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JEDAN PRISTUP OPTIMIZACIJI IZLAZNE TEMPERATURE RASHLADNOG FLUIDA KOD KONDENZATORA
ONE METHOD FOR OPTIMIZATION OUTLET TEMPERATURE OF REFRIGERANT IN CONDENSER

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Rezime
U radu je za kondenzatore kao karakteristične grupe rekuperatora toplote, polazeći od funkcije ukupnih troškova kao funkcije cilja, određena optimalna vrednost izlazne temperature rashladnog fluida. Pri ovome izvršena je detaljna ekonomska analiza investicijskih i pogonskih troškova na godišnjem nivou i uspostavljena njihova korelacija sa parametrom koji se optimizira. Pogodnim matematičkim transformacijama termodinamičkih relacija koje važe za proces kondenzacije, dobijena je pogodna funkcija ukupnih troškova koja je detaljno analizirana i ispitana metodom matematičke analize. Optimalna vrednost izlazne temperature rashladnog fluida dobijena je minimiziranjem složene funkcije ukupnih troškova pri čemu su primenjene osnovne teoreme diferencijalnog računa. Pored tačnog modela na bazi srednje logaritamske temperaturne razlike u radu je postavljen i približan model na osnovu srednje aritmetičke temperaturne razlike. Radi efikasnijeg rešavanja postavljenog problema u radu je predložena odgovarajuća numerička matematička metoda uz podršku računarskih programa koja je kombinovana sa grafičkom metodom. Na kraju rada date su mogućnosti primene prikazane metode kod ostalih grupa razmenjivača toplote. Ovakav tehnoekonomski pristup postavljenom problemu, nakon određivanja karakteristične optimalne temperature, omogućio je određivanje čitavog niza parametara neophodnih za projektovanje kondenzatora.

Ključne reči*: kondenzatori, promena faza fluida, kondenzacija pare, investicijski i pogonski troškovi, optimizacija troškova, tehnoekonomska analiza, izlazna temperatura rashladnog fluida, numerička analiza, diferencijalni račun*

Resume*:*
In this paper for condenser as specific heat exchanger optimal outlet temperature of refrigerant was calculated using function of the total cost. Detail economic analysis of investment and operating costs on an annual basis was performed and established their correlation with optimization parameter. By suitable mathematical transformations of thermodynamic relations that use to condensation process adequate function of the total cost was obtained. This function was detail analyzed and tested by mathematical analysis. The optimal outlet temperature of the refrigerant is obtained by minimizing the total cost of the complex functions. In this method fundamental theorems of differential calculus were used.
Besides exact model based on mean logarithmic temperature difference the approximate model based on the arithmetic mean temperature difference was used in this paper. In order to efficiently solve defined problem the corresponding numeric mathematical method with using computer program in combination with a graphical method was suggested. Finally, some possibilities of using presented methods in other heat exchangers was given.
This techno-economic access to the set problem, after determining the optimal temperature was enable calculation series of parameters necessary for condenser design.

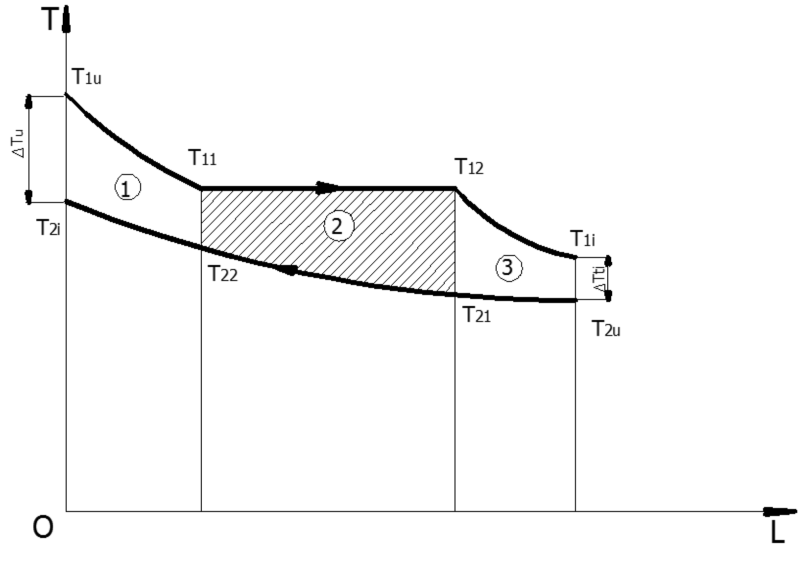
Key words*: condensers, change of fluid phase, condensation of vapor, investment and operating costs, cost optimization, techno-economic analysis, outlet refrigerant temperature, numerical analysis, differential calculus*

1. UVODNA RAZMATRANJA

U industrijskoj praksi se od svih razmenjivača toplote najviše koriste rekuperatori. Kod velikog broja rekuperatora agregatno stanje fluida na ulazu i izlazu iz aparata je nepromenjeno. Usled toga pri razmeni toplote temperatura toplijeg fluida opada, a hladnijeg raste. Isto tako postoji dosta slučajeva kod rekuperatora u kojima dolazi do promene faza fluida kako toplijeg tako i hladnijeg, [1-4].

Pored razmene toplote između različitih tečnih fluida, u praksi u velikoj meri zastupljen je prenos toplote sa toka zasićene pare na tok tečnog fluida. U ovom procesu dolazi do kondenzacije pare. Nastali tok kondenzata je obično iste temperature kao i zasićena para pa u tom slučaju smer strujanja fluida nema uticaja na temperaturnu razliku i količinu prenesene toplote, [4, 5, 14, 17].

Najsloženiji prenos toplote se javlja pri kondenzaciji toka pregrejane pare, sl. 1, [2, 4, 14, 15, 16]. Pregrejana para temperature T_{1u} na ulazu, se u sekciji 1 razmenjivača toplote prvo hladi do temperature zasićenja T_{11}. Pri tome joj se oduzima osetna toplota. Nakon toga se, u sekciji 2, na konstantnoj temperaturi $T_{11}=T_{12}$, vrši kondenzacija zasićene pare. U procesu razmene toplote odaje se latentna toplota kondenzacije pare. Na kraju, u sekciji 3, prenos toplote je na račun pothlađivanja kondenzata pare. Ukupna količina toplote usled hlađenja pregrejane pare, njene kondenzacije i pothlađivanja kondenzatora, se prenosi na tok hladnog fluida koji se pri tome zagreva od T_{2u} do T_{2i}.

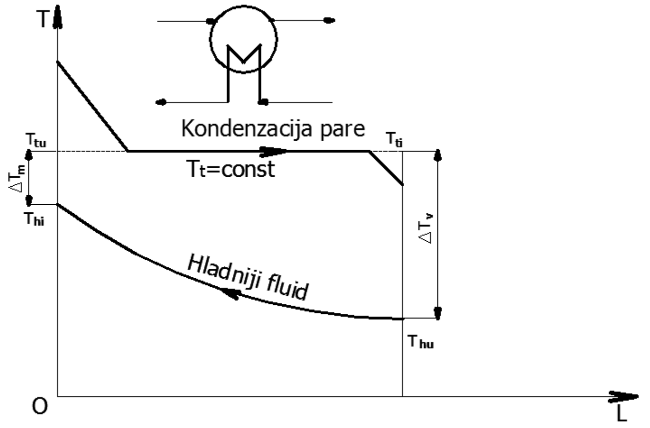


Slika 1. Prenos toplote sa toka pregrejane pare na tok tečnog fluida

Teorijski, moguće je postaviti bilansne jednačine za sve tri zone prema sl. 1 i proračunati potrebnu površinu za razmenu toplote u svakoj zoni. Ukupna potrebna površina kondenzatora bila bi jednaka zbiru ovih površina, [16-19].

Ovaj postupak proračuna kondenzatora može se koristiti samo onda ako su u pojedinim zonama tačno definisani uslovi strujanja kako za fluid koji se kondenzuje tako i za rashladni fluid. Ovo u praksi često nije slučaj, pa će u kondenzatoru doći odmah do kondenzacije pregrejane pare odnosno do nekontrolisanog pothlađivanja. Iskustva su pokazala da površina, na kojoj se hladi para i pothlađuje tečni fluid, praktično zanemarljiva u odnosu na površinu na kojoj se događa kondenzacija.

To omogućuje da se kao merodavne uzmu razlike temperatura na krajevima, prikazane na sl.2. Ovo posebno važi za slučaj preliminarnih proračuna kondenzatora, [18, 20, 21, 22].



Slika 2. Prenos toplote sa toka zasićene pare na tok tečnog fluida

Očigledno da sl. 2 predstavlja raspored temperature (temperaturni profil), po dužini kondenzatora (L), sa jednim prolazom fluida pri suprotnosmernom toku. Po istoj šemi moguć je i istosmerni tok fluida. Prema tome, kod razmenjivača toplote u kojima dolazi do promene faze toplijeg ili hladnijegfluida, promena temperature je tako mala da se može zanemariti. Do promene ove temperature dolazi usled pada pritiska u aparatu, [23, 24].

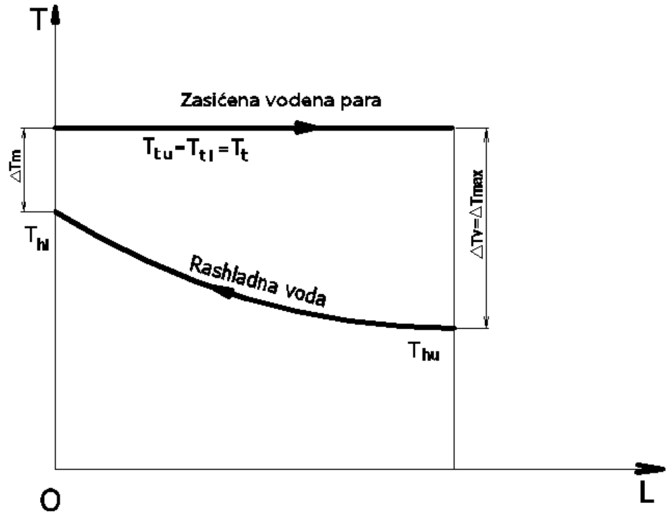
Treba zapaziti da je za slučaj kondenzacije vodena vrednost toplotnog kapaciteta toplog fluida $C_t = m_t \cdot c_t = \infty$, iz razloga konstantne temperature ($T_t = const.$).

U savremenim postrojenjima za odvođenje toplote pregrevanja, kondenzacije i pothlađivanja se najčešće koriste aparati: pregrejač, kondenzator i pothlađivač, [28, 30].

Kondenzatori se najčešće izvode sa snopovima horizontalnih cevi na kojima dolazi do filmske kondenzacije uz laminarno strujanje kondenzata, [25, 26].

2. DEFINISANJE OSNOVNIH RELACIJA KOD PRORAČUNA KONDENZATORA

Čest slučaj u praksi je da je topli fluid zasićena vodena para koja se kondenzuje dok je hladniji fluid voda koja se zagreva. Na sl. 3, za ovaj slučaj pokazana je šematski raspodela temperatura u kondenzatoru sa jednim prolazom fluida. Smer proticanja fluida kod koga dolazi do fazne transformacije nema uticaja na termodinamičku analizu. Na sl. 3 je pretpostavljen suprotnosmerni tok fluida, ali bi ista analiza važila i za slučaj istosmernog toka, [3, 5, 14, 15, 32, 34].



Slika 3. Šematski prikaz raspodele temperature u kondenzatoru

U ovom slučaju tokom procesa hlađenja temperatura vodene pare opada do temperature kondenzacije. Pri kondenzaciji vodene pare, kao što je rečeno, od stanja suvozasićene pare do stanja ključale tečnosti, temperatura je približno konstantna, $T_{tu} = T_{ti} = T_t = const.$.

Daljim odvođenjem toplote temperatura kondenzata opada tako da fluid napušta aparat u stanju pothlađene tečnosti, [27, 28, 29].

Na osnovu jednačine toplotnog bilansa za topliji (t) i hladniji fluid (h), toplotni protok će biti, [20, 22, 30, 31]:

$$q_t = m_t \cdot r_t \quad [W] \tag{1}$$

Odnosno

$$q_t = m_h \cdot c_h \cdot (T_{hi} - T_{hu}) \; [W] \tag{2}$$

Ovde je r_t latentna toplota isparavanja, a m_t i m_h odgovarajući maseni protoci fluida.

Izjednačavanjem relacija (1) i (2) biće:

$$m_t \cdot r_t = m_h \cdot c_h \cdot (T_{hi} - T_{hu}) \tag{3}$$

Ukupni toplotni protok može se izraziti kao:

$$q_t = k \cdot A_t \cdot \Delta T_{sr} \tag{4}$$

gde je:

$$\Delta T_{sr} = \frac{\Delta T_v - \Delta T_m}{\frac{\ln(\Delta T_v)}{\Delta T_m}} \tag{5}$$

srednja logaritamska razlika temperature, koja je ovde merodavna za proračun.

U relaciji (4), k predstavlja ukupni koeficijent prolaza toplote, a A_t površina za razmenu toplote kondenzatora, [1, 3, 4].

Veća i manja razlika temperatura na krajevima kondenzatora prema sl. 3 je:

$$\Delta T_v = T_t - T_{hu} \qquad \Delta T_m = T_t - T_{hi} \tag{6}$$

Zamenom razlika temperatura (6) u (5) biće:

$$\Delta T_{sr} = \frac{(T_t - T_{hu}) - (T_t - T_{hi})}{\frac{\ln(T_t - T_{hu})}{T_t - T_{hi}}}$$

(7

odnosno nakon sređivanja, dobija se konačno:

$$\Delta T_{sr} = \frac{T_{hi} - T_{hu}}{\frac{\ln(T_t - T_{hu})}{T_t - T_{hi}}} \quad [K] \qquad (8)$$

3. ANALIZA FUNKCIJE TROŠKOVA KOD KONDENZATORA

Za praktične potrebe optimizacije, za bilo koji razmenjivač toplote pa i kondenzator najbolje je koristiti ekonomski kriterijum koji poredi ukupne godišnje troškove za različite aparate. Po ovom kriterijumu najbolji aparat je onaj čiji su ukupni godišnji troškovi najmanji, [9, 10].

