Merenje, upravljanje i vizuelizacija procesa proizvodnje toplotne energije u kotlarnici „Nova Kolonija“, JEP Kraljevo

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Ovaj rad se bavi rekonstrukcijom izvora toplote - kotlarnice kao dela sistema za daljinsko grejanje (DHS) sa primenjenim merama energetske efikasnosti. Pored zamene kotlova i zastarele opreme sa novom visoko efikasnom opremom, pažnja je usmerena na primeni sistema upravljanja SCADA (BMS), upravljanje i akviziciju parametara. Tehnološki objekat opremljen je pretvaračima fizičke količine energije koji su od suštinskog značaja za praćenje performansi i procenu energetske efikasnosti kotla sa aspekta proizvedene energije i to od procesa sagorevanja do distribucije toplote na izvoru. Izmerene količine su: potrošnja goriva, toplotna energija proizvedena u kotlu, korišćenje toplotne energije iz dimnih gasova, prenos toplotne energije, proizvodi sagorevanja, potrošnja električne energije, veličine pritiska i temperature. Procena energetske efikasnosti generatora toplote - kotla se vrši prema EN standardima. Rad, osim tehničkog opisa sistema, prikazuje metodologiju određivanja efikasnosti kotla prema standardu SRPS EN 15316-4-1: 2012.

Ključne reči: centralni sistem grejanja, energetska efikasnost, stepen efikasnosti, SCADA

1. UVODNE NAPOMENE

U okviru programa Rehabilitacije daljinskog sistema grejanja u Srbiji, faza III koji je sufinansiran od strane Vlade SR Nemačke, Kfw razvojne banke Nemačke i Vlade Republike Srbije, JP „Toplana“ Kraljevo je učestvovala sa 14 projekata. Ukupna vrednost projekata finansirana je iz sredstava kredita u iznosu od 3.351.955€, subvencije 921.788€ i iz sopstvenog učešća Toplane u iznosu od 1.780.000€. Kroz Projekat nabavljena je oprema, izvedeni radovi u sledećim objektima:

I. Kotlovska postrojenja – nabavljena su 4 kotla ukupne instalisane snage 62.5MW, što čini 80% ukupne instalisane snage toplane. Kotlovi su montirani u kotlarnici Nova Kolonija 3x12MW, pušteni u pogon u oktobru 2011 godine a u toku rada ostvaren je stepen korisnosti od 98%. U Centralnoj toplani montirana su 2 kotla i puštena u rad u 2009 i 2010 godini i postigli su stepen korisnosti od 96%.

II. Toplovodna mreža – nabavljene su i montirane fabrički predizolovane toplovodne cevi u dužini od oko 20km i tom prilikom su postignute uštede u gubicima vode kao i u termičkim gubicima toplote toplovoda. Novi toplovodi su omogućili bezbedno grejanje i daju mogućnost priključenja novih korisnika što prati i kapacitet kotlovskih postrojenja iz prethodne tačke.

III. Podstanice – nabavljeno je i ugrađeno 110 podstanica čime smo rekonstruisali stare podstanice i time dobili bolje grejanje i mogućnost uštede povezivanjem u sistem centralnog daljinskog nadzora, regulacije i upravljanja.

IV. Merači toplotne energije – nabavljeno je i ugrađeno 120 merača kao i 116 merača u okviru novih podstanica, JP Toplana je iz svojih sredstava nabavila još 120 merača i time omogućila merenje toplotne energije u svim podstanicama.

Sva ostala oprema dimnjaci, pumpe, kolektori, HPV, zaporna i druga armatura ugrađena je u kotlarnicama Centralna toplana i Zelena Gora čime je se postigla potpuna realizacija programa KfW faza III. Realizacijom Projekta KfW-III završen je jedan deo „ukupne celine“ Toplane i time su se ostvarili sledeći benefiti:

- bolji stepen korisnosti u kotlovskim postrojenjima
- automatski rad i nadzor kotlarnica
- smanjenje emisije Nox i CO₂, manji uticaj na životnu sredinu
- merenje isporučene toplotne energije na pragu kotlarnice
- sigurnost u radu kotlovskih postrojenja
- sigurnost u isporuci toplotne energije
- viši stepen obuke i obrazovanja radnika u proizvodnji i distribuciji toplotne energije
- smanjen gubitak u distributivnoj mreži i bolji parametri energetske efikasnosti
- zamenom podstanica dobilo se u energetske efikasnosti i data je mogućnost merenja toplotne energije predate krajnjem kupcu
- omogućen je automatski rad podstanica i povezivanje u sistem daljinskog nadzora i upravljanja
- ugradnjom merača pokriveni su svi potrošači i pripremljen je tehnički uslov za naplatu i primenu tarifnog sistema

2. OPIS PROJEKTA

Projektom je realizovana zamena kotlovskih jedinica u kotlarnici Nova Kolonija imajući u vidu da su stari kotlovi ugrađeni 1975 godine (2 komada VIESSMANN i 1 komad MINEL).

Kotlovi su dotrajali i u toku grejne sezone učestala su pucanja - curenja na dimnim cevima i plamenicama što je zahtevalo učestale prekidne u snabdevanju toplotom i troškove remonta dimnih i plamenih cevi. Projektom je obuhvaćena zamena starih kotlova sa tri nova 3x 12MW u kompletu sa gorionicima, ekonomajzerima i ostalom pratećom opremom za snabdevanje gorivom, zaštitom hladnog kraja i hemijskom pripremom vode.

Osim puke zamene kotlova JEP Toplana je želela da Projektom realizuje i primeni moderna tehnološka rešenja u ovoj oblasti i ugradi opremu koja omogućuje povećanje energetske efikasnosti toplotnog izvora:

- Promena režima sa 150/70 °C na 130/70 °C
- Primena ekonomajzera na dimnoj strani
- Primena automtizovanih gorionika sa O₂ regulacijom
- Primena frekventne regulacije b.o. elektromotora
- Automatizovan hemijski tretman vode
- SCADA sistem za nadzor, akviziciju i upravljanje celokupnim postrojenjem kotlarice

Poštujući savremene trendove uštede energije (goriva, el. energije) kao i ekološke zahteve zaštite čovekove okoline prilikom izbora opreme poštovani su sledeći principi:

- Visok stepen korisnog dejstva, > 94 %
- Mogućnost povećanja korisnog dejstva ugradnjom ekonomajzera za kondenzaciju dimnih gasova do 105%
- Nisko opterećenje ložišta, <2MW/m³
- Mala emisija NO_x s obzirom na ložište veće zapremine
- Veliki radni vek upotrebom zaštite hladnog kraja
- Prilagođavanje snage elektomotora trenutnim potrebama, upotrebom frekventnih regulatora
- Mogućnost nadogradnje sistema za akviziciju i nadzor radnih parametara, SCADA sistema
- Sigurnosna oprema birana prema standardima SRPS M.E6.204, DIN 4752 i EN12953
- Optimalan odnos vrednosti investicija – kvalitet opreme

Projektno rešenje omogućuje maksimalno iskorišćenje energije uz minimalno zagađenje okoline.

