'g'h'a' 'Z'f' 'X'f'nb['U'X'g'c'f]b['W'f'b']'f'U'b'"
'f'Y'g'U'f'W' k'U'g'g' d'c'c'f'h'X'V'm'B'7'6']F' U'X'k'U'g'W'f'f]Y'X'c'i'h'V'm
D'C@B'9'H'g'l' c'c']'K'g'l']b']W'h'G'd']_U'?c'a'U'b'X'nt'k'U'z']b'U'W'W'X'U'W'
k']h' h'Y'W'W'f'U'W'bc.DC= " S'%'S("SS'! 'S!&+ #%'z'U'g'U' d'f'c'W'W' s
r r h'Z'ca' h'Y'9'i'f'c'd'Y'U'b'F'Y']c'b'U'8'Y'Y'c'd'a'Y'b'i: i'b'X'z'i'b'X'f' h'Y'
='b'bc'j'U'j'Y'9'W'b'c'a'm'c'd'Y'f'U'j'cb'U' D'f'c']f'U'a' 'Z'f' h'Y' n'Y'f'g' &\$S'+!&\$S%'z'
A'Y'U'g'f'Y'%'("G' d'c'c'f'h'Z'f']U'f']h'X'd'f'c'W'W'g'"

References

- % 9'Y'g'b'F'9z ; c''b'8' f'&\$%'L'5'g'g'g'b['h'Y']a'd'U'W'c'Z'h'Y']f'Y'b
f'Y'c'i']h'c' "G'W'W'W' SS'+), !+*&'
- &' :5'c'G'U']g']W'8'U'U'U'g'g'f'&\$%'L'G'U']g']W'8'U'U'U'g'g'U'X'8'U'U'G'Y'g'c'Z
h'Y':cc'X'U'b'X'5']f']W'h'f'Y'c'f']U']r'U'c']b'g'c'Z'h'Y'i' b']h'X'B'U'j'cb'g'
- '" <Y'f'a'U'bb'5'z'f'U'h'>f'&\$%'L'6']c']U'g' d'f'c'X'i'W']c'b'Z'ca' 'a'U'n'Y'W'f'f'Y'bh'g'U'z
W'U'Y'b']Y'z'U'X' d'f'c'g']W'g' "% 'A'Y'h'U'Y']M'Y'X' D'c'h']h'U'" '6']c'Y'b'F'Y'g').
'%&\$'+!&\$%'&'
- (" 6'Y'Y'Y'G'Z'a'U'Y'A'z'6'f'U'b'< z'8'i'j'Y']'Y'f'9'z'F'Y'nt'c'X'g'A'z'Y'i'U'" f'&\$%'L'
7'f'c'd'g'h'U'i'Z'Y'X'h'Y'k'c'f'X'%'D'U']g']W'g'g'U'X'Z'h'f'Y'W'U'Y'b']Y'g'lc'h'Y'
f'c'Y'd'U'h'X'V'nt'k'\Y'U']b['c'U'Z'c'X'g'W'f']h'f' cc'X'G'W'f']m']&'%'%'&' "
-)" 6'i']U'c'j']z'6'U'b'X'i'f'U'j'z'5'f'U']A'z'c'h'>f'&\$%'L'r r sr'c'Z'f'U'g'Y'X'