Ukupni godišnji troškovi izraženi u novčanim jedinicama na osnovu približne ekonomske analize mogu se definisati kao, [11, 12]:

$$C_{uk} = C_{inv} + C_{pog} \quad [EUR] \qquad (9)$$

gde su:

C_{inv} – ukupni godišnji investicijski troškovi,

C_{pog} – ukupni godišnji pogonski troškovi.

Ukupni godišnji investicijski troškovi mogu se izraziti kao, [12, 13]:

$$C_{inv} = f_k \cdot \frac{C_{rt}}{\tau_g} \quad [EUR] \qquad (10)$$

Ovde je:

C_{rt} $[EUR]$ – cena instalisanog kondenzatora,

τ_g $[god]$ – predviđeni radni vek kondenzatora,

f_k – faktor koji uzima u obzir amortizaciju, kamate, održavanje i ostale troškove (svedeno na jednu godinu).

Za procenu investicijskih troškova, C_{inv} važan je princip da troškovi opreme pa i kondenzatora C_{inv} rastu nelinearno s povećanjem dimenzija ili kapaciteta, [9], [11], [13]:

$$C_{rt} = \bar{c} \cdot A_t^{\alpha} \qquad (11)$$

Ovde su $\bar{c}$ i α konstante koje se mogu odrediti za domaće uslove za pojedine grupe razmenjivača. Zavisnost (11) je eksponencijalnog karaktera i važi za neki interval površina za razmenu toplote $A_{t,min} = A_{t,max}$, slika 4. Napomenimo ovde da se ponekad cena instalisanog aparata izražava uprošćeno u linearnom obliku, slika 4, čime se čini principijelna greška s obzirom da cena razmenjivača nije linearno proporcionalna površini, [9, 12].

Pogonski troškovi na godišnjem nivou za slučaj hlađenja kod kondenzatora mogu se izraziti preko cene rashladnog fluida i njegovog pumpanja, odnosno transporta:

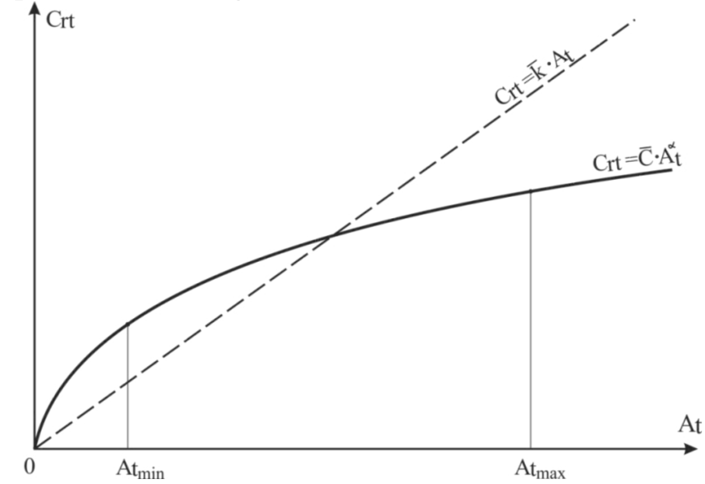
$$C_{pog} = c_{rv} \cdot \tau \cdot m_h \quad [EUR] \qquad (12)$$

gde je:

c_{rv} $\left[\frac{EUR}{kg}\right]$ – cena rashladnog fluida i njegovog pumpanja,

τ $[h]$ – broj radnih sati kondenzatora u godini dana,

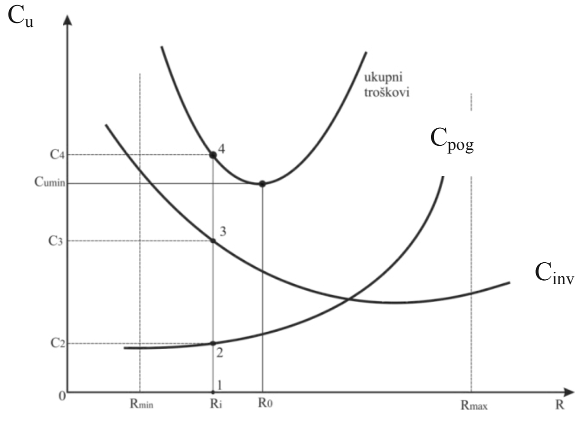
m_h $\left[\frac{kg}{h}\right]$ – maseni protok rashladnog fluida.



Slika 4. Zavisnost cene kondenzatora od površine za razmenu toplote

Ovde je učinjena realna pretpostavka da su pogonski troškovi, proporcionalni protoku rashladnog fluida, [12, 26].

Često se dešava da jedna od komponenti ukupnih troškova (C_{inv} i C_{pog}) opada a druga raste, sa porastom veličine koja se optimizira, R . Sa matematičkog aspekta sledi da ukupni troškovi moraju imati minimum $C_{\min}$ □ kojem odgovara optimalna veličina R_o, sl. 5. Kriva ukupnih troškova može se u ovom slučaju dobiti grafički, sabiranjem ordinata za niz proizvoljnih tačaka: $C_4 = C_2 + C_3$, [24, 25].



Slika 5. Funkcija ukupnih godišnjih troškova

Veličine $R_{\min}$ □ i $R_{\max}$ □ na sl. 5 predstavljaju odgovarajuća ograničenja veličine R .

4. USPOSTAVLJANJE FUNKCIJE UKUPNIH TROŠKOVA ZA PROCES HLAĐENJA KOD KONDENZATORA

Prema relaciji (4) površina za razmenu toplote kondenzatora je:

$$A_t = \frac{q_t}{k \cdot \Delta T_{sr}} \quad [\mathrm{m}^2] \tag{13}$$

Iz ove relacije sledi da veća logaritamska temperaturna razlika ΔT_{sr} uz konstantne vrednosti q_t i k podrazumeva manju površinu A_t a time i niži investicijski trošak.

Detaljnom analizom relacija (8) i (13) sledi da pri manjoj izlaznoj temperaturi rashladnog fluida, opada površina A_t pri ostalim nepromenjenim uslovima. U ovom slučaju investicijski troškovi su manji, dok pogonski troškovi (12) rastu. Iz ove analize proizilazi da funkcija troškova (9) mora da ima minimum.

Zamenom relacije (11) u (10) godišnji investicijski troškovi biće:

$$C_{inv} = \frac{f_k}{\tau_g} \cdot \bar{c} \cdot A_t^{\alpha} \tag{14}$$

Maseni protok rashladnog fluida s obzirom na relaciju (1) biće:

$$m_h = \frac{q_t}{c_{ph} \cdot (T_{hi} - T_{hu})} \quad [\mathrm{kg/s}] \tag{15}$$

Uzimajući u obzir relaciju (15), pogonski troškovi prema (12) mogu se izraziti kao:

$$C_{pog} = \frac{c_{rv} \cdot \tau \cdot q_t}{c_{ph} \cdot (T_{hi} - T_{hu})} \tag{16}$$

Sada je očigledno da porastom izlazne temperature rashladnog fluida T_{hi}, pri ostalim nepromenjenim uslovima, prema (16), pogonski troškvi opadaju, dok prema (14) investicijski troškovi rastu (jer u tom slučaju ΔT_{sr} opada).

Zamenom (14) i (16) u (9) ukupni godišnji troškovi mogu se izraziti kao:

$$C_{uk} = \frac{c_{rv} \cdot \tau \cdot q_t}{c_{ph} \cdot (T_{hi} - T_{hu})} + \frac{f_k}{\tau_g} \cdot \bar{c} \cdot A_t^{\alpha} \tag{17}$$

odnosno prema relaciji (13):

$$C_{uk} = \frac{c_{rv} \cdot \tau \cdot q_t}{c_{ph} \cdot (T_{hi} - T_{hu})} + \frac{f_k \cdot \bar{c}}{\tau_g} \cdot \left(\frac{q_t}{k \cdot \Delta T_{sr}}\right)^{\alpha} \tag{18}$$

Odavde sledi da je:

$$C_{uk} = \frac{c_{rv} \cdot \tau \cdot q_t}{c_{ph} \cdot (T_{hi} - T_{hu})} + \frac{f_k \cdot \bar{c}}{\tau_g} \cdot \left(\frac{q_t}{k}\right)^{\alpha} \cdot \left(\frac{1}{\Delta T_{sr}}\right)^{\alpha} \tag{19}$$

Zamenom relacije (8) u (19), ukupni godišnji troškovi biće izraženi u funkciji temperature rashladnog fluida na izlazu T_{hi}:

$$C_{uk} = \frac{c_{rv} \cdot \tau \cdot q_t}{c_{ph} \cdot (T_{hi} - T_{hu})} + \frac{f_k \cdot \bar{c}}{\tau_g} \cdot \left(\frac{q_t}{k}\right)^{\alpha} \cdot \left[\frac{\ln(T_t - T_{hu})}{\frac{T_t - T_{hi}}{T_{hi} - T_{hu}}}\right]^{\alpha} \tag{20}$$

Rešavanje problema možemo uprostiti uvođenjem smena:

$$y = C_{uk} \qquad x = T_{hi}$$

$$A = \frac{c_{rv} \cdot \tau \cdot q_t}{c_{ph}} \qquad B = T_{hu}$$

$$C = \frac{f_k \cdot \bar{c}}{\tau_g} \cdot \left(\frac{q_t}{k}\right)^{\alpha} \qquad D = T_t \qquad D - B = T_t - T_{hu} = E \tag{21}$$

Prema smenama (21), jednačina (20) prelazi u:

$$y = \frac{A}{x - B} + C \cdot \left(\frac{\frac{\ln E}{D - x}}{x - B}\right)^{\alpha} \tag{22}$$

Funkciju (22) možemo posmatrati kao dve funkcije:

$$y = y_1 + y_2 \qquad y_1 = C_{pog} \qquad y_2 = C_{inv}$$

gde je:

$$y_1 = \frac{A}{x - B} \qquad y_2 = \frac{C}{(x - B)^{\alpha}} \cdot \left(\frac{\ln E}{D - x}\right)^{\alpha} \tag{23}$$

Sa sl. 3 sledi da izlazna temperatura rashladnog fluida mora biti u granicama:

$$T_{hu} < T_{hi} < T_t \tag{24}$$

Analizom funkcije (23) s obzirom na njenu definisanost mora biti:

$$x \neq B \qquad x \neq D \qquad D \neq B$$

$$T_{hi} \neq T_{hu} \qquad T_{hi} \neq T_t \tag{25}$$

$$D > B \qquad \rightarrow \qquad T_t > T_{hu}$$

Poslednja nejednakost, proizilazi iz definicije logaritma u izrazu (22), odnosno iz E > 0

Isto tako očigledni su uslovi $T_{hi} < T_t$ i $T_{hi} > T_{hu}$.

Ponekad se u praksi postavlja uslov da najmanja temperaturna razlika ΔT_m bude veća od 3 ^{0}C, [20, 31].

Takođe, ograničava se i maksimalna izlazna temperatura rashladnog fluida, pa za slučaj rashladne vode je $T_{hi,max} = 45 \div 50$ ^{0}C, jer se na temperaturama većim od ovih kamenac počinje intenzivnije da taloži, [3, 5, 14, 34].

5. OPTIMIZACIJA FUNKCIJE TROŠKOVA

Za postojanje ekstremuma funkcije (20) prema osnovnoj teoremi diferencijalnog računa mora biti, [14, 34]:

$$\frac{dC_{uk}}{dT_{hi}} = 0 \tag{26}$$

odnosno s obzirom na (22):

$$y' = \frac{dy}{dx} = 0 \tag{27}$$

Uzimajući u obzir (23), biće:

$$y' = y_1' + y_2' \tag{28}$$

Pri ovome je:

$$y_1' = \frac{-A}{(x - B)^2} \tag{29}$$

$$y_2' = \left[\frac{C}{(x-B)^\alpha}\right]' \cdot ln^\alpha \frac{E}{D-x} + \left(ln^\alpha \frac{E}{D-x}\right)' \cdot \frac{C}{(x-B)^\alpha} \tag{30}$$

odnosno nakon diferenciranja:

$$y_2' = \frac{-C \cdot \alpha}{(x-B)^{\alpha+1}} \cdot ln^\alpha \frac{E}{D-x} + \frac{\alpha \cdot C \cdot E}{(D-x)^2 \cdot (x-B)^\alpha} \cdot \left(\frac{\ln E}{D-x}\right)^{\alpha-1} \cdot \frac{D-x}{E} \tag{31}$$

Zamenom (29) i (31) u (28), dobija se osnovna jednačina postavljenog problema:

$$y' = \frac{-A}{(x-B)^2} - \frac{C \cdot \alpha}{(x-B)^{\alpha+1}} \cdot \left(\frac{\ln E}{D-x}\right)^\alpha + \frac{\alpha \cdot C}{(D-x) \cdot (x-B)^\alpha} \cdot \left(\frac{\ln E}{D-x}\right)^{\alpha-1} \tag{32}$$

Pri ovome mora biti zadovoljen uslov (27).