2.1 Koncept

Sistem se zasniva na šemi sa odvojenim hidrauličkim krugovima kotlovskog i distributivnog dela mreže. Distributivni deo mreže se sastoji odva nezavisna kruga za toplotovode "DOSITEJEVA" i "VOJVODE PUTNIKA" sa mogućnošću centralnog kvalitativnog regulisanja polazne temperature grejne vode. Zaštita kotla se vrši kotlovskim pumpama u kombinaciji sa trokrakim ventilom. Pumpe obezbeđuju konstantan protok kroz kotao zadate minimalne temperature povratne vode u ovom slučaju 110°C. Kotlovski hidrauliki krug se razdvaj hidrauličkom skretnicom od mrežnog kruga tako da nema hidrauličkog uticaja jedan u odnosu na drugi. U mrežnom krugu povratna voda se meša sa potisnom vodom u zavisnosti od spoljne temperature i sa željenom temperaturom koja je definisana kliznim dijagramom se cirkulacionom pompom distribuira do toplotne podstanice potrošača. Projektom je predviđena mogućnost podešavanja radne tačke pumpe ručno ili u automatskom režimu (PID regulacija) po $Dp=const$, tako da podržava lokalnu kvantitativno kvalitativnu regulaciju u podstanicama na tom području. Pumpe imaju mogućnost kontinualne promene broja obrtaja, takođe se vrši ugradnja kalorimetara sa ultrazvučnim davačem protoka na izlazu toplane.

Ekspanzioni sud se oprema "diktir" pumpama i pripadajućim regulatorima pritiska. Vrš se ugradnja automatizovane hemijske pripreme vode sa filterima delimičnog toka. Radi merenja i akvizicije karakterističnih parametara sistema ugrađuju se davači temperature i pritiska na svim karakterisptičnim mestima od uticaja na rad i praćenje celokupnog postrojenja, proizvođač kotla i gorionika svoju automatiku isporučuju sa mogućnošću komuniciranja sa nadređenim SCADA sistemom, a ceo sistem se povezuje u jedinstven SCADA sistem koji omogućuje praćenje, kontrolu i regulaciju postrojenja.

Svi podaci se memorišu u bazu podataka tako da je moguća naknadna analiza i kreacija izveštaja po svim bitnim kriterijumima rada postrojenja.

Slika 1: Šema hidrauličkih krugova

2.2 Sistem za nadzor i upravljanje radom gorionika – BMS (Burner Management System)

Projektom je predviđen sistem za nadzor i upravljanje radom gorionika koji omogućuje:

- elektronsku objedinjenu regulaciju
- O₂ merenje i regulaciju
- frekventno regulisane motore ventilatora
- merenje potrošnje goriva
- mogućnost povezivanja u nadređeni SCADA sistem

Sistem je razvio proizvođač ugrađenih gorionika WEISHAUPT. Konfiguracija sistema je data na sledećoj šemi:

Slika 2: BMS sistem rada gorionikom

Sistem omogućava da svi demperi na vazduhu za sagorevanje i na dovodu goriva imaju svoje servo uređaje sa motorima koji omogućuju preciznu kontrolu odnosa vazduh/gorivo za razliku od mehaničkih regulatora sa 10 položaja. O₂ regulacija omogućuje konstantno merenje sastava dimnih gasova na osnovu čega se vrši korekcija protoka – količine goriva i/ili vazduha putem servomotora a ujedno i preko frekventnog regulatora na karakteristik ventilatora.

Slika 3: BMS system rada gorionikom

2.3 Sistem za nadzor i upravljanje radom kotla

Izabrane kotlovske jedinice su kotlovi za loženje tečnog i gasovitog goriva, tropromajni sa izvedenom termoizolacijom niskom emisijom NO_x. Kotlovi su opremljeni sigurnosnom i zaštitnom opremom u skladu sa SRPS M.E6.204 I EN12953, DIN 4752 i TRD604. Zaštita hladnog kraja od niske temperature korozije se vrši trokrakim ventilom i kotlovskom pompom koji temperature vode na ulasku u kotao održava kontinualnom regulacijom na zadanom nivou. Razlika temperature na potisu i povratu se održava u granicama max. $\Delta T < 30^{\circ}\text{C}$. Kontrola rada ekonomajzera radi zaštite pothladjivanja dimnog gasa se vrši na vodenoj strani. Ostale veličine i parametri se mere odgovarajućim sondama-transmitterima pritiska i temperature. Merači protoka u toplotne energije su montirani na kotlu i na ekonomajzeru. U GRO je montirana mrežni analizator - jedinica za nadzor napona, struje i utroška električne energije za svki kotao posebno. Takođe je ugrađena i jedinica za korekciju $\cos\varphi$ i smanjenje reaktivne snage induktivnih elektro potrošača.

Kotao je opremljen termostata, presostaima, nivo prekidačima, davačima položaja i ostalom sigurnosnom armaturom u skladu sa standardima EN12953, DIN 4752, TRD604 i SRPS M.E6.204, a koji su deo sigurnosnog lanca rada kotla. Sa druge strane na kotlu su montirane i sonde – transmitteri fizičkih veličina koje su od značaja za praćenje rada postrojenja, ultrazvučni merači toplotne energije, sonde pritiska i temperature, O₂ sonde. U napojnim elektro ormanima su ugrađeni za svaki kotao zasebno mrežni analizatori – transmitteri struje, napona i aktivne i reaktivne električne energije koju kotao troši za pomoćne sisteme.

Slika 4: Sigurnosni lanac kotla i sigurnosna oprema

- D08.000 - Sigurnosni ventil kotla – podešenavrednost otvaranja 9,2 bar
- D10.004 - Sigurnosni graničnik temperature "STB" – podešena vrednost 150°C
- D10.104 - Sigurnosni graničnik temperature "STB" – podešena vrednost 150°C
- D10.013 - Sigurnosni graničnik protoka "FLOW SWICH"
- D10.014 - Senzor temperature – temperature potisa - (mazut 140 °C, gas 130 °C)
- D11.002 - Senzor temperature – temperature povrata – (mazut 111 °C, gas 100 °C)

Slika 5: P&ID dijagram merenih veličina na kotlu

Slika 6: Aplikaciona šema merenih veličina na kotlu

Tabela 1: Merne veličine na kotlu

Red. broj	Oznaka senzora	Opis signala	Tip signala		
			DI	AI	Komunikacioni protokol
1	TIC-01	Temperatura vode na ulazu u kotao		1	
2	TI-09	Temperatura dimnog gasa iz ekonomajzera		1	
3	TIC-03	Temperatura vode na ulazu u ekonomajzer		1	
4	TI-04	Temperatura vode na povratu kotla		1	
5	TI-05	Temperatura vode na potisu kotla		1	
6	TI-06	Temperatura vode iz mreže na ulazu u ekonomajzer		1	
7	TI-08	Temperatura vode na izlazu ekonomajzera		1	
8	TI-10	Temperatura vazduha za sagorevanje		1	
9	TI-11	Temperatura gasa		1	
10	TI-12	Temperatura mazuta		1	
11	FQR01	Protok vode kroz kotao			1
12	FQR02	Protok gasa	1		
13	FQR03	Protok mazuta	1		
14	FQR04	Protok vode kroz ekonomajzer			1
15	PI-01	Pritisak na povratku kotla		1	
16	PI-02	Pritisak na potisu kotla		1	
17	PI-03	Pritisak vazduha za sagorevanje		1	
18	PI-04	Pritisak gasa		1	
19	PI-05	Pritisak mazuta		1	
		Signalni statusi		n	
		Alarmi iz KO1			
		Komunikacija sa ABE modulom na gorioniku		1	