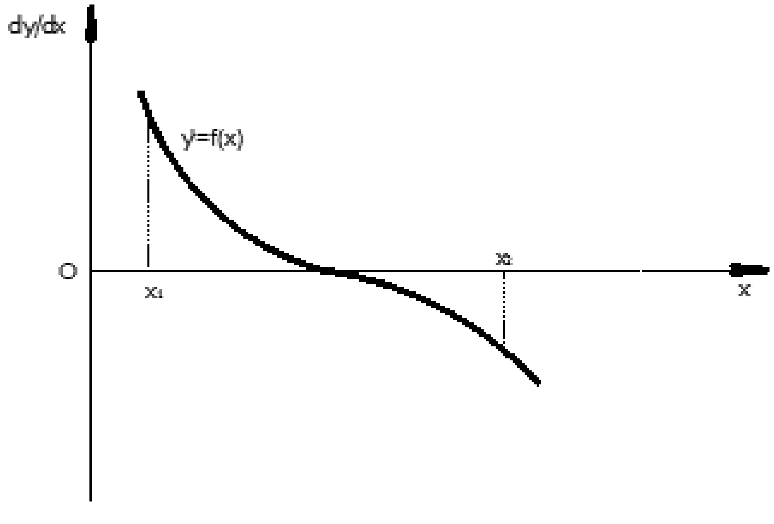
Da bi funkcija (22) imala minimum, njen drugi izvod u tački optimuma, mora biti, [19, 20, 33]:

$$y'' = \frac{dy'}{dx} = \frac{d^2y}{dx^2} > 0 \tag{33}$$

Drugi izvod funkcije y , dobija se diferenciranjem prvog izvoda (32):

$$y'' = \frac{d^2y}{dx^2} = \frac{2A}{(x-B)^3} + \frac{\alpha \cdot (\alpha+1) \cdot C}{(x-B)^{\alpha+2}} \cdot \left(\frac{\ln E}{D-x}\right)^\alpha - \frac{\alpha^2 \cdot C}{(D-x) \cdot (x-B)^{\alpha+1}} \cdot \left(\frac{\ln E}{D-x}\right)^{\alpha-1} +$$
$$+ \frac{\alpha \cdot C \cdot \left(1 - \alpha \cdot \frac{D-x}{x-B}\right)}{(D-x)^2 \cdot (x-B)^\alpha} \cdot \left(\frac{\ln E}{D-x}\right)^{\alpha-1} + \frac{\alpha \cdot (\alpha-1) \cdot C}{(D-x)^2 \cdot (x-B)^\alpha} \cdot \left(\frac{\ln E}{D-x}\right)^{\alpha-2} \tag{35}$$

Rešenje jednačine (32) ne može se eksplicidno izraziti pa će se primeniti iterativni postupak na bazi grafika na sl. 6.



Slika 6. Principijelno rešenje problema grafičkom metodom

Očigledno rešenje problema $x_o = T_{hi,o}$, dobija se na mestu preseka funkcije prvog izvoda $y' = \frac{dy}{dx} = f(x)$ prema (32), sa apscisnom osom. Pri ovome koristi se odgovarajući računarski program. Funkcija se analizira u području realnih vrednosti izlazne temperature rashladne vode $x_1 \div x_2$ odnosno prema (24) za interval temperatura $T_{hu} \div T_t$.

6. OPTIMIZACIJA FUNKCIJE TROŠKOVA PREMA PRIBLIŽNOM MODELU

Za izračunavanje srednje temperaturne razlike u razmenjivaču toplote sa dovoljnom tačnošću, umesto srednje logaritamske temperaturne razlike (8) može se koristiti relacija za srednju aritmetičku temperaturnu razliku:

$$\Delta T_{sr} = \frac{\Delta T_v + \Delta T_m}{2} \tag{35}$$

pri čemu odnos veće i manje temperaturne razlike na krajevima razmenjivača treba da bude manji od dva, [3, 14, 15, 32]:

$$1 \le \frac{\Delta T_v}{\Delta T_m} < 2 \tag{36}$$

Zamenom (6) u (35) biće:

$$\Delta T_{sr} = \frac{(T_t - T_{hu}) + (T_t - T_{hi})}{2} = \frac{2 \cdot T_t - T_{hu} - T_{hi}}{2} \tag{37}$$

Ako relaciju (37) zamenimo u (19) biće:

$$C_{uk} = \frac{c_{rv} \cdot \tau \cdot q_t}{c_{ph} \cdot (T_{hi} - T_{hu})} + \frac{f_k \cdot \bar{c}}{\tau_g} \cdot \left(\frac{q_t}{k}\right)^{\alpha} \cdot \left(\frac{2}{2 \cdot T_t - T_{hu} - T_{hi}}\right)^{\alpha} \tag{38}$$

Uvođenjem smena

$$C_{uk} = y \qquad T_{hi} = x$$

$$A = \frac{c_{rv} \cdot \tau \cdot q_t}{c_{ph}} \qquad B = T_{hu} \tag{39}$$

$$C_1 = \frac{f_k \cdot \bar{c}}{\tau_g} \cdot \left(\frac{2 \cdot q_t}{k}\right)^{\alpha} \quad D_1 = 2 \cdot T_t - T_{hu}$$

relacija (38), postaje jednostavnija za analizu:

$$y = \frac{A}{x - B} + C_1 \cdot \left(\frac{1}{D_1 - x}\right)^{\alpha} \tag{40}$$

Prvi izvod funkcije (40) je:

$$y' = \frac{dy}{dx} = \frac{-A}{(x - B)^2} + \alpha \cdot C_1 \cdot \left(\frac{1}{D_1 - x}\right)^{\alpha+1} \tag{41}$$

Drugi izvod funkcije (40), prema (41) biće:

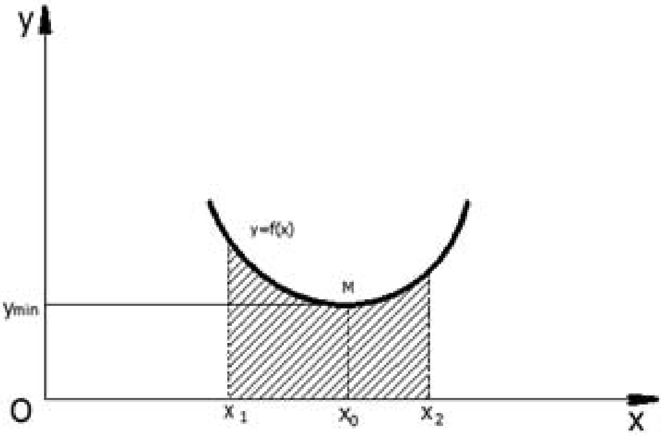
$$y'' = \frac{d^2y}{dx^2} = \frac{2A}{(x-B)^3} + \alpha \cdot (\alpha+1) \cdot C_1 \cdot \left(\frac{1}{D_1 - x}\right)^{\alpha+2} \tag{42}$$

Očigledno, ovde su funkcije prvog i drugog izvoda funkcije troškova znatno jednostavnije nego za slučaj tačnog modela.

Funkcija troškova (22) u opštem slučaju ponekad može imati veći broj lokalnih minimum. Zbog ovoga se pri rešavanju problema mora oprezno postupati, iz razloga što u tom slučaju trebautvrditi pri kojem od tih lokalnih minimum, troškovi imaju najmanju vrednost. Znači s obzirom na sl. 7 neophodno je putem odgovarajućeg računarskog programa i grafika funkcije pretražiti područje $x_1 \div x_2$ u kome izlazna temperatura rashladnog fluida T_{hi} ima realne vrednosti. Ukoliko se u tom intervalu za neko x_o dobije minimalna vrednost funkcije $y_{\min}$ □ onda vrednost x_o predstavlja optimalnu izlaznu temperaturu rashladnog fluida.

Treba zapaziti da se minimum funkcije (tačka M) može nalaziti i izvan područja $x_1 \div x_2$. To je nerealni minimum koji se ne može usvojiti.

Na kraju napomenimo da je prikazana metoda verifikovana na jednom karakterističnom primeru višecevnog kondenzatora sa omotačem kroz koji struji vodena para, dok je rashladni fluid voda. Pri ovome, dobijeni su zadovoljavajući rezultati.Zbog ograničenog prostora i obima postupka ovo nije dato u radu.



Slika 7. Analiza funkcije troškova pri optimizaciji izlazne temperature rashladne vode

ZAKLJUČAK

Prilikom projektovanja kondenzatora kao specifične grupe razmenjivača toplote u mnogim praktičnim slučajevima radni uslovi nisu precizno definisani. Na primer, u posmatranom slučaju svi glavni parametri kao i maseni protok zasićene vodene pare koji se kondenzuje su poznati (T_t i m_t), s obzirom da su to parametri od primarne važnosti. Maseni protok (m_h) kao i izlazna temperatura (T_{hi}) rashladne vode ovde su od sekundarne važnosti. Kada ovi parametri nisu unapred definisani može se pristupiti optimizaciji na način kako je predloženo u radu.

Tehnoekonomski proračuni, koji se uključuju tokom termohidrauličkih proračuna, znatno usložnjavaju postupak.Razlog za ovo je matematičke prirode s obzirom da se gotovo uvek dobijaju složene matematičke funkcije (kao i njihovi izvodi) koje se ne mogu eksplicitno izraziti odnosno rešiti.

Isto tako problem nije dovoljno posmatrati kao termodinamički već je neophodno uzeti u obzir i ekonomske uslove. Zbog ovakvog pristupa može se slobodno reći da je tehnoekonomska optimizacija jedan od složenijih odnosno komplikovanijih zadataka inženjera projektanta. Pri ovome kriterijumi optimizacije mogu biti različiti.

Prikazani model može se primeniti za kondenzatore sa različitim fluidima kao i za slučaj da postoji veći broj prolaza fluida kroz cevi.

Kod kondenzatora, zbog konstantne temperature toplijeg fluida, korekcioni faktor srednje temperaturne razlike za slučaj više prolaza fluida kroz cev, je jednak jedinici.Odavde sledi da optimizacija prikazana u radu važi i za ovaj slučaj.Izvedena funkcija troškova omogućuje kako kvantitativne proračune tako i kvalitativnu analizu. Isto tako od dva ili vise kondenzatora koji zadovoljavaju zadate uslove moguće je odabrati onaj koji je najpovoljniji sa ekonomskog aspekta.

Prikazani model moguće je uz određena prilagođavanja primeniti na proizvoljan razmenjivač toplote sa istosmernim odnosno suprotnosmernim tokom. Pri ovome se dobijaju znatno složenije funkcije u matematičkom smislu.Slučaj kada nije poznat koeficijent prolaza toplote odnosno kada je njegova vrednost nepouzdana, moguće je takođe rešiti prikazanom metodom. Ovde bi se morao primeniti iterativni postupak, s obzirom da nisu poznate sve karakteristične temperature.

Rešavanje problema tehnoekonomske optimizacije razmenjivača toplote zahteva multidisciplinarno znanje i nemoguće ga je sprovesti bez primene savremene računarske tehnike i odgovarajućih računarskih programa.

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THE LACK OF VADOSE ZONE IN AQUIFER WITH INTERGRANULARY POROSITY TYPE, AS A FACTOR OF ENHANCED CONCENTRATIONS OF IRON AND MANGANESE IN GROUNDWATER

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Abstract: The authors in their professional praxis have seen that the presence and absence of vadose zone in the upper part of aquifer, with intergranulary porosity type, is a prerequisite for enhanced concentrations of iron and manganese in groundwater. The natural aeration zone in vadose zone of the upper part of aquifer enables additional enrichment of groundwater with oxygen, which is spent on the account of biochemical processes in the direction of their flow. The absence of this zone in aquifer directly influences higher iron and manganese content in groundwater, often above the permissible concentration in drinking water.

Kew words: unsaturated zone, iron, hydrochemistry

1. Introduction

Vadose zone is zone above water table, through which water is infiltrated, and in which the pores and cracks in the soil, and rocks are filled with air and partially with capillary water (Fig 1). This work processes the influence of part of the vadose zone which is situated (or is sometimes completely missing) in the aquifer with marked intergranulary type of porosity, i.e. in its upper or higher part on the content of iron and manganese. Namely, in this aquifer zone, natural aeration of the groundwater is made which has a positive influence on its chemical composition. Role of vadose-zone flow process is explained by Harter T. & Hopmans J.W. 2004 [1] and Hopmans J.W. and M Th. Van Genuchten, 2005 [2].

One major cause of manganese mobilization in aquifers is reductive decomposition and dissolution of compounds such as Mn-OOH and MnO_2. In the normal pH range of groundwater (pH 5 – 8), dissolved iron is present as Fe^{2+}. The main sources of Fe^{2+} include [3]:

- the dissolution of iron (II) bearing minerals;
- the reduction of iron oxyhydroxides (Fe-OOH) present in the sediments e.g. magnetite, ilmenite, pyrite, siderite, iron (II) bearing silicates and clay minerals such as smectites (Appelo and Postma, 1994);
- the oxidation of arsenopyrites.

If the saturation zone in direct contact with aquitard in overlie of the aquifer, with marked intergranular type of porosity, i.e. if the aquifer is subartesian or artesian (Fig. 2), due to biochemical processes, anaerobic conditions are created which generates an increased content of iron and manganese in groundwater.

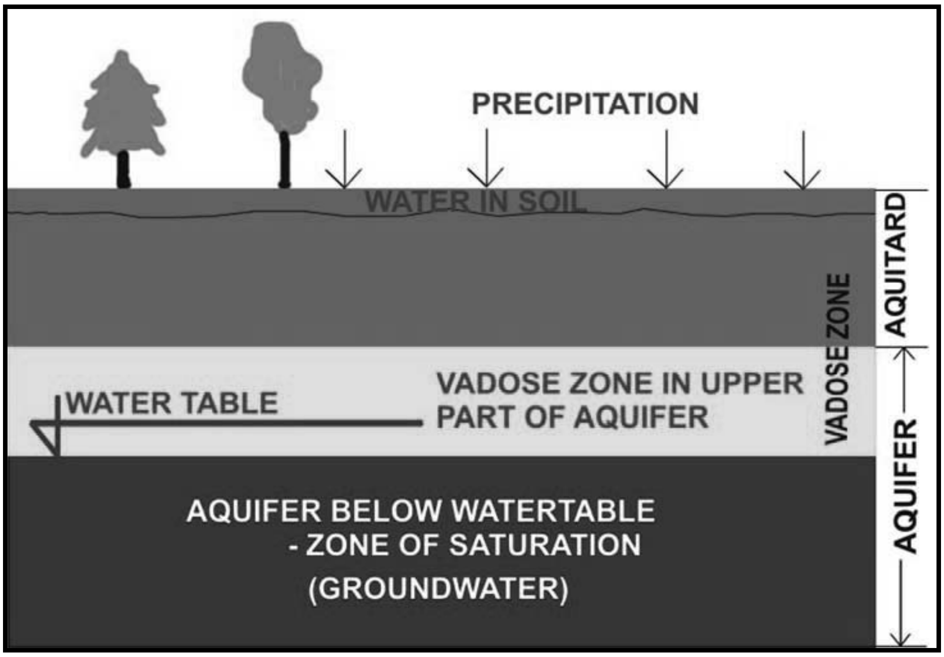

Figure 1: The scheme of the aquifer with present vodose zone in the aquifer itself

A good understanding of this influence can help the researchers with planning the research works, the choice of well location and projecting the well for abstraction of groundwater.

The authors of this paper have noticed in their professional practice on many terrains in Republic of Srpska that the presence or absence of vadose zone in aquifer (zone of natural aeration), just above the water table, influences the content of iron and manganese in aquifers with strong intergranular porosity type. It is often the case that this water cannot be used for water supply. In aquifers with fractured porosity type, this influence is not present because of the great speed of the groundwater flow, and the short time of retaining water in underground, and little total intensity of biochemical and chemical processes in goundwater.

Many cases with higher presence of iron and manganese and groundwater along with the absence of vadose zone in the aquifer itself, which proves spatial this dependence.

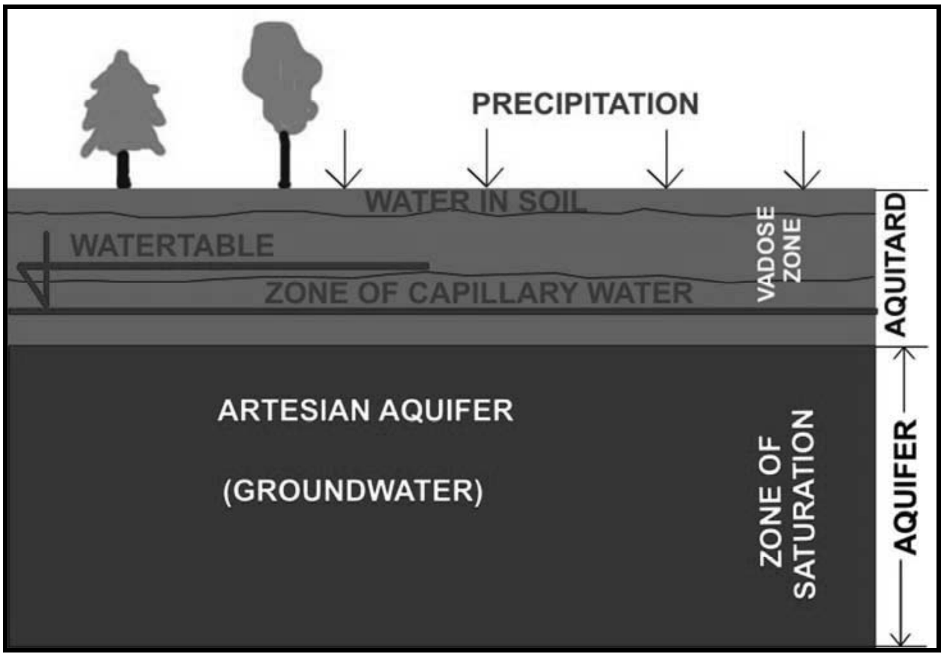

Figure 2: The scheme of vadose zone and saturation zone in aquifer with the level of water under pressure

2. Presence and origin of iron and manganese in the groundwater

Higher level of iron and manganese in water changes organoleptic properties because of sediment, which stands out (orange and brown colour), it has an unpleasant smell and the taste of water associates with metal. Iron and manganese react with dissolved oxygen to form insoluble compounds. Therefore, they are usually not found in waters that contain high amounts of dissolved oxygen [3].

Interpretation of origin of these components in certain aquifer is different. The reasons are first to be searched in the existence of local pollutants in the zone of sanitary protection of water source. In certain cases the reasons are searched in mineralogical-petrographic, i.e. lithological characteristics of terrain, because at first glance it is thought that the rocks, through which water passes, are the cause of such an unpleasant the chemical content. However, the most common cases are those with higher presence of iron and manganese in groundwater, where there are no mineral deposits, rich with iron (alluvial, pliocene and pleistocene gravely-sadly aquifers). In sand and gravel, there are different minerals in the structure of grains made from dissolution of primary rocks, their transport and sedimentation in river valley and neogene basin. From the iron minerals, in sand the following can be found: magnetite (Fe_3O_4), siderite ($FeCO_3$), hercinite ($FeAl_2O_4$), jacobsite ($MnFe_2O_4$), franclinite ($ZnFe_2O_4$), chromite ($FeCr_2O_4$), etc. Frequently minerals of menganese are galaxy ($MnAl_2O_4$) and hrodochrosite ($MnCO_3$).

Apart from these, the presence of the following iron-manganese minerals is also possible: axinite, pyralspite, almadine, spessartine, turmaline, etc. Excerpts of dolomite and limestone, and deposited conglomerates, gravel and sand made from transport of these parts, usually contain chemical impurities of iron and manganese.

So, iron and manganese are practically present in all geo-environments, but in groundwater of all these environments, they are not present in higher percentage.

In the area of fractured limestone and dolomite terrains of Herzegovina and Romanija, and the basin of the upper flow of the river Drina, Bosna, Vrbas, where the groundwater flow is fast, and where the upper part of aquifer has present vadose zone, i.e. the aquifer is not artesian, groundwaters do not have a higher content of iron and manganese. However, groundwaters of the Panonian basin rim (in the immediate catchment of the river basin in the territory of Republic of Srpska) and some aquifers in northern part of Republic of Srpska and Brcko district have higher content of these elements in wider area, in what the authors of this work convinced through their own hydro geologic and hydro chemical research, i.e. based on the results of physical-chemical water analysis results, whose statement is given in this paper.

3. Correlation of vadose zone existence in aquifers with intergranular porosity type and iron and manganese content in groundwater

In the following text, the examples of presence or absence of close zone of natural aeration in vadozna zone of the aquifer itself are presented, with present air above the level of groundwater, and along with that, the presence of iron and manganese in those aquifers. This type of correlation of two characteristics of aquifer can give contribution to the understanding of existence and intensity of this dependence, i.e. influence.

In the far northeast of Republic of Srpska, in peripheral part of Panonian basin (Semberija and Posavina), with many years of research and following, we established that groundwater in pliocene gravel and sand sediments from the recharge zone (I) and closer zone (II) in mountainous part of Majevica mountain, have good quality. But, in further zones of groundflow (IV), groundwater have increased content of iron and manganese sometime in some of boreholes in artesian aquifer near river Sava. In Fig. 3 a conceptual hydrogeological model of peripheral part of Panonian neogene basen, which in the zone far from the recharge zone, does not have vadose zone in the aquifer itself, i.e. there is no natural aeration, so it has anaerobe conditions and by that the conditions for generating higher content of iron and manganese. Figure 3 shows simplified schematic display of the zone of higher iron content in artesian groundwater on the peripheral part of Panonian basin in the function of nonexistence of vadose zone in aquifer itself, and on the account of consumption oxygen during transport of groundwater

The so-called consumption oxygen in groundwater flow happens because of present microorganisms in water, on the account of biodegradation of organic matters in groundwater and geo-environment, and on the account of chemical processes of oxidation in geo-environment. A rainwater contents average 63,2% nitrogen, 35,0% oxigen and 1,8 % CO_2 [1]. That implies high content of dissolved oxygen in groundwater, because in hilly terrains, where pliocene layers have contact with surface, recharge of aquifer is done mainly from rainfall with dissolved oxygen.

In transitional zone (III), i.e. in the first part of groundwater flow, although there is no present vadose zone of natural aeration in the aquifer itself, oxygen dissolved in water is "wasted", so water in that part of aquifer in its physical-chemical characteristics corresponds drinking water.

Spatial distribution of water with different quality is interesting in the same aquifer, from the aspect of drinking water norms.

In the zone closer to the recharge zone of this part of goundwater flow, water in its physical-chemical structure, often matches the norms of drinking water, but is microbiologically faulty. In transitional zone it is both physically-chemically and bacteriologically valid. However, om the zone further from the recharge zone, i.e. in the zone where the whole aquifer is in saturation zone, where vadose zone in aquifer is completely missing, water becomes faulty to drink due to higher content of iron, and sometimes manganese, although it is still bacteriologically correct (example of Posavina). Higher content of iron in aquifers is contributed by little speed of underground flow, present marly sediments and peat, as well as low pH [3].

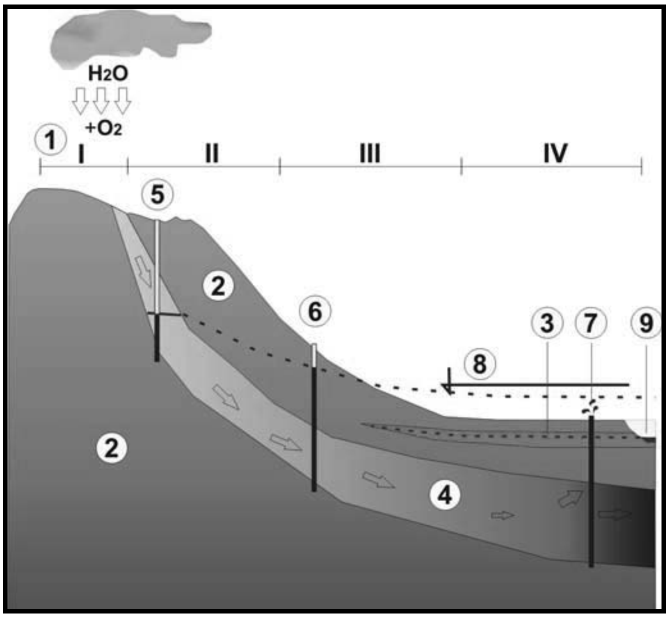

Figure 3: Simplified schematic display of the zone of higher iron content in artesian groundwater on the peripheral part of Panonian basin; Legend: I Recharge zone, II Zone of good quality of groundwater, III Transitional zone, IV Zone of groundwater with higher content of iron and sometimes manganese, 1 - Infiltration area, 2 - aquitard, 3 - Unconfined aquifer, 4 Confined aquifer, 5 Water well, 6 Nonflowing artesian well, 7 Flowing artesian well, 8 Water table, 9 River

Higher content of iron near the City of Zvornik (Fig. 2) is recorded in water from piezometer BCP-4 [2], concentration 9,8 mg/l and manganese 4,0 mg/l, and in piezometers BCP-7, 6 and 9 in the limits of drinking water [4].

This can be explained by presence, i.e. absence of vadose zone and bigger speed of underground flow in the parts of aluvijon which is closer to the river Drina.

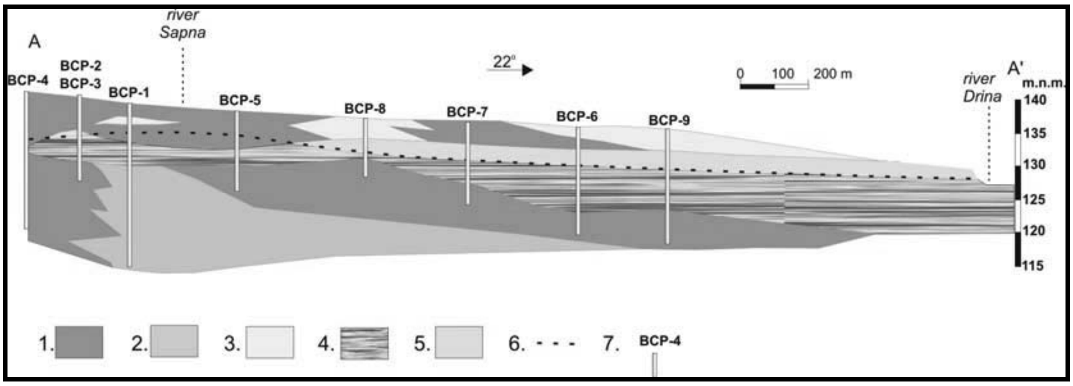

Figure 2: Hydrogeological cross section of area near Zvornik with higher content of iron in water in one part of cross hole (borehole BCP-1 where the level of the groundwater is in the zone of clay overlayer i.e. there is no vadose zone in aquifer.
Legend: 1. Clay 2. Marl 3. Sand and sand with clay 4. Aquifer below the watertable 5. Vadose zone of aquifer 6. The water table 7. Borehole

Higher content of iron from 0,72 – 1,7 mg/l and manganese from 0,20 to 1,55 mg/l, and occasionally ammoniac in groundwater near Kozarska Dubica (table 1) is the result of anarebic conditions in the zones where vadose zone in the aquifer itself is missing (this is determined by boreholes in areas Djolovi and Medjedja).