D11.004 - Termostat predupozorenje – zaštita hladnog kraja kotla - (mazut 110°C, gas 90 °C)

D11.104 - Termostat isključenje gorionika – zaštita hladnog kraja kotla -(mazut 108°C, gas 88 °C)

D14.002 – Sigurnosni graničnik maksimalnog pritiska – podešena vrednost (8,2 bar)

D14.006 – Sigurnosni graničnik minimalnog pritiska – podešena vrednost (5 bar)

D14.007 – Sigurnosni krajnji prekidač

D15.006 – Sigurnosni graničnik nivoa vode (nivoelektroda)

W32.002 - On/off motor klapne u ekonomajzeru za produkte sagorevanja

W32.D21 – Sigurnosni graničnik temperature (STB) ekonomajzera –120°C

W32.016 – Sigurnosni ventil ekonomajzera –otvaranja sigurnosnog ventila je 9,2 bar

W32.025 - Senzor temperature – ulazna temperatura vode u ekonomajzer – za gas 60°C

2.4 SCADA sistem

Postrojenje se nadzire i upravlja sa jednog mesta, tako da je projektom merenja i regulacije predviđen centralni PLC za nadzor i upravljanje celokupnog sistema. Svi regulacioni krugovi na kotlu i gorioniku su upravljani lokalno sa regulatorima koje isporučuje proizvođač kotla odnosno gorionika sa mogućnošću komuniciranja sa nadređenim NEUBERGER SCADA sistemom. U okviru kotlarnice je predviđen elektrokomandni orman sa centralnim NEUBERGER PLC regulatorom i pratećom opremom. Centralni PLC nadgleda regulacioni krug temperature i novoa kao i stanja i statuse pritiska, temperature i protoka, takođe komunicira sa lokalnim PLC regulatorima kotla i gorionika i prati predviđena stanja. U prostoriji elektroormana je smešten kontrolni "touch" panel za lokalno praćenje i kontrolu radnih parametara kao i priključno mesto za prenosni računar sa SCADA aplikacijom time je moguće preuzeti rad sistemom u slučaju ispada PC računara preko koga operater nadzire SCADA softver. Nadređeni SCADA softverska aplikacija je instalirana na PC računaru koji se nalazi na drugoj lokaciji u Centralnoj Toplani tako što je komunikacija ostvarena Wlan bežičnim internetom.

Predviđeni sistem automatskog upravljanja, organizovan je u tri nivoa:

- oprema u polju – merni i izvršni elementi (senzori, termostati, presostati, regulacioni ventili, pokretači žaluzina itd.),
- automatske podstanice – programabilni kontroleri sa odgovarajućim programskim paketima,
- centralni računar sa odgovarajućim programskim paketima neophodnim za efikasan nadzor i upravljanje tehničkim sistemima objekta (centralni računar nije predmet ovog projekta).

Predviđeni sistem automatskog upravljanja obezbeđuje:

- efektivno funkcionisanje tehničkih sistema objekta putem centralnog nadzora i automatizovanog ispunjavanja funkcija upravljanja opremom,
- daljinsku kontrolu i upravljanje opremom tehničkih sistema,

- dobijanje informacija o statusu i parametrima opreme tehničkih sistema u obliku pogodnom za operatera,
- povećanje sigurnosti, bezbednosti i kvaliteta funkcionisanja opreme tehničkih sistema,
- praćenje i racionalnije korišćenje energetskih resursa sa ciljem omogućenja ušteda energenata uz održanje komfora,
- automatizovano praćenje eksploatacije opreme u cilju blagovremenog sprovođenja aktivnosti preventivnog i korektivnog održavanja,
- racionalno dimenzionisanje i organizovanje službe održavanja,
- smanjenje troškova održavanja
- dokumentovanje i registrovanje toka tehnoloških procesa, rada tehničkih sistema i aktivnosti angažovanog osoblja,
- lokalnu i daljinsku kontrolu tehnoloških parametara,
- lokalno i daljinsko upravljanje uređajima i sistemima objekta,
- automatsku regulaciju zadatih tehnoloških parametara i upravljanje tehničkim sistemima u skladu sa zadatim režimima rada,
- automatsko isključenje neispravnog agregata i uključenje rezervnog (gde je moguće),
- signalizaciju alarmnih i predalarmnih stanja tehničkih sistema,
- registrovanje uključenja i isključenja opreme, kvarova i neispravnosti u radu CSNU,
- registrovanje osnovnih tehnoloških parametara,
- generisanje i arhiviranje izveštaja o radu tehničkih sistema objekta,
- pristup sistemu sa drugih lokacija,
- definisanje različitih nivoa pristupa sistemu u skladu sa nadležnostima.

Predviđena automatska podstanica – kontroleri imaju mogućnost autonomnog rada u slučaju prekida komunikacije sa centralnim računarom i mogućnost komunikacije sa drugim kontrolerima u sistemu bez učešća centralnog računara.

Sistem automatskog upravljanja obezbeđuje sledeće funkcije u okviru sistema:

- signalizaciju poremećaja napona napajanja ormana elektromotornog pogona,
- signalizaciju alarma kvara svakog motornog potrošača (sa zaštitnog prekidača),
- radni status svakog motora,
- mogućnost daljinskog upravljanja svim uređajima,
- merenje svih potrebnih veličina (temperature, pritiska),
- signalizaciju alarma zaštitnih termostata,
- merenje utroška energenata preko Mbus protokola
- vrednost regulacionih signala.
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- SCADA sistemom je obuhvaćeno 798 info tačaka koje se arhiviraju na godinu dana
- Primenjene komunikacije su: PROFIBUS sa regulacionim modulima u polju, MODBUS RTU sa gorionicima i mrežnim analizatorima postrojenja i sva tri kotlari MBUS sa kalorimetrima kotla, kalorimetrima ekonomajzera i kalorimetrima konzuma
- Postoje sledeći merno regulacioni krugovi sa PID regulacijom: Održavanje polazne temperature kotla (3 kruga), održavanje povratne temperature kotla (3 kruga), održavanje temperature ekonomajzera (3 kruga), održavanje polazne temperature ka mrežama (2 kruga), održavanje diferencijalnog pritiska mreže (4 kruga – za svaku pumpu po jedan), održavanje pritiska diktir sistema (2 kruga – za svaku pumpu po jedan), održavanje pritiska azota u ekspanzionoj posudi (1 krug), grejanje omekšane vode u ekspanzionom sudu (jedan krug), grejanje mazuta u cisternama (1 krug)
- Postoje 4 impulsna brojača (vodomer + gasni merači) a potencijalno će se meriti i potrošnja mazuta
- Za sve diskretne izvršne elemente se vrši proračun broja radnih sati
- Fizički ulazi/izlazi: 208 digitalnih ulaza, 37 digitalnih izlaza, 76 analognih ulaza, 21 analogni izlaz

2.5 Grupa standarda za određivanje energetskih zahteva i efikasnosti termotehničkih sistema SRPS EN 15316

Ova grupa standarda definiše algoritam određivanja energetskih potreba i stepena efikasnosti termotehničkih sistema prvenstveno u stambenim zgradama. Baziran je na međunarodnim normama evropskog komiteta za standardizaciju CEN/TC 228 i sastoji se od 14 celina koje obuhvataju:

SRPS EN 15316-1:2012 Sistemi grejanja u zgradama, Metoda proračuna energetskih zahteva i efikasnosti sistema — Deo 1: Opšte

SRPS EN 15316-2-1:2012 Sistemi grejanja u zgradama, Metoda proračuna energetskih zahteva i efikasnosti sistema — Deo 2-1: Sistemi zračenja za grejanje prostora

SRPS EN 15316-2-3:2012 Sistemi grejanja u zgradama, Metoda proračuna energetskih zahteva i efikasnosti sistema - Deo 2-3: Distributivni sistemi za grejanje prostora

SRPS EN 15316-3-1:2012 Sistemi grejanja u zgradama – Metoda proračuna energetskih zahteva i efikasnosti sistema - Deo 3-1: Sistemi za pripremu potrošne tople vode, pokazatelj ipotreba (zahtevi izlivanja)

SRPS EN 15316-3-2:2012 Sistemi grejanja u zgradama, Metoda proračuna energetskih zahteva i efikasnosti sistema — Deo 3-2: Sistemi za pripremu potrošne tople vode, distribucija

SRPS EN 15316-3-3:2012 Sistemi grejanja u zgradama, Metoda proračuna energetskih zahteva i efikasnosti sistema — Deo 3-3: Sistemi za pripremu potrošne tople vode, proizvodnja

SRPS EN 15316-4-1:2012 Sistemi grejanja u zgradama , Metoda proračun energetskih zahteva i efikasnosti sistema

— Deo 4-1: Sistemi zaproizvodnju toplote za grejanje prostora, sistemi za sagorevanje (kotlovi)

SRPS EN 15316-4-2:2012 Sistemi grijanja u zgradama, Metoda proračuna energetskega zahteva i efikasnosti sistema
— Deo 4-2: Sistemi za proizvodnju toplote za grejanje prostora, sistemi sa toplotnim pumpama

SRPS EN 15316-4-3:2012 Sistemi grijanja u zgradama, Metoda proračuna energetskega zahteva i efikasnosti sistema
— Deo 4-3: Sistemi za proizvodnju toplote, termalno-solarni sistemi

SRPS EN 15316-4-4:2012 Sistemigrijanja u zgradama, Metoda proračuna energetskega zahteva i efikasnosti sistema
— Deo 4-4: Sistemi za proizvodnju toplote, sistemi kogeneracije ugrađeni u zgradu

SRPS EN 15316-4-5:2012 Sistemigrijanja u zgradama, Metoda proračuna energetskega zahteva i efikasnosti sistema
— Deo 4-5: Sistemi za proizvodnju toplote zag rejanje prostora, pokazatelji i kvalitet daljinskog grejanja i sistemi velikih zapremina

SRPS EN 15316-4-6:2012 Sistemigrijanja u zgradama, Metoda proračuna energetskega zahteva i efikasnosti sistema
— Deo 4-6: Sistemi za proizvodnju toplote, fotonaponskisistemi

SRPS EN 15316-4-7:2012 Sistemigrijanja u zgradama, Metoda proračuna energetskega zahteva i efikasnosti sistema
— Deo 4-7: Sistemi zaproizvodnju toplote za grejanje prostora, sistemi za sagorevanje biomase

SRPS EN 15316-4-8:2012 Sistemigrijanja u zgradama, Metoda proračuna nergetskegih zahteva ie efikasnosti sistema
— Deo 4-8: Sistemi za proizvodnjut oplote za grejanje prostora, grejanje vazduhom i nadzemni sistemi za grejanje zračenjem,

2.6 SRPS EN 15316-4-1:2012 Sistemi za proizvodnju toplote za grejanje prostora, sistemi za sagorevanje (kotlovi)

Standard daje metodologiju za proračun efikasnosti kotlova za proizvodnju toplotne energije i može poslužiti da se ilustruje kako primenom SCADA sistema i akvizicijom merenih parametara pri proizvodnji toplotne energije može da se direktno generiše izveštaj stepena efikasnosti pri sagorevanju i proizvodnji toplotne energije bez sprovođenja

relativno komplikovanog računa koji iziskuje korišćenje mnoštvo tabela i preporuka za procenu pojedinih gubitaka, a koji se u okviru SCADA sistema mere i generišu direktno iz procesa. Standard daje tri postupka procene, kalkulacije u zavisnosti od uslova rada i eksploatacije kotla – generatora toplote.

1. Pojednostavljena metoda koja zahteva adekvatne ulazne podatke obzirom na ulsove rada generatora. Metoda daje procenu na nivou grejne sezone. Ulazni podaci od značaja su: Klimatski uslovi, režimi rada generatora, Tipologija distribucije i potrošača koji su priključeni na generator (stambeni, poslovni, industrijski...). Na osnovu navedenih inputa vrši se korekcija standardnog testa efikasnosti kotla (fabričkog ispitivanja koje se radi u skladu Direktive 92/42 EEC) u efikasnost generatora na nivou grejne sezone
2. Metoda detaljnog proračuna se takođe zasniva na standardnom testu efikasnosti kotla definisanom u Direktivi 92/42 EEC uzimajući detaljnije u obzir uslove eksploatacije za konkretno postrojenje: tip i karakteristika kotla i gorionika, režime rada, tip automatike kotla, lokaciju kotla, uslove rada, zahteve potrošača za toplotnom energijom, sepe ne efikasnosti pri 100% opterećenja, pri delimičnom opterećenju i toplotne gubitke genertaora pri 0% opterećenju. Osim na nivou sezone metoda daje rezultate i za kraće vremenske intervale (sedmično, mesečno)
3. Treća metoda daje tačnu procenu gubitaka tokom eksploatacije, gubitke pri procesu sagorevanja, gubitke toplotne izolacije, energiju za pomoćne sisteme i energiju koja se vraća u sistem. Uzima se u obzir vereme pogone kotla, vreme u stand-baj modu, vrši se određivanje gubitaka za svaki režim rada. Neke od ovih parametara je moguće odrediti merenjem tokom eksploatacije pa je metoda pogodna za primenu u automatizovanim postrojenjima sa implementiranim SCADA sistemom koji vrši akviziciju i arhiviranje merenih parametara u rial-tajm vremenu. Na osnovi tih podataka moguće je generisati izveštaj prema metodologiji standarda.