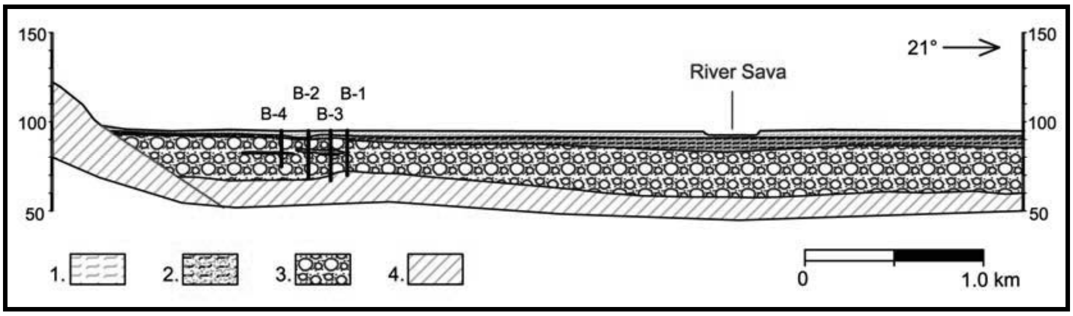

Figure 3: Cross section of spring Medjedja for water supply of Dubica – the whole aquifer in saturation zone i.e. below the water table
Legend: 1. Clay 2. Clay and sand with clay below the watertable (zone of saturation) 3. Sandy gravel 4. underlie aquifer

Table no.1 shows the values of iron and manganese content in groundwater at the fourteen different locations in river basin of rivers Drina, Bosna, Ukrina, Vrbas, Sana and direct sliv of Sava. The authors of this work have established the same dependence. The results of correlation with presence, i.e. absence of vadose zone in the aquifer itself shows the clear connection between the lack of vadose zone and higher content of ions in water. This influence is present in such degree that water cannot be used for water supply without previous treatment.

Table 1 – Display of results of analyses of content of Fe, Mn in quaternary age aquifers in the neogene basins of Republic of Srpska

Location:	Name of water well/borehole	Age of aquifer: 1. Quaternary (alluvial or terrace sediments) **a** 2. Pliocene or pleistocene(**pl**)	River basin	Fe (mg/l)	Mn (mg/l)	Presence of vadose zone in aquifer itself +/-
PS Mejdan at City of Zvornik	B-1	al	Drina	max 0,1	max 0,01	+
Čelopek near City of Zvornik	BČP-1	al	Drina	9,80	4,00	-
Čelopek near City of Zvornik	BČP-6	al	Drina	0,08	0,00	+
Kozluk near City of Zvornik	VEB-1	al	Drina	max 2,80	max 0,10	-
Brodac near City of Bijeljina	B-1	pl	Sava	0,57	0,00	-
PS Grmić near City of Bijeljina	*	al	Drina	max 0,1	max 0,01	+
PS Plazulje near City of Brčko	*	al	Sava	max 2,00	max 0,35	-
EFT Stanari near City of Doboj	BS-12	pl	Ukrina	max 3,27	max 0,30	-
PS Rudanka near City of Doboj	*	al	Bosna	max 0,2	max 0,01	-
PS in City of Brod	*	al	Ukrina	max 4,00	max 0,07	-
PS Rafinerija Modriča	*	al	Bosna	max 0,2	max 0,01	+
"Stirokard" City of Srbac	BS-2	al	Vrbas	1,70	0,05	-
PS Međeđa City of Koz. Dubica	*	al	Sava	max 1,70	max 1,55	-
Mira in City of Prijedor	BM-2	pl	Sana	max 1,74	max 1,75	-

* - group of wells

In alluvium of bigger rivers such as the river Sava, the river bed is carved in clay and alluvial gravel and sand which often have no direct connection with significant aquifer in depth of several tens of meters because of clay aquitard layers between them. Recharge of deeper aquifer happens, most frequently upstream, and it is far tens of kilometers from exploitation well.

Great lengths of the underground flow from the zone of recharge as well as in regimes of artesian aquifer of peripheral parts of big neogene basins, slow water replacement, biochemical processes and aquifers, and the lack of vadose zone in the aquifer itself are a precondition for higher content of iron and manganese.

The consumption of oxygen in a slow groundwater flow because of biochemical processes happens as well in this type of aquifer, by the bio-degradation processes of organic matters, presence microorganisms in groundwater, and by chemical processes of oxidation in aquifer.

Such is the case in most part of Cities of Brcko, Samac, Brod and Gradiska.

This work also shows aquifers from alluvial and terrace's gravel and sand in which vadose zone is present in upper part of aquifer, so the content of iron and manganese in groundwater is in limits of drinking water (PS Mejdan, Čelopek - Zvornik, Grmić kod Bijeljine, Rafinerija Modriča, PS Rudanka near City of Doboj).

4. CONCLUSION

By correlation of iron and manganese content in aquifers of quaternary age and sand-point and artesian aquifers in negenskim basins of Republic of Srpska and Brcko district with the existence of vadose zone in the aquifer itself, the authors of this work have made a conclusion that nonexistence of vadose zone in the upper part of the aquifer itself, with the condition of sufficient length of underground flow in such conditions, creates a crucial prerequisite of higher iron content, and occasionally manganese in groundwater.

According to this criterion, the authors of this work stress the following:

- The zone of aquifer with present vadose zone in the aquifer itself (content of iron and manganese in the limits of drinking water),
- transitional zone and
- Zone of aquifer without present vadose zone in the aquifer itself (the content of iron and manganese is higher in relation to the drinking water norms).

Contribution to the knowledge of the influence of vadose zone in the aquifer itself to chemical content of water can help researchers with planning, research, predicting, the choice of location and projecting wells for groundwater abstraction and planning treatment plants and total investments.

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A REVIEW OF THE CONTENTS OF AFLATOXINS IN ANIMAL FEED SAMPLES IN THE MONTENEGRIN MARKET USING ELISA AND HPLC METHODS

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Aflatoxins are naturally occurring mycotoxins produced by many species of *Aspergillus fungi, i.e*. molds, that grow on grains, of which the most important are *Aspergillus flavus* and *Aspergillus parasiticus* .[1] The main aflatoxins are aflatoxin B1 , B2 , G1 and G2 . Aflatoxin B1 is in a group of carcinogenic substances, i.e. belongs to a group 1 according to a classification by IARC (International Agency for Research on Cancer)[2]

In the period from January to October of 2013, total of 1467 of samples of animal feed, intended for consumption of different types of domestic animals, were analyzed using a screening ELISA (Enzyme Linked Immuno Sorbent Assay) and the confirmation method of liquid chromatography with fluorescence detection

. In this paper we summarize the results of comparative analysis of animal feed obtained by screening and confirmation method.

It is also given a comparison of the results with acceptable levels of EU / national legislation

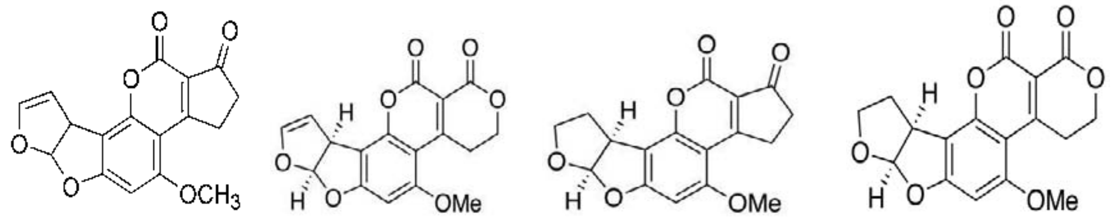
Keywords: aflatoxin B1 , B2 , G1 , G2 , animal feed , HPLC , RF detector

1. Introduction

Aflatoxins are mycotoxins that can be encountered in nature as a products of activities of different types of Aspergillus fungi - mold, where the most significant producers of fungi are Aspergillus flavus and Aspergillus parasiticus. They are produced in the field or during storage and are commonly found in corn, barley, rice, sunflower seeds and pumpkin seeds, dried fruit and spices. As a further products in the food chain they can be found in milk and meat as well as in their processed products [1].

The most important from group of aflatoxins are aflatoxins B1, B2, G1 and G2. Aflatoxin B1 is the most toxic one from this group and it is always present where there are B2, G1 and G2 . It belongs to the group of cancer-causing substances in the group 1 by IARC classification (International Agency for Research on Cancer), which means that the agent is carcinogenic and that have been proved in humans. Aflatoxin B1 can be found in food products that contain unprocessed grains, but it can’t be found in the milk. Aflatoxins are named by combining abbreviations: according to A (Aspergillus) + FLA (flavus) + toxin, while codes B and G mark the appearance of Blue or Green color of fluorescence under UV light. After entering the body of the animal, aflatoxins are metabolized in the liver. There are two ways of metabolism and they are: oxidation to the reactive epoxide, which is toxic and carrier of carcinogenic effects, or hydroxylation, forming aflatoxin M1, which is about 10 times less toxic. Aflatoxin B1 is with the strongest mutagenic activity and is considered one of the strongest human mutagens [2].

According to their chemical structure, aflatoxin B is a derivative of difurocoumarocyclopentenone and aflatoxin G is a derivative of difurocoumarole. Figure 1 shows the chemical structure of aflatoxins B1, B2, G1 and G2.



Aflatoxin B1 Aflatoxin G1 Aflatoxin B2 Aflatoxin G2

Figure 1. Chemical structures of aflatoxins B1, B2, G1, G2

2. Materials and methods

In the period from January to October in 2013, it was analyzed 1467 samples of animal feed which are intended for feeding of different types of farm animals. The samples were analyzed first by ELISA screening method, then every positive result, in the sense that the value exceeds the maximum permitted concentration prescribed by Regulation, were prepared and analyzed with confirmation method - liquid chromatograph with fluorescence detection.

Reagents and standard solutions

Total Aflatoxin Kit 5121AFT was from the manufacturer Europroxima (Netherlands). Commercial standards of individual aflatoxins G1, B1, G2, and B2 with the concentration of 3 mg / ml each in acetonitrile, were from the manufacturer Supleco. Certified reference material containing certified concentrations of aflatoxins B1, G1 and B2 in the sample of feed (ERM-BE 376, IRMM) is from manufacturer LGC. Acetonitrile, methanol, benzene, hexane and trifluoroacetic acid (TFA) were from Sigma-Aldrich.

PBS-buffer preparation: weigh 8g of NaCl, 1.16g $Na_2HPO_4x2H_2O$, 0.2g KH_2PO_4, 0.2g KCl, and dissolved them in 990 ml of distilled water, adjust to pH 7.4 using NaOH or HCl and fill up the volumetric flask of 1000ml to the mark.

From the commercial standards with concentrations of 3 mg / ml each, in acetonitrile, first it was made standard of 0.1 mg / l of each aflatoxin separately, from which are made mixes for calibration. Aflatoxins are susceptible to degradation in the daylight therefore calibration standards are kept in the cold (4 ° C) and dark place (refrigerator). Before going to use, standards, should be termostated to room temperature.

Apparatus

For sample preparation there were used digital IKA HS501 digital horizontal shaker (IKA ® Werke GmbH & CO.KG, Germany) and IKA A11basic mill (IKA ® Werke GmbH & CO.KG, Germany). For analyzing sample with screening method it was used Chromate micro plate reader (Awareness Technology, Ins. USA), and for confirmation method liquid chromatograph with fluorescence detection (HPLC / RF 10Axl, Shimadzu, Japan) was used.

2.1. Screening method – ELISA

ELISA (Enzyme Linked Immuno Sorbent Assay) is a test method in which antibodies are used, and the change of color for the identification of the desired substance. In the conducted tests Total Aflatoxin Kit 5121AFT from the manufacturer Europroxima, Netherlands was used. The principle upon which the determination of aflatoxin in this kit is, that the present aflatoxin B1 is bounded to specific antibodies, with which are wells on the strips have already been covered, in the process of incubation after the addition of conjugate . In the process of washing the strips, all unbound reagents are discarded, and the related aflatoxins become colored after addition of chromogen. Based on the color intensity measured photometrically at 450nm, namely absorbance, the concentration of aflatoxins is determined in a sample. Cross - reactions of the present kit was 100 % for aflatoxin B1 and total aflatoxins by this method are expressed as aflatoxin B1, as a sum of all of the 4 aflatoxin (B1, B2, G1 and G2), but which is present in the sample with the highest concentration . The sensitivity of the test for all types of samples is 0.5μg/kg [3].

Sample preparation for ELISA

Sample, before taking appropriate weight, must be well pulverized and homogenized. From such sample 3g is taken and added 9 ml of 80% methanol and then the sample was stirred for 30 minutes on a shaker at room temperature. After stirring, the sample was filtered, and 50μl of the filtrate was diluted with a dilution buffer, which is part of the kit, to obtain a solution with 20% methanol. Such diluted sample is ready for application to the strip for analysis, wherein for the test 50μl is taken from each 200μl diluted sample prepared.

The process of adding the appropriate reagents for the analysis was conducted in accordance with the manufacturer's instructions, while absorbances have been measured at a wavelength of 450nm.

The interpretation of the results and recalculation of the absorbance to a concentration of aflatoxin was done according to the manufacturer's instructions in the already prepared excel table.

2.2. Confirmation method – liquid chromatography with fluorescence detection

Method for determinination of aflatoxins B1, G1, B2 and G2 in feed by HPLC is based on "Instruction Manual for immunoaffinity column for the purification of Aflatoxins in conjunction with HPLC." Aflatoxins B1, G1, G2, and B2 are extracted and purified with immunoaffinity columns. This column contains specific antibodies bounded to the solid phase of immunoaffinity column. When the sample passes through the column, the antibodies are selectively binding with aflatoxin B1, G1, G2, and B2 (an antigen) contained in a sample, thereby forming an antibody-antigen complex. All other components of the sample is washed from the column with water and eluting of aflatoxin B1, G1, G2, and B2 from the column is accomplished with a mixture of acetonitrile and water. The content of aflatoxin B1, G1, G2, and B2 are determined by liquid chromatography [4].

Sample preparation for HPLC analysis

Weight 25 g of sample in a 250 ml flask, add 100 ml of extraction solution (methanol: water 60/40 v / v) and shake for 1 hour on a shaker . Using a funnel , filter the extract through a qualitative filter paper . The extract was diluted with PBS until the acetonitrile concentration is not lower than 5 % (v / v) . In the case of methanol extract, the methanol concentration of the extract may be up to 20 % (v / v) . Take 4ml of extract (60/40 (v / v) methanol / water) and add 8 ml of PBS . Check and adjust pH to 6-8 with NaOH . Diluted extract was passed through an immunoaffinity column so that the flow rate is not higher than 1-3 ml / min . When the complete sample passes through the column, approach to the washing step . Washing is carried out with 2 portions of 10 ml of distilled or deionized water . First portion may serve to rinse the container in which the sample was applied to the column , while the other is applied directly to the column. Place the vial for collection of the eluate below the column. Aflatoxin elution is carried out using HPLC grade methanol . Elution is done with 1.5-3 ml methanol (3x1ml) .

Micro concentration is carried out under a stream of nitrogen. The vial in which the extract is placed, is located in a stream of nitrogen and the extract was dried to dryness after which is done its derivatization with hexane and 2 ml of TFA, followed by addition of H_2O: ACN 9 +1 to precise volume.

HPLC condition for sample analysis

Analysis of samples were performed by HPLC, identifying the component on the basis of retention time. Area and height of the peak is a measure of the concentration of the test components in the sample. For the chromatographic separation of aflatoxins used column was Lichrosorb RP18-5, 15cmx4.6mm, 5 µm (Supelco). The mobile phase consists of a mixture of H_2O: ACN: MeOH composed of 700: 220: 220 v/v in isocratic conditions, flow rate is 1ml/min. Column temperature was 30 ° C, injection volume was 75µl. Retention times were: 4.2min for aflatoxin G1, 5.4min for aflatoxin B1, 7.9 min for aflatoxin G2 and 11.3 min for aflatoxin B2.

Confirmation method for determination by liquid chromatography with fluorescence detection has been validated, and the relevant characteristics of the method were determined. Method validation was performed on the certified reference material containing certified concentrations of aflatoxins B1, G1 and B2 sample of feed (ERM-BE 376, IRMM). With the validation, limit of detection was determined, which is 0.001mg/kg, and also the recovery of method, which ranges from 85 - 87% for each of the analyzed aflatoxin.

3. Result and discussion

During testing of the feed in the period from January to October in 2013. total of 1467 samples were examined, which can be classified on the basis for the consumption of what animal species are designed. Number of samples depending on the kind of animal which is intended to be given is showed in Table 1

Table 1. The number of samples of different types of surveyed feed

Type of feed, depending on the purpose and type	**Number of tested samples**
Feed for chickens and broilers	251
Feed for dairy cows	211
Feed for calves	28
Feed for turkeys	22
Feed for the lambs	20
Feed for laying hens	289
Feed for sows, piglets and pigs	135
Feed for cattle	25
Wheat, wheat bran and substrate	93
Barley in grain and grits	25
Oat	7
Sunflower pellets	2
Sugar beet noodles	8
Corn in grain, corn flour and grits	321
Fodder mixtures intended for multiple species	30
Total number of samples	**1467**

Previously given table is presented graphically where the number of samples is given as a percentage of the total number of tested samples of the feed. As in the previous table, also in the graph it is evident that most of the samples which have been tested were corn and its products (flour, grits), as the grain that is commonly contaminated with aflatoxin.

Furthermore, a large percentage were feed for chickens, broilers and laying hens, which are essentially enriched corn mixtures. Besides these a large number of mixtures for feeding dairy cows have been examined, because the input of aflatoxins in feed reflects in cow's milk as aflatoxin M1. This is an extremely toxic aflatoxin as it is expressed in its defined low maximum permitted level in the milk which is 0.050 mg / l.

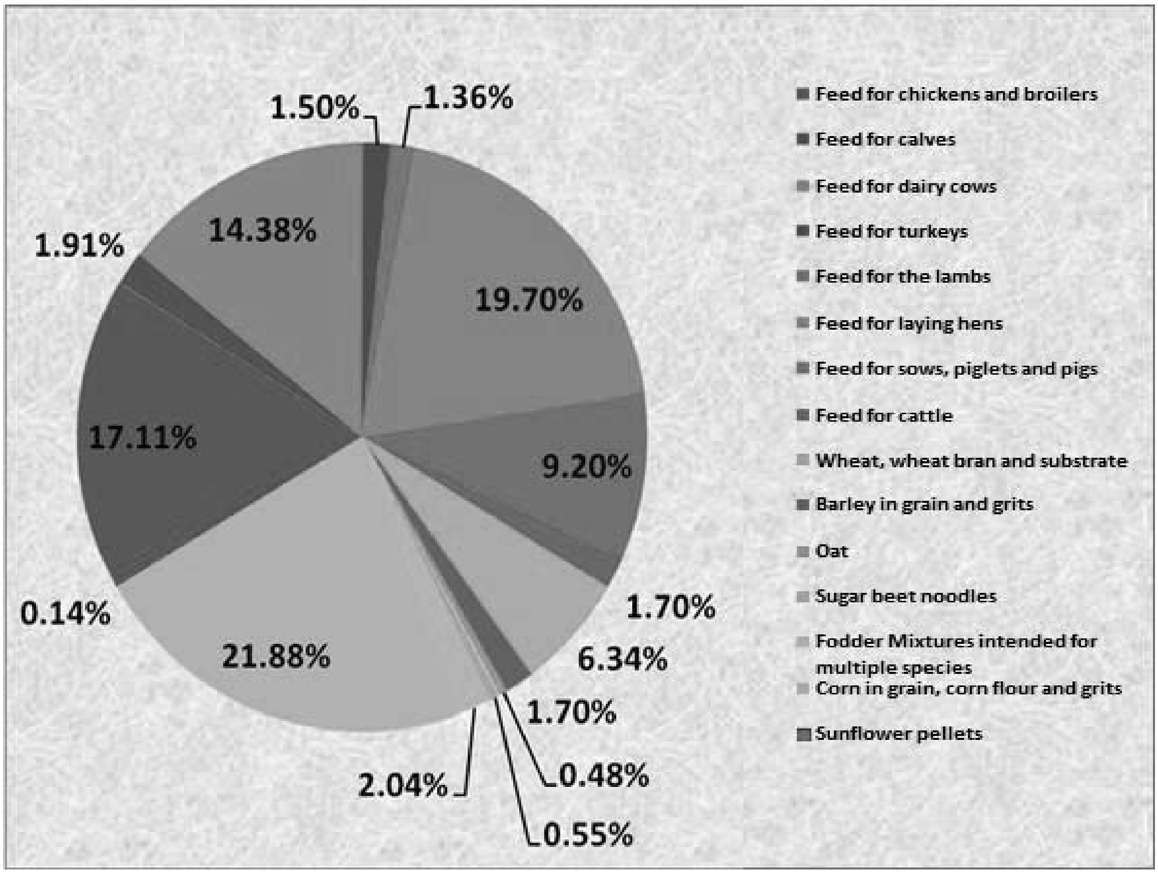


Figure 2. Graphical view of the percentage of samples of certain types of animal feed in relation to the total number of samples tested

Obtained results are compared to the permitted levels of EU and national legislation. Current Regulations in Montenegro concerning the maximum amount of toxins from toxic fungi, mold, in animal feed is the Rule book on maximum permitted levels of harmful substances and ingredients in animal feed ("Official Gazette. of SFRJ", no. 2/90 and 27/90). in which are in Section 11 given following allowed levels:

Animal feed	**mg/kg**
Feed	0,05
Fodder mixtures for calves, pigs, chickens, turkeys and ducks	0,01
Fodder mixtures for pigs and poultry	0,02
Fodder mixtures for dairy cows	0,01
Fodder mixtures for adult bovine animals	0,05
Fodder mixtures for sheep	0,05
Fodder mixtures for goat	0,05

Within the EU, maximum levels (MLs) for aflatoxin B1 in animal feed are listed in Commission Directive 2003/100/EC and they are as follows:

Products intended for animal feed	**Maximum content in mg/kg relative to a feedingstuff with a moisture content of 12 %**
All feed materials	0,02
Complete feedingstuffs for cattle, sheep and goats with the exception of:	0,02
— complete feedingstuffs for dairy animals	0,005
— complete feedingstuffs for calves and lambs	0,01
Complete feedingstuffs for pigs and poultry (except young animals)	0,02
Other complete feedingstuffs	0,01
Complementary feedingstuffs for cattle, sheep and goats (except complementary feedingstuffs for dairy animals, calves and lambs)	0,02
Complementary feedingstuffs for pigs and poultry (except young animals)	0,02
Other complementary feedingstuffs	0,005

Of the total number of analyzed samples, 109 samples were positive in the sense that the calculated value exceeds the maximum permitted levels for this type of feed. Table 2 gives the number of samples that comply and that do not comply in accordance to the conditions of the Rule book for each feed depending on their purpose.

Table 2. Number of feed samples that comply and that do not depending on their purpose

Type of feed, depending on the purpose and type of animals for which is intended to be used	**Number of samples that comply**	**Number of samples that do not comply**
Feed for chickens and broilers	231	20
Feed for dairy cows	180	31
Feed for calves	25	3
Feed for turkeys	21	1
Feed for the lambs	20	0
Feed for laying hens	272	17
Feed for sows, piglets and pigs	120	15
Feed for cattle	25	0
Wheat, wheat bran and substrate	93	0
Barley in grain and grits	25	0
Oat	7	0
Sunflower pellets	2	0
Sugar beet noodles	8	0
Corn in grain, corn flour and grits	304	17
Fodder mixtures intended for multiple species	30	5
Total number of samples	**1358**	**109**

The following graph is plotted above table which represents number of samples that comply and not comply to the prescribed levels for each tested feed depending for what animals is intended to be used. Studies have shown that most of the feed that did not comply were the ones intended to be used for dairy cows, chickens and broilers and laying hens and pigs, which have the lowest permissible level of 0.010 mg / kg and 0.020 mg / kg respectively. As already indicated that the most frequently occurring aflatoxins are in corn and its products, the analysis has shown that a number of these particular samples did not comply the requirements of the Rule book.

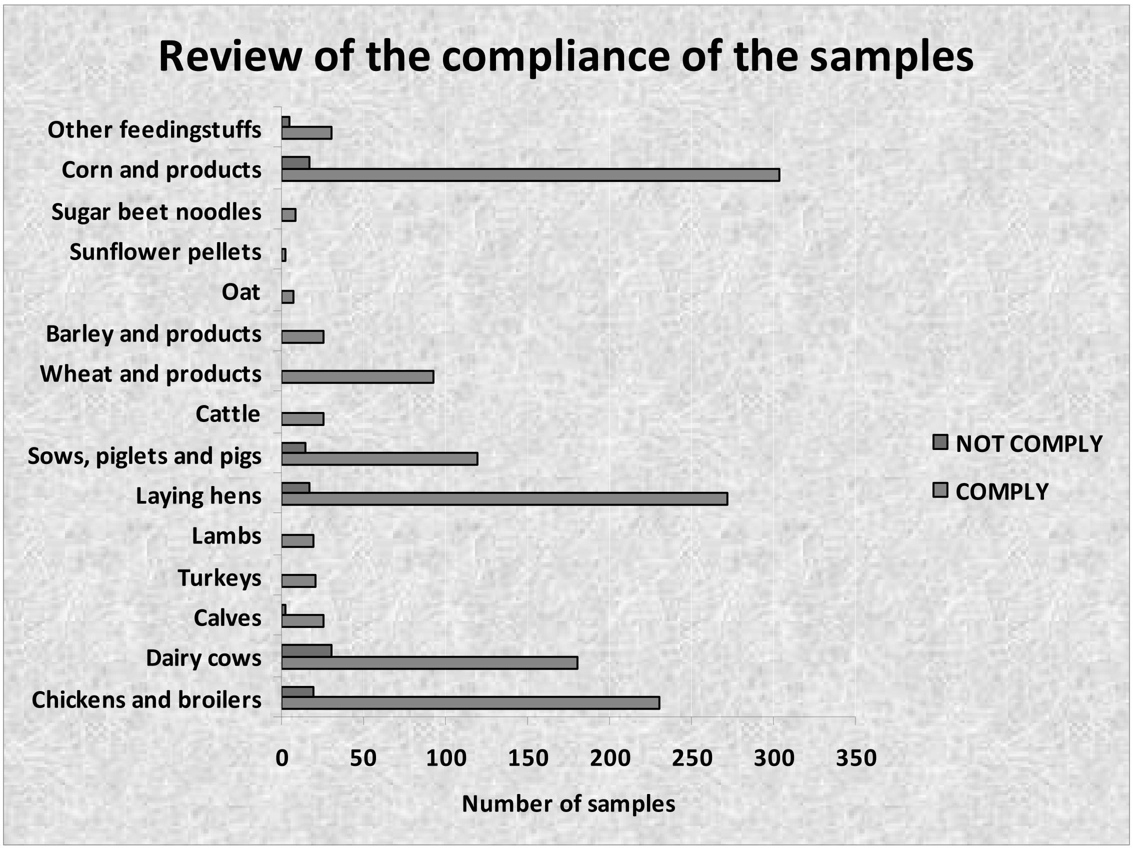
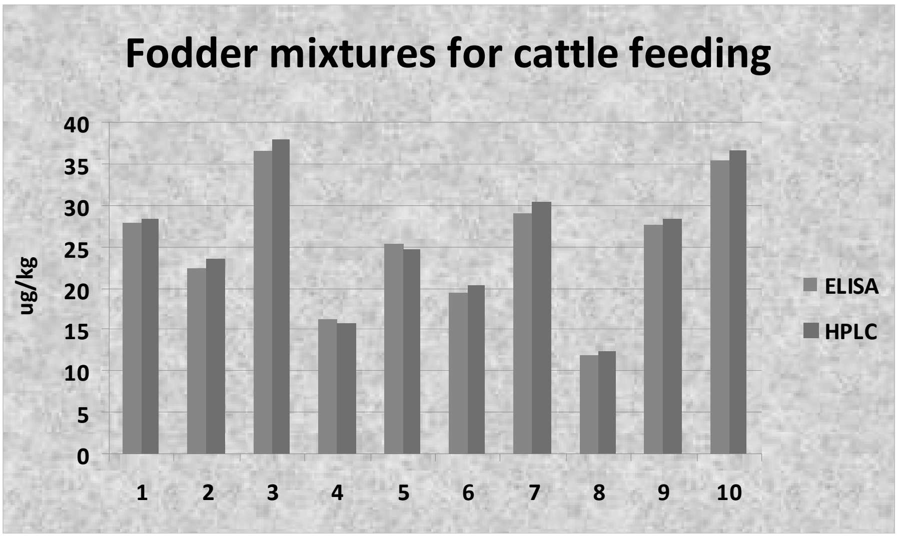