Slika 7: Toplotni bilans kotla-generatora toplote i njegovih podsistema (treća metoda)

$Q_{H,gen,out}$ – toplotna energija na izlazu iz podsistema proizvodnje (kWh);

$Q_{H,gen,ls}$ – ukupni toplotni gubici podsistema proizvodnje (kWh);

$WH_{gen,aux}$ – pomoćna energija podsistema proizvodnje (kWh);

$QH_{gen,ls,rbl}$ – vraćena toplotna energija u podsistem proizvodnje (kWh);

$QH_{gen,nrbl}$ – neiskoristivi toplotni gubici pomoćnih uređaja podsistema proizvodnje (kWh);

$EH_{gen,in}$ – toplotna energija na ulazu u podsistem proizvodnje (kWh);

$QH_{gen,out}$	Meri se	Ultrazvučni merač toplotne energije na kotlu	$FQR01$
$QH_{gen,ls}$	Meri se deo koji se odnosi na dimni gas	Sonda O2 u sklopu BMS sistema za rad gorionika	
$WH_{gen,aux}$	Meri se	Uređaj za nadzor napona, struje, aktivne i reaktivne energije u okviru napojnih elektro ormara za svaki kotao	
$QH_{gen,ls,rbl}$	Meri se	Ultrazvučni merač toplotne energije na ekonomajzeru	$FQR04$
$EH_{gen,in}$	Meri se	Merači protoka gasa	$FQR02$

2.7 Struktura investicije i izvori finansiranja

Troškovi nabavke i izgradnje bili bi 1.406.100 € koji su se obezbedili preko kfw kredita i sopstvenih sredstava.

Tabela 2: Struktura troškova izgradnje

Obezbeđenje projekta	KfW kredit	Učešće Toplana
Pribavljanje potrebne dokumentaciju za gradnju	/	16.000€
Nabavka opreme i mašinski radove	720.000€	336.000€
Elektro radovi	99.000€	15.000€
Merenje i regulacija	78.000€	/
Gradevinski radovi i parterno uređenje	104.000€	28.000€
Vršenje stručnog nadzora nad izgradnjom i konsultantske usluge	3.700€	1.900€
Tehnički prijem i Upotrebna dozvola	/	4.500€
U K U P N O	1.004.700€	401.400 €

2.8 Ekonomska ocena projekta

Osim smanjena godišnjih troškova remonta savremena tehnološka rešenja omogućuju uštedu goriva i električne energije:

Smanjeni su godišnji troškovi remonta prema evidenciji zadnjih nekoliko sezona iznose 800.000,00dinara

Stepen korisnosti kotla je za 100% snage 91%

Regulacijom gorionika po O2 postiže se stepen korisnosti 94%

Primenom ekonomajzera postignuto je povećanje stepena korisnosti do 98%

Primenom frekventnih regulatora reaktivna snaga elektromotora je 0kW odnosno $\cos\phi=1$, analizom maksigrafa i računa za el. energiju ustanovljena je ušteda od 0.13€/MWh proizvedene toplotne energije. Ovim projektom je osim cirkulacionih pumpi predviđena i frekventna regulacija ventilatora gorionika pa bi procenjena ušteda bila oko 0.25€/MWh proizvedene toplotne energije.

Prost period otplate iznosi 14.5 godina.

Tabela 3: Ostvarena finansijska korist projekta

			godišnje
Smanjeni troškovi remonta		Na osnovu pregleda faktura i račna iz ranijih godina , dimne cevi	11.000€
		Remont gorionika	8.000€
Povećan stepen korisnosti	$0.94+0.40=0.98$	$\frac{32330000}{9} \times 0.07 = 251.455 \text{ Nm}^3/\text{h} \times 23,00 + \text{PDV}$	69.400€
Ušteda električne energije	$35.000 \text{ MWh} \times 0.25\text{€}$	Na osnovu pregleda računa iz ranijih godina i procene	8.750€
ukupno			97.150€

3. ZAKLJUČAK

U strukturi troškova investicije uočljivo je da je deo koji se odnosi na merenje i regulaciju i implementaciju SCADA softvera srazmerno mali u odnosu na druge celine u izvođenju pa treba težiti da se primenjuje u ovoj vrsti

postrojenja jer se omogućuje akvizicija i analiza bitnih parametara za ocenu efikasnosti i ekonomičnosti rada toplotnih izvora u sistemima daljinskog grejanja.

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Measurement, Management and Visualisation of the Thermal Energy Production Process in the Boiler Facility „Nova Kolonija“, Public Energy Company Kraljevo

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This paper deals with the reconstruction of heat source - boiler facility as a part of the district heating system (DHS) with the applied energy efficiency measures. In addition to replacement of boilers and outdated equipment with new highly efficient equipment, emphasis is given to the implementation of SCADA (BMS) control system, management and acquisition of the parameters. Technological facility is equipped with transducers of the physical quantities of energy which is essential for performance monitoring and energy efficiency assessment of the boiler facility at the level of produced energy and from the combustion process to the heat distribution on the heating source. Measured quantities are: fuel consumption, thermal energy produced in the boiler, utilization of thermal energy from the flue gas, transferred heating energy on the heating source, the products of combustion in the flue gas, electricity expenditure, other sizes of pressure and temperature. Assessment of energy efficiency of heat generators - the boiler is done according to EN standards. Paper, except technical description of the system depicts the methodology of determining the efficiency of the boiler according to the standard SRPS EN 15316-4-1:2012.

Keywords: Central heating system, energy efficiency, degree of efficiency, SCADA

1. INTRODUCTION

Within the Rehabilitation of Remote Heating System in Serbia Programme, phase III co-financed by Government of Federal Republic of Germany, KfW Development Bank and Government of Republic of Serbia, PEC Toplana Kraljevo participated with 14 projects. The total value of projects was financed from a loan in the amount of € 3,351,955, subsidies in the amount of €921,788 and Toplana Kraljevo contribution in the amount of € 1,780,000. Through the project equipment was procured and works were performed in the following facilities:

- I. Boiler plants - purchased 4 boilers total installed power of 62.5MW, which makes up 80% of the total installed power of the heating plant. The boilers were installed in the boiler house Nova Kolonija 3x12MW; it was put into operation in October 2011 and during its work it achieved (thermal) efficiency of 98%. 2 boilers were installed in Central heating plant and put into operation in 2009 and 2010, and achieved (thermal) efficiency of 96%.
- II. Heating network - the factory pre-insulated heating pipes were purchased and installed in length of cca 20 km and thus savings in water loss and thermal heat loss in the pipelines were achieved. New pipelines have enabled safe heating and provide the opportunity to connect new users in line with the capacity of boiler plants mentioned in the previous paragraph.
- III. Substations – 110 substations were purchased and installed with which old substations were reconstructed and thus attained better heating and saving possibilities

by connecting to the central remote monitoring, control and management.

- IV. Thermal energy measuring devices - 120 measuring devices were purchased and installed as well as 116 measuring devices which were installed within new substations. PEC Toplana purchased 120 measuring devices from its own funds and thus enabled the measurement of heat energy in all substations.

All other equipment: chimneys, pumps, collectors, HPV, locking and other armature have been installed in Central heating plant and heating plant Zelena Gora thus achieved complete realization of KfW program, phase III. By implementing the KfW - III project, a part of "the complete system" of PEC Toplana was finished and thus achieved the following benefits:

- Better efficiency in boiler plants
- Automatic operation and control of boiler houses
- Reduced emissions of NO_x and CO₂, reduced negative impact on the environment
- Measurement of delivered heating energy on the threshold of boiler house
- Safety in the operation of boiler plants
- Safety in the delivery of heating energy
- Higher level of training and education of workers in the production and distribution of heat energy
- Reduced losses in the distribution network and better energy efficiency parameters
- Energy efficiency was achieved by replacing the substations, and enables measurement of heat energy delivered to final customer.

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- The automatic work of substations and connecting to the system of remote control and management was enabled
- All consumers are covered by installation of measurement devices and technical conditions for payment and application of tariff system are prepared.

2.PROJECT DESCRIPTION

Through the project implementation, the replacement of boiler units in boiler house Nova Kolonija was realised, bearing in mind that the old boilers were built in 1975 (2 pieces of VIESSMANN and 1 piece of MINEL). The boilers were worn out and during the heating season bursting - leaks in the fire tubes and blow pipes were frequent which required frequent interruptions in the heat supply and overhauling costs of them. The project included a replacement of old boilers with three new 3x12 MW completed with burners, economizers and other additional equipment for fuel supply, protection of the cold end and chemical water treatment.

Besides the mere replacement of boilers, within this Project, PEC Toplana wanted to realize and apply modern technological solution in this area, and to install equipment that enables increased energy efficiency of the heat source:

- Changing the regime mode from 150/70 °C to 130/70 °C
- Application of the economizer on the smoke side
- Application of automated burners with O₂ control/regulation
- Application of frequency control of b.o. electric motor
- Automated chemical water treatment
- SCADA monitoring system, acquisition and management of the entire boiler plant

- High degree of efficiency > 94%
- The possibility of increasing the efficiency by installing of the economizer for the condensation of flue gases up to 105%
- Low firebox load < 2MW/m³
- Small NO_x emissions in relation to the greater volume of the firebox
- Long working life by using cold-end protection
- Adjusting the power of the electric motor to the current needs, by using frequency regulators
- Possibility of upgrading the system for acquisition and control of operating parameters, SCADA system
- Safety equipment is selected according to standards SRPS M. E6.204, DIN 4752 and EN12953
- Optimal ratio of investment value - quality of equipment

The Project solution allows maximum utilization of energy with minimal pollution of the environment.

2.1 Concept

The system is based on scheme with separate hydraulic circuits of boiler and distribution part of network. Distribution part of network consists of two independent circuits for heating lines "DOSITEJEVA" and "VOJVODE PUTNIKA" with the possibility of central qualitative regulation of the heating water starting temperature. The protection of the boiler is performed by boiler pumps in combination with three-way (reversing) valve.

The pumps provide a constant flow through the boiler with set minimum temperature of returning water - in this case 110°C. The boiler hydraulic circuit is separated by hydraulic switch from network circuit so there is no hydraulic impact in relation to each other.

Figure 1. - Scheme of hydraulic circuits

Respecting the contemporary trends in energy savings (fuel, electricity) as well as ecological requirements in environmental protection, the following principles were taken into account in the selection of equipment:

In network circuit, the returning water is mixing with pressure water in relation to the outdoor temperature and with the desired temperature which is defined by a sliding

diagram and by the circulation pump is distributed to the heat substation of the consumer.

Project foresees the possibility of adjustment the operating point of pump manually or in automatic regime (PID control) by $D_p = \text{const}$, so it supports local quantitative/qualitative regulation in substations in that area. The pumps have the possibility of continuous change of revolving number and installation of calorimeters with an ultrasonic flow probe at the exit of the heating plant is also done.

Expansion vessel is equipped with "dictating" pumps and belonging pressure regulators. Installation of automated chemical preparation of water with partial flow filters is carried out.

2.2 Burner Management System - BMS Burner Management System

The Project envisages a system for monitoring and managing of the operation of the burner that provides:

- Electronic unified regulation
- O_2 measurement and regulation
- Frequency controlled motors of the fan
- Measurement of fuel consumption
- The possibility to connect to the superior SCADA system

The system was developed by a manufacturer of embedded burners -WEISHAUPT. System configuration is given in the following scheme:

Figure 2: BMS burner system

The system allows that all the dampers on the air for combustion and on the fuel, supply have their servo devices with engines that allow their precise air/fuel ratio control as opposed to 10-position mechanical controllers. The O_2 regulation allows continuous measuring the composition of flue gases on which basis the flow is adjusted – quantity of fuel and/or air through the servomotor and at the same time through the frequency regulator to the ventilator characteristics. The parametric model of the human mandible is a geometric model defined as a point cloud. Each point in point cloud is defined by a parameter function.

In order to measure and acquisition of system characteristic parameters, temperature and pressure encoders are installed in all characteristic locations which have impact on operation and monitoring of the entire plant; the boiler and burner manufacturer delivers its automation with the ability to communicate with the superior SCADA system, and the entire system is connected into a single SCADA system that allows the tracking, the control and regulation of the plant. All data is stored in the database so that it is possible to subsequently analyze and create reports on all essential operating criteria of the plant.

Figure 3: BMS burner system

2.3 The boiler monitoring and management system

Selected boiler units are boilers for liquid and gaseous fuels, triple drought, with the derived thermal insulation low NOx emission. The boilers are equipped with safety and protective equipment in accordance with SRPS M.E6.204 and EN12953, DIN 4752 and TRD604. The protection of cold end of the low-temperature corrosion is performed with three-way valve and boiler pump which maintain water temperature at the entrance to the boiler by continuous regulation at a set level.

The temperature difference between the push and reverse is maintained within the limits of max. $\Delta T < 30^\circ\text{C}$. For the protection of flue gas cooling, the control of economizer work is done on the water side. Other sizes and parameters are measured with appropriate probes pressure and temperature transmitters.

The heat energy flow measurers are installed on the boiler and on the economizer. A network analyzer is installed in GRO - a unit for voltage monitoring, electricity and electricity consumption for each boiler separately.

Also, the unit for correction of $\cos\phi$ and reduction of the reactive power of inductive electro consumers has been installed.

The boiler is equipped with thermostats, pressure switches, level switches, position transmitters and other safety armatures in accordance with standards EN12953, DIN4752, TRD604 and SRPS M.E6.204, which are a part of the safety chain of the boiler performances.