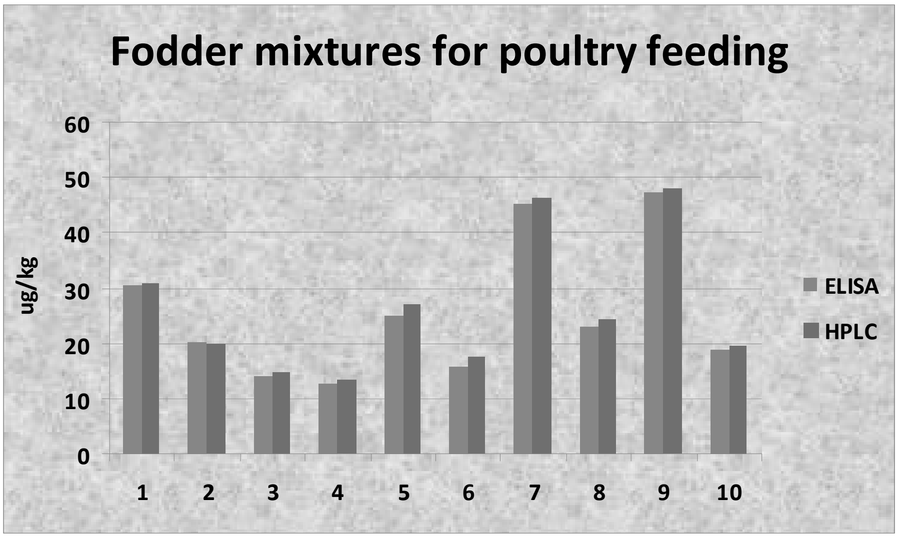
Figure 3. Graphical review of the compliance of samples of certain types of animal feed

Analysis of all above mentioned samples first was acquired by screening method using the ELISA. Since this method is primarily a qualitative, all positive results were confirmed and quantified by a technique that is confirmatory using HPLC with fluorescence detection. In order to determine the reliability of the method for screening of this type of testing, results obtained by both of these methods were compared. Comparative analysis of the obtained results showed that the samples that were positive on ELISA, were also confirmed with confirmation technique.

Comparison of the results is presented graphically where the tested feedingstuffs were grouped by the type of animals for whose feeding was intended to be used.



a)



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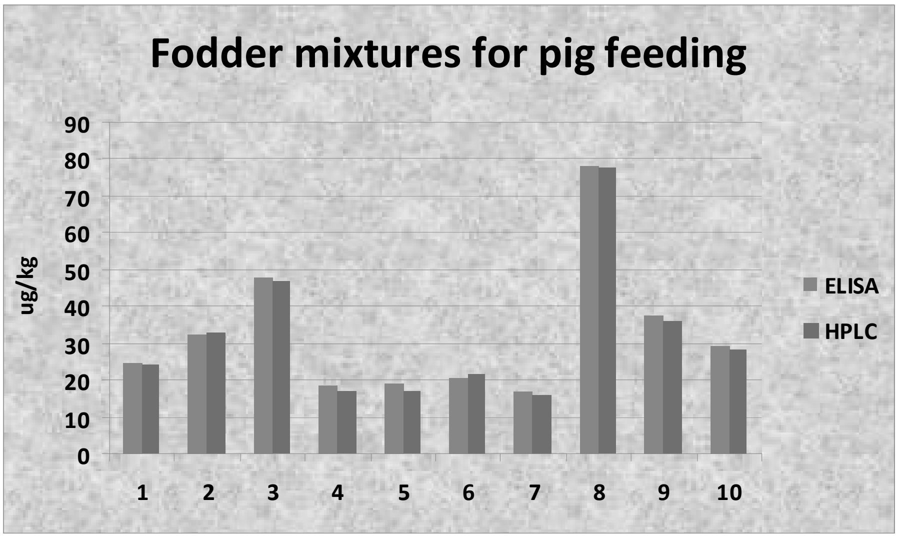

c)

Figure 4. Graphical view of comparative analysis of the results obtained by ELISA and HPLC of fodder mixtures for feeding: a) cattle, b) poultry and c) pig.

A matching between the values obtained by ELISA method as the ratio of absorbance B/B0 and the true value obtained by confirmatory HPLC technique proved to be good. Difference between the values obtained by these two techniques is about ± 15%, which essentially corresponds to the uncertainty of measurement that was obtained in the validation of a liquid chromatography method. Expanded uncertainty determined with the validation of method for individual aflatoxins ranged from 10 to 16%.

Good matching on lower values was not repeated for the results that on the ELISA is shown to be beyond the range of its determination, which is 80 mg / kg. Even when the dilution of samples was made, matching of the results came out of the range of a particular measurement uncertainty for confirmation technique. This just supports the fact that every result that has been shown a positive on ELISA must be confirmed by the liquid chromatography as a confirmation method.

4. Conclusion

Examination of large number of animal feed on a market of Montenegro demonstrated the presence of aflatoxin in approximately 10% of the samples. Mostly these were feed based on corn enriched mixtures intended for feeding of different types of farm animals.

All samples were initially assayed by ELISA sreening, then every positive result is verified and confirmed with confirmation method - liquid chromatography with fluorescence detection. Matching of the obtained result with these two techniques is well in the field of concentration that are within the range of determination of the screening method. In the case of concentrations that were outside the range of the determination of screening methods, and where it was necessary to make dilutions, matching proved to be poor.

Since the ELISA method itself is semiquantitative, even though the good matching, it is necessary to confirm the results with the confirmation technique.

Since present aflatoxins in animal feed may reflect in foods of animal origin that are used in human nutrition, it is necessary to constantly carry out regular checks of the feed and thus ensure the correctness of these types of feed. Such is the case, for example with milk, which is used commonly in the diet of children, in which extremely toxic aflatoxin M1 may be present as a result of the presence of total aflatoxin in feed for dairy cows.

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Zaštita materijala i životne sredine (2014), broj 1

UDK 628.477(4)

DEVELOPMENT OF SOLID RECOVERED FUELS FROM WASTE IN EUROPA AND THE STUDY OF LOCAL POTENTIALS

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ABSTRACT

This paper discusses the development of the solid recovered fuels (SRF) in Europe and the possibilities to include local municipal solid waste (MSW) energy potential in these streams. The waste generation is closely related to the nation wealth. Thus great amounts are generated daily and part of it cannot be recycled and has high calorific value what makes it a resourceful domestic energy source.

The energy utilization of any waste stream is not technically simple and environmental issues must be specially addressed, as the negative impacts in case of malpractice can be immense.

Developed countries in Europe have already developed national standardized procedures to help overlook the SRF sector from the production to utilization. This paper partly reviews some of most commonly used standards in Europe and addresses local challenges that have not yet been utilized. This energy source can save other conventional types of energy and reduce the emissions of pollutants and greenhouse gases.

Key words: refuse derived fuel (SRF), municipal solid waste (MSW), energy from MSW, incineration, environmental protection.

1 INTRODUCTION

For some time we are witnessing in the field of waste management the growing demand for better waste management resulting in the better material and energy utilization and the minimization of its environmental impacts at the landfill.

Residual wasteafter thewaste separation,which cannot berecycledand at the same timeitcannot be disposedat landfillsbecause of highcalorific valueandthe level of totalbiodegradablecarbonisaccordingto waste hierarchyan energy source and the only possible solution is its incineration. Solidwaste fuelsare an important formof alternative energy sourceanda substitute forfossil fuels.Development of thesefuelsin terms of theirenergy, chemical and physical propertiesrequiresan analytical approachby usinga propersamplingof waste as araw material inputandproductsamplingof solid fuelsby taking into accountthe standardized methods. By knowing the characteristics of the waste materials going into the solid fuel,it enables proper processing and mixing of these input waste materials into the final product – SRF – fuels with high calorific value and limited content of materials causing pollution during combustion.

This article discusses the developmentof solid fuelsin Europe and research work done locally in Slovenia and Montenegro. An integral part of this research and development is the series of testing offuels.

2 PRODUCTION AND UTILIZATION TESTS OF SRF

The EU Landfill Directive [1]requireshigh reduction of landfilled biodegradable waste by 2015 and setsstrict rules forwaste calorific value and composition. This has 15 years ago led tothe search for technical and environmental solutionsfor all the biodegradablewaste thatis not suitable formaterial recovery. In this context,the use ofenergy-rich solid fuelsderived from non-hazardousandbiodegradablemixedor separatewaste fractionsfrom mixedmunicipal waste arethe main substituents inthe futurewaste management systemsin the form ofsolid recovered fuels (SRF). This is very much the direction of the latest EU Waste Directive [11]. Of course, the waste materials that from technical and economical aspect can be used for recycling cannot be processed into fuel.

Co-incineration of SRF in existing combustion plants can play an important role. Partial substitution of coal with SRF can effectively help in covering the capacity limitation and also ensure the saving of valuable fossil fuel and reduce carbon dioxide emissions (~ 1 g CO_2/g SRF) in large power plants [2]. Co-incineration of SRF in existing thermal power plants requires low additional investment. It is a reductionof the cost for“green” electricity productioncompared to other alternative energy sources such as wind power and photovoltaics.

Annually in Europa, over 600 waste-to-energy plants incinerate around 130 million tons of mixed MSW for the production of heat and/or production of electricity [2]. The new waste-to-energy facilities have a maximum electrical efficiency of 30% (at 580 °C and 289 bars of steam pressure) [3]. For comparison, the steam boilers with anthracite in Germany have an average efficiency of 37%, which the potential to be increased up to 47% [4].

The extensiveresearch in the field of SRF utilizationin Germany reaches backalmost ten yearsago. Thus,in Germanyhas in the year 2005within the framework ofthe European projectRECOFUELperformedco-incineration ofsolid fuelfrom wastein two RWE owned and operated largelignite-firedpower plant boilerswith the powerof 600MW_{el}inWeisweiler, of Germany[5]. Figure 1 shows thefuel dosing systeminto theplantwhere coal is mixing with SRF andpapersludge.

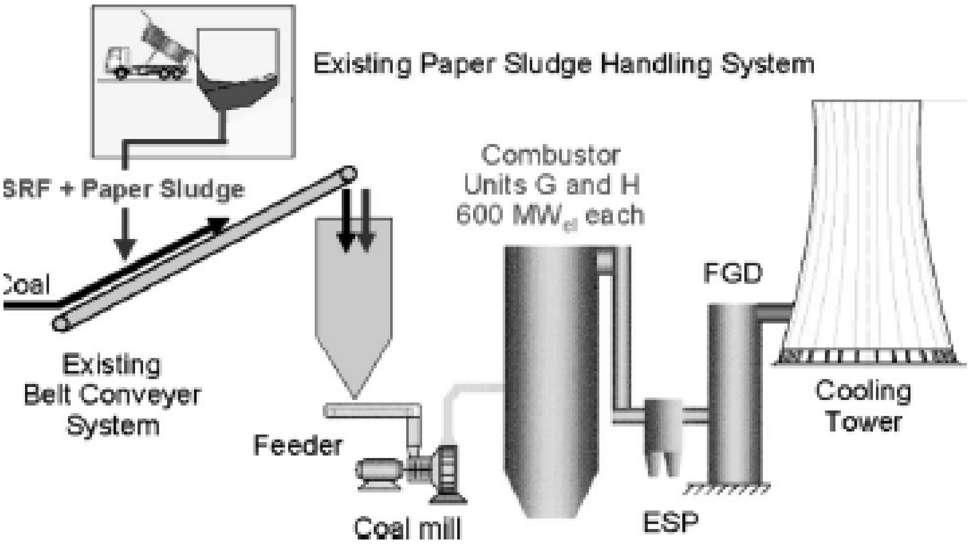


Figure 1: The dosing system forcoal, SRF and paper sludge into the steam boiler [5]

The evaluation of the resultsof measurements at theboilerduringco-incineration ofSRFinRWEWeisweilergavethe followinginteresting findings[5]:

1. A continuous detailed environmental and technical measurements within 3 weeks showed that there was no negative impact due to co-incineration of solid fuels, except for minor deviations. The level of CO emission was slightly increased, but the differences to the everyday values were within the statistical standard deviations. Co-incineration of SRF had no effect on SO_2 emissions, neither on mercury, dioxins/furans, nor not even on the dust particles. Other operating data, such as the production of steam, the temperature of the steam, fuel and air mass flow rate were comparable to basic operation and operation in co-incineration of solid fuel mode.Table 1shows the analysis of the measurements.