On the other side, the probes - physical size transmitters that are important for monitoring the operation of the plant, ultrasonic heat measurers, pressure and temperature probes, O₂ probes, are also installed on the boiler. Separate network analyzers - transmitters of electricity, voltage and active and reactive electricity that boiler consumes for auxiliary systems - are installed for each boiler in feed electro-cupboards.

Figure 4: Safety boiler chain and safety equipment

D08.000-Boiler safety valve - set value of the opening 9.2 bar
 D10.004-Safety temperature limiter "STB" - set value of 150°C
 D10.104-Safety temperature limiter "STB" – set value of 150°C
 D10.013-Safety flow limiter "FLOW SWICH"
 D10.014-Temperature sensor - push temperature - (oil fuel 140°C, gas 130°C)
 D11.002-Temperature sensor - reverse temperature - (oil fuel 111°C, gas 100°C)
 D11.004-Thermostat precaution – protection of boiler's cold end - (oil fuel 110°C, gas 90°C)
 D11.104-Thermostat burner disengagement protection of boiler's cold end - (oil fuel 108°C, gas 88°C)
 D14.002-Safety maximum pressure limiter - set value (8.2 bar)
 D14.006-Safety minimal pressure limiter - set value (5 bar)
 D14.007-Safety end switch
 D15.006-Safety level water limiter (level electrode)
 W32.002-The On/off motor flap into the economizer for combustion products
 W32.D21- Safety temperature limiter of the economizer (STB) - 120°C
 W32.016- Safety valve of economizer - opening security valve is 9.2 bar
 W32.025 - Temperature sensor - input temperature water into economizer - for gas 60°C

Figure 5: P&ID diagram of the measured values on the boiler

Figure 6: Application chart of the measured values on the boiler

Table 1: Measured values on the boiler

No	Sensor label	Signal description	Signal type		
			DI	AI	Communication protocol
1	TIC-01	Water temperature at the entrance to the boiler		1	
2	TI-09	Gas temperature from the economizer		1	
3	TIC-03	Water temperature at the entrance to the economizer		1	
4	TI-04	Water temperature on boiler return		1	
5	TI-05	Water temperature on boiler pressure		1	
6	TI-06	Water temperature from the net at the entrance to the economizer		1	
7	TI-08	Water temperature at the economizer exit		1	
8	TI-10	Air temperature for combustion		1	
9	TI-11	Gas temperature		1	
10	TI-12	The temperature of the low pressure fuel oil		1	
11	FQR01	Water flow through the boiler			1
12	FQR02	Gas flow	1		
13	FQR03	Oil fuel flow	1		
14	FQR04	Water flow through the economizer			1
15	PI-01	Pressure on the return of the boiler		1	
16	PI-02	Pressure on the inlet of the boiler		1	
17	PI-03	Air pressure for combustion		1	
18	PI-04	Gas pressure		1	
19	PI-05	Oil fuel pressure		1	
		Signal statuses and alarms from KOI	n		
		Communication with the ABE module on the burner		1	

2.4 SCADA system

The plant is monitored and managed from one location, so the project of measurement and regulation provides a central PLC for monitoring and management of the entire system. All boiler and burner control circuits are managed locally with regulators supplied by the boiler or burner manufacturer, with the ability to communicate with the superior NEUBERGER SCADA system.

There is an electric cabinet with a central NEUBERGER PLC regulator and additional equipment within the boiler room.

The central PLC monitors, the control circuits of temperature and level as well as the conditions and states of pressure, temperature and flow, also communicates with the local PLC controllers of the boiler and burner and monitors the predicted states. In the electro cupboard room there is a control "touch" panel for local monitoring and control of operating parameters as well as a connection point for a notebook with SCADA application, so it is possible to take over the operation of the system in the event of a PC failure through which the operator is monitoring the SCADA software. The superior SCADA software application is installed on a PC computer located at a different location in Central heating plant and communication is achieved by WLAN wireless internet. The planned automatic management system is organized in three levels:

- Equipment in the field - measuring and executing elements (sensors, thermostats, pressure regulators, control valves, blinds drivers, etc.)
- Automatic substations - programmable controllers with corresponding software packages,
- A central computer with appropriate software packages necessary for efficient monitoring and management of technical systems of the facility (the central computer is not the subject of this project).

The foreseen automatic management system provides:

- The effective functioning of the facilities technical systems through central monitoring and the automated fulfillment of equipment management functions,
- Remote control and management of technical systems equipment,
- Obtaining information on the status and parameters of the technical systems equipment in a form suitable for the operator,
- Increasing safety, security and quality of functioning of the technical systems equipment,
- Monitoring and rational use of energy resources with the aim of enabling energy savings while maintaining comfort,
- Automated monitoring of the equipment exploitation in order to timely implement preventive and corrective maintenance activities,
- Rational dimensioning and organization of the maintenance service,
- Reduction of maintenance costs
- Documenting and registering the flow of technological processes, the technical systems operations and the activities of engaged personnel,
- Local and remote control of technological parameters,

- Local and remote control of the facility devices and systems,
- Automatic regulation of set technological parameters and management of technical systems in accordance with set operating modes,
- The automatic shutdown of the faulty generator and the activation of the backup (where possible),
- Signalization of alarm and pre-alarm state of technical systems,
- Registration of starting and shutting down of equipment, defects and malfunction in the CSNU performance,
- Registration of basic technological parameters,
- Generating and archiving reports on the performances of the facility technical systems,
- Access to a system from other locations,
- Defining different levels of system access in accordance with the competencies.

Foreseen automatic substation - controllers have the possibility of autonomous operation in case of interrupted communication with the central computer and the possibility of communication with other controllers in the system without the participation of the central computer. The automatic management system provides the following functions within the system:

- signaling voltage disruption of the power supply of the electric motor drive cabinets,
- alarm signal failure of each motor consumer (from a protected switch),
- working status of each engine,
- possibility of remote control of all devices,
- measuring all the necessary values (temperature, pressure),
- signaling alarm of protection thermostats,
- measurement of energy consumption through the MBUS protocol,
- the value of the control signals,
- SCADA system includes 798 info points which are archived on the one-year period
- Applied communications are: PROFIBUS with regulatory modules in the field, MODBUS RTU with burners and network analyzers of plants and all three boilers, MBUS with boiler calorimeters, economizer calorimeters and consumption calorimeters
- There are the following measuring control circuits with PID control: Maintenance of the boiler starting temperature (3 circuits), maintenance of the boiler reverse temperature (3 circuits), maintenance of economizer temperature (3 circuits), maintenance starting temperatures towards networks (2 circuits), maintenance of network differential pressure (4 circuits - one per each pump), maintenance of diktir system pressure (2 circuits - one per each pump), maintenance of nitrogen pressure in expansion vessel (1 circuit), heating of softened water in expansion vessel (1 circuit), heating of oil fuel in tanks (1 circuit)
- There are 4 impulse counters (water meter + gas meters) and consumption of crude oil will be measured potentially

- For all discrete executive elements, the calculation of the number of working hours is performed
- Physically inputs/outputs: 208 digital inputs, 37 digital outputs, 76 analogue inputs, 21 analogue outputs

2.5 Group of standards for determination of energy requirements and efficiency of thermo-technical systems SRPS EN 15316

This group of standards defines the algorithm for determining energy needs and the degree of efficiency of thermo technical systems, primarily in residential buildings. It is based on the international standards of the European Committee for Standardization CEN/TC 228 and consists of 14 units that include:

SRPS EN 15316-1:2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 1: General

SRPS EN 15316-2-1:2012 Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 2: Space emission systems (heating and cooling)

SRPS EN 15316-2-3: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 2-3: Space heating distribution systems

SRPS EN 15316-3-1: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 3-1: Domestic hot water systems, characterization of needs (tapping requirements)

SRPS EN 15316-3-2: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 3-2: Domestic hot water systems, distribution

SRPS EN 15316-3-3: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 3-3: Domestic hot water systems, generation

SRPS EN 15316-4-1: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space heating generation systems, combustion systems (boilers)

SRPS EN 15316-4-2: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-2: Space heating generation systems, heat pump systems

SRPS EN 15316-4-3: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-3: Heat generation systems, thermal solar systems

SRPS EN 15316-4-4: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-4: Heat generation systems, building-integrated cogeneration systems

SRPS EN 15316-4-5: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-5: Space heating generation systems, the performance and quality of district heating and large volume systems

SRPS EN 15316-4-6: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-6: Heat generation systems, photovoltaic systems

SRPS EN 15316-4-7: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-7: Space heating generation systems, biomass combustion systems

SRPS EN 15316-4-8: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-8: Space heating generation systems, air heating and overhead radiant heating systems

SRPS EN 15316-4-1: 2012 Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space heating generation systems, combustion systems (boilers)

The standard gives a methodology for calculating the efficiency of boilers for production of heat energy and can be illustrated by the use of SCADA systems, and the acquisition of measured parameters in the production of heat energy can directly generate a report on the efficiency degree in combustion and production of heat energy without implementing a relatively complicated calculation which requires use of multiple tables and recommendations for assessment of individual losses, which are measured and generated directly from the process within the SCADA system. The standard provides three assessment methods, calculations depending on conditions of operating and exploitation of the boiler - heat generator:

1. A simplified method that requires adequate input data considering the operating conditions of the generator. The method gives an assessment at heating season level. Input data of importance are: climate conditions, generating modes, distribution and consumers connected to the generator (residential, business, industrial...) typology. On the basis of these inputs, correction of the standard boiler efficiency test is performed (factory testing in accordance with Directive 92/42 EEC) in the generator efficiency at heating season level.
2. The detailed calculation method is also based on the standard boiler efficiency test defined in Directive 92/42 EEC, taking into account the conditions of exploitation for a concrete plant in more details: type and characteristics of the boiler and burner, operating mode, type of boiler automatics, location of the boiler, operating conditions, consumers' demands for heat energy, degrees of efficiency at 100% load, at partial load and heat losses of generator at 0% load. In addition to the season level, the method also gives results for shorter time intervals (weekly, monthly).
3. The third method provides an accurate estimate of losses during exploitation, losses in the combustion process, thermal insulation losses, energy for auxiliary systems and energy that returns to the system. The boiler's operating time and the time in standby mode are taken into account and the loss of each mode is made. Some of these parameters can be determined by measurement during exploitation, so the method is suitable for use in automated facilities with the applied SCADA system that performs acquisition and archiving of measured parameters in the real time. Based on this data it is possible to generate a report according to the methodology of the standard.

Figure 7: Thermal balance of the boiler-heat generator and its subsystems (third method)

QH, gen, out -thermal energy at the exit from the production subsystem (kWh);

$QH, gene, ls$ -total heat losses of the production subsystem (kWh);

WH, gen, aux -auxiliary energy of the production subsystem (kWh);

$QH, gene, ls, rbl$ -returned heat energy into the production subsystem (kWh);

$QH, gene, nrbl$ -unusable heat losses of the auxiliary devices of the production subsystem (kWh);

EH, gen, in -hot energy at the entrance of the production subsystem (kWh);

QH, gen, out	To measure	Ultrasonic heat meter on the boiler	FQR01
QH, gen, ls	The part related to the flue gas is measured	O2 probe within the BMS system for burner operation	
WH, gen, aux	To measure	Device for monitoring of voltage, electricity, active and reactive energy within the frame of the feed electro-cupboards for each boiler	
QH, gen, ls, rbl	To measure	Ultrasonic heat meter on the economizer	FQR04
EH, gen, in	To measure	Gas flow measurers	FQR02

2.7 Investment structure and sources of financing

The procurement and construction costs were 1.406.100€ provided through kfw loan and own funds.

Table 2: Structure of construction costs

Securing the project	KfW credit	Participation of PEC Toplana
Obtaining the necessary construction documentation	/	16.000 €
Purchase of equipment and machine works	720.000 €	336.000 €
Electrical works	99.000 €	15.000 €
Measurement and regulation	78.000 €	/
Construction works and parterre arrangement	104.000 €	28.000 €
Conducting expert supervision of construction and consulting services	3.700 €	1.900 €
Technical acceptance and Use permit	/	4.500 €
IN TOTAL	1.004.700 €	401.400 €

2.8 Economic assessment of the project

In addition to reduced annual overhaul costs, modern technological solutions enable savings in fuel and electricity: The annual repair costs are reduced according to the records of the last several seasons in the amount of 800.000,00RSD. The efficiency of the boiler is 91% for 100% of the power. The O2 burner regulation ensures 94% of efficiency. By the

application of the economizers, the efficiency is up to 98 %. Using the frequency regulators, the reactive power of the electric motor is 0kW, i.e. $\cos\varphi=1$, analyzing the maxi-graph and the invoices for electricity, determined savings are 0.13€/MWh of produced thermal energy. Besides the circulation pumps, frequency regulation of burner fans is also envisaged with this project and estimated savings would be approx.0.25€/MWh of produced heat energy.

Table3: The financial benefit of the project

			per year
Reduced repair costs		Based on invoices and bills from previous years, fire tubes	11.000 €
		Burner repair	8.000 €
Increased efficiency	$0.94 + 0.40 = 0.98$	$\frac{32330000}{9} \times 0.07 = 251.455 \text{ Nm}^3/\text{h} \times 23.00 + \text{VAT}$	69.400 €
Electricity savings	$35,000 \text{ MWh} \times 0.25 \text{ €}$	Based on an invoice review from previous years and estimates	8.750 €
in total			97.150 €

The free repayment period is 14.5 years.

3.CONCLUSION

In the structure of the cost of the investment, it is noticeable that the part related to the measurement, regulation and implementation of SCADA software is relatively small compared to other parts in the implementation, so it should strive to be applied in this type of plant, since it enables the acquisition and analysis of important parameters for assessing efficiency and effectiveness of heat sources operations in remote heating systems.

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