Table 1: The analysisof themeasurementsfor alloperating conditions [5]

Parameter	Ligniteandpaper sludge	SRF co-incineration	Limit values– plant environmental permit (RWE Power)	German legislation (17. BlmSchV – Verordnung des Bundes-Immission Schutzgesetzes)
Dust (mg/m^3)	3,0	1,5	20	30
Total carbon (mg/m^3)	0,3	0,5	8,4	20
HCl (mg/m^3)	0,3	<0,1	20	60
HF (mg/m^3)	<0,1	<0,1	1	4
Hg (mg/m^3)	0,009	0,007	0,016	0,05
PCCD/F* (ng TE/m^3) –mean value	<0,001	<0,001	0,026	0,1

*PCCD/F – poly chlorinated dibenzo dioxins/furans

2. The evaluation of the co-incineration resultsof SRFdid not showsignificant impacton theoperation of the boilerandemissionsfor the SRFshare of2% and4%. With regard tothe combustion in the boiler the minor differencesin the operation ofthe boiler weredetected compared to the baseoperating conditions withoutSRF. The carbon contentinfly ashhas not increasedduring the tests, so it concluded that there was acomplete combustionof solidfuels.
3. Analysis of thecorrosionon boilershowed thatdue toco-incineration ofSRF it hadnosignificant effect oncorrosion. Data showedslightlyincreaseof corrosionin case 4%SRF share, while2%SRF share had no effect oncorrosion. It must pointed out thatcorrosion detection was possible only in one placeandfor a short time. For a morecomprehensive and reliablestatement of thecorrosionfrom the co-incineration ofSRF it would be requiredto performlong-termtestsand perform inspections at several locationsboiler.
4. The ashsampleswere analyzedbyX-rayfluorescencemethod. It had slightly higherproportion of$Al_2O_3$and CaO, whilethe$SiO_2$and MgOremained the same concentrations as without co-incineration, although no practicaldifferencebetween residuessampleswith or withoutco- incinerationof SRFwas found.

Table 2 shows a comparison of heavy metalslevels infly ash, measuredforthe combustion of conventional fossil fuelsandco-incinerationSRF in the share of4%.

Table 2: Analysis of heavy metals in fly ash without co-incinerationand with co-incinerationof SRF[5]

Component	Withoutco-incineration of SRF [mg/kg]	Co-incineration of SRF [mg/kg]
Cd	0,23	0,45
Ta	< 1	< 1
Hg	0,47	0,42
Sb	< 1,5	5,2
As	6,74	8,86
Pb	12	22
Cr	17,4	23,9
Co	22,5	15,1
Cu	63,77	58,9
Mn	2207	1719
Ni	23	19,8
V	21,8	22,3
Sn	< 2	2,7
Zn	71,6	137

The co-incineration of SRF produced higher concentrations of some metals (Sb, As, Pb, Cr, Zn)in comparison with the tes twithout SRF. The concentrations of other metals from co-incineration of SRF were even lower than the value of the test without co-incineration of SRF.

To determine thecharacteristics of the waste andSRF, a large number o fstudies in laboratory combustion plantsorincinerators were performed. Parameters such as thecalorificvalue, moisture, ashandthe chlorinecontentwere analyzedusinga large number ofsamples. On the basis ofthe measurementof the fluegasemissions the environmental and technical influence was determined [7],[9]. Due to the heterogeneous structure of the waste materials it is necessary to take into an account interdependence of a number of parameters, which determine the characteristics of the waste and consequently a SRF, including the calorific value, the temperature of combustionand pollutant emissions [9].

Chlorineis one ofthe most problematic elements in the use of SRF to produce energy from waste, because of the formation of acid, harmful to the environment and the technology components. Besidethe chlorine are also important parameterssuch asmoisture content, calorific valueandashresiduethat all together determine thequalityof solid fuels. Therefore,researchers havedevoteda series of studies, whichdeal withthe issue of quality of solid fuels, including chlorine.[6]

With the aimto reduce thechlorine contentin SRF there were implemented several processing technologiesfor the separation ofmaterials. Different approaches of materials separation consequently result in to the different technology and input (MSW)/output(SRF) proportions andthe amount of chlorine included in it.

Figure 2 and Figure 3 show the efficiency ofSRF productionin a masswaste streamproduction andthe amount of chlorine contentinSRFwith differenttechnologies ofwaste separation[7]:

a) Technology A: separation ofresidual wasteon particles < 30 mm and particles > 30 mm
b) Technology B: separation ofthe residual wasteto particlesof < 30 mm and particles > 30 mm with additional particles separation> 30 mm with aballisticseparator.

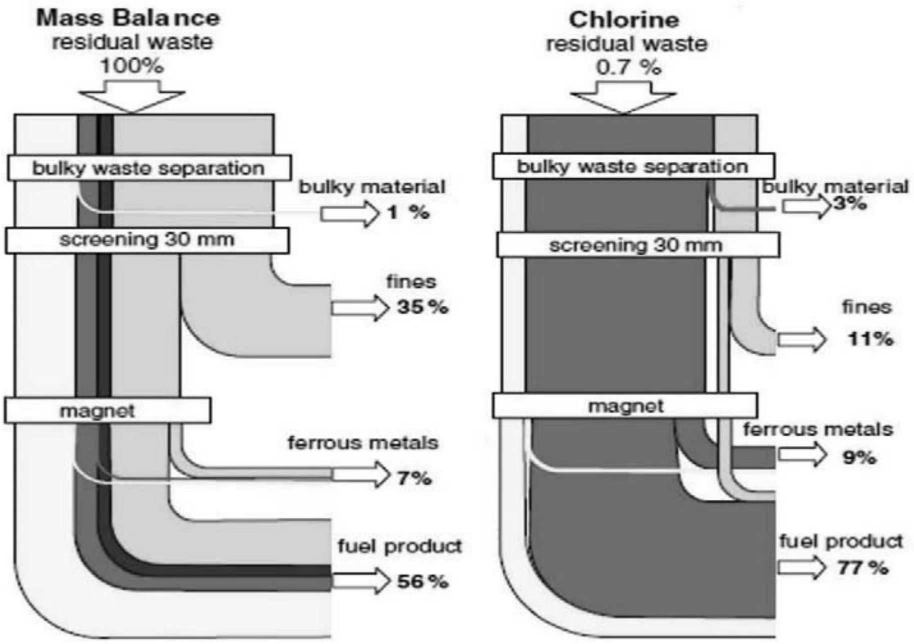


Figure 2: Mass balance and chlorine contentfor the individual fractions using technology A[7]

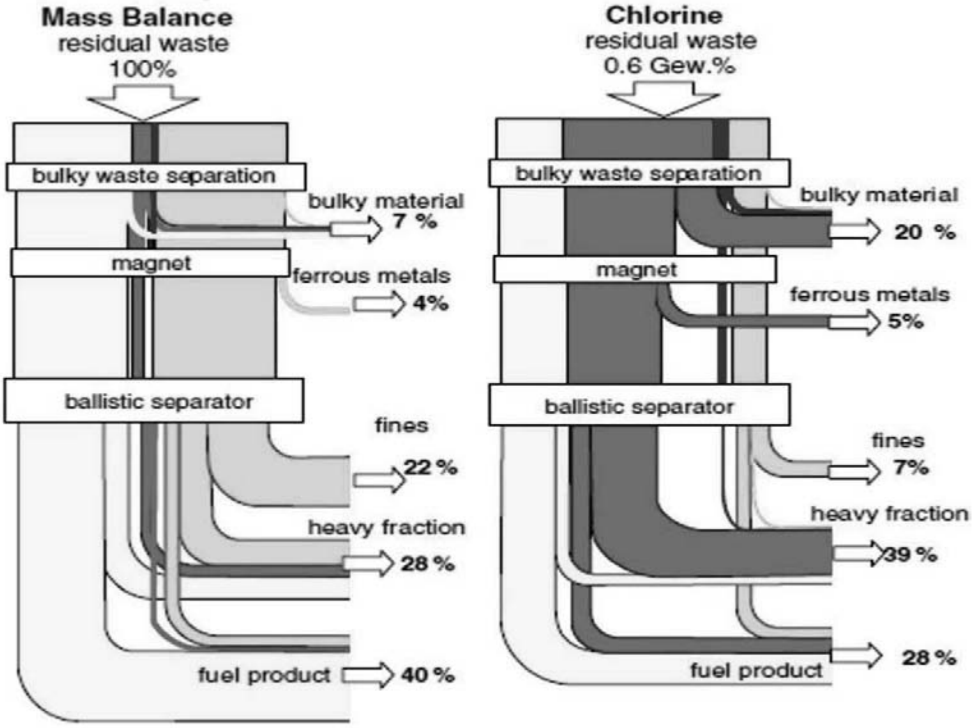


Figure 3: Mass balance and chlorine contentfor the individual fractions using technology B[7]

3 SRF QUALITY REQUIREMENTS AND ASSURING THE QUALITY OF SRF PRODUCTIONIN EUROPE

The quality assurance of SRF is important because of the environmental and technical criteria that apply between producers and users of SRF.Nevertheless, it very much helps in the SRF marketing.

GermanInstitutefor Quality AssuranceandCertificationfor substitute fuels (RAL)has prepared instructions for testin gand quality assurance for producers of SRF in 2008 [7][8]. There were certain quality criteria, in particular, the limitvalues for heavy metal sand for those producers who have metthe quality requirements they were granted thequality label (RAL-GZ-724). The quality criteriais defining two classes, namely SRF, which was produced from mostly homogenous wastedirectly from industry and SRF originating from MSW. These requirements have since tightened during the SRF product development processes. Nowadays they are regulated with the European standards at the European Commission for Standardization under the supervision of CEN343.

Back in 2008 has RAL set the main parameters of SRF with regard to its final utilization and they are presented in the Table 3.[8]

Table 3: Parametersof SRFandthe requirementsfor its use[8]

Parameter	**Technical, economic and environmental impact**	**Co-incineration**		**Incineration**
		Cement kilns	**Thermal Power Plants (fuel – coal)**	**SRF**
Net calorific value (NCV) (kJ/kg), (d.s.)	Impact on productive capacity - revenue	> 20.000	> 18.000	12.000 – 16.000
Moisture content(%)	Impact on the calorific value / productive capacity	< 15	< 15-25	< 30-40
Disposal (€)	The cost of disposal	< 15	< 15-20	< 25-30
Chlorine content (%), (s.s.)	Corrosion, effect on the quality of by-products, waste residue	< 1	< 0,5-1,5	< 1–1,5
Heavy metals content (mg/kg), (s.s.)	Impact on the environment, effect on the quality of the product	In accordance with the RAL GZ-724	In accordance with the RAL GZ-724	

Some European countries haveadopted their ownnational standards:

- Italy: UNI 9903 Non mineral Refuse Derived Fuels RDF 1992 (IT); alignment with European standardization of solid fuels CEN by Decree 205/2010.
- Finland: SFS 5875 Solid Recovered Fuel - Quality Control System 2000 (FIN).

Table 4 and Table 5 show the parameterlimits and classes of solid fuels in Italy and Finland, respectively.

Table 4: Italiannational standardUNI9903

Parameter	*Statisticalcalculation of the average*	Unit	Quality Class				
			I	II	III	IV	V
NCV	average	MJ/kg	≥ 25	≥ 20	≥ 15	≥ 10	≥ 3
Cl	average	%	≤ 0.2	≤ 0.6	≤ 1.0	≤ 1.5	≤ 3
Hg	median	mg/MJ	≤ 0.02	≤ 0.03	≤ 0.08	≤ 0.15	≤ 0.5
	80th percentile		≤ 0.04	≤ 0.06	≤ 0.16	≤ 0.30	≤ 1.0

Table 5: Finlandnational standard SFS 5875

Parameter	Unit	Quality class		
		I	II	III
Cl	%	< 0.15	< 0.5	< 1.5
S	%	< 0.2	< 0.3	< 0.5
N	%	< 1.0	< 1.5	< 2.5
K +Na	%	< 0.2	< 0.4	< 0.5
Hg	%	< 0.1	< 0.2	< 0.5
Cd	%	< 1.0	< 4.0	< 5.0

The industry that utilizes the SRF has mostly set its owmquality parameters. The industry sectors have more or less same requirements as the processes are mostly the same in the SRF influence on the production process is rather the same.

3.1 Co-incineration in the cement industry (Belgium, Germany and France)

The maximumvalue of the NCVis not prescribed. In addition, the cementkilns technology allows the utilization of SRF with a relatively lowcalorific value. The concentration of Chlorineis limited up to 3% (depending on the content ofK and Nabecause of the formationof potassium chloridesandsalts).Table 6 presents these values.

Table 6: The limit values for co-incineration of SRF in the cement industry[10]

Parameter	**Unit**	**Value**
NCV	MJ/kg	12-22*
Cl	%	0,5-1 (max. 3)

3.2 Co-incineration in the coal power plants

Chlorine is problematic due to high temperature boiler corrosion and the need for flue gas treatment. In the Netherlands, it is usually permissible maximum value of Cl 0.2% in the UK up to 0.4%. Table 7 presents the SRF properties for coal power plants

Table 7: Limit values for co-incineration of SRF in thermal power plants[10]

Parameter	Unit	Black coal (without grate cooling)	Brown coal (grate cooling)	Brown coal (without grate cooling)
NCV	MJ/kg	13.5 (mean) 11-18 (range)	17 (mean) 13-22 (range)	13.5 (mean) 11-18 (range)
Cl	%	0.6 (mean) 1.3 (max)	1.1 (mean) 2.5 (max)	0.5 (mean) 0.6 (max)

Co-incineration of SRF is highly applicable for the combustion in the fluidized bed boilers. Limitsof NCV and the chlorine content in the caseof theco-incinerationin the fluidized bed combustion for Sweden, Italy and Germanyare in Table 8.

Table 8: The limit values for co-incineration in the fluidized bed combustion devices[10]

Parameter	Unit	Value
NCV	MJ/kg	13.5 (mean) 9-18 (range)
Cl	%	0.4 (mean) 0.5 (max)/0.8 (max)/ 1.4 (max)

For Cadmium and Mercury, the following limits presented in Table 9 apply.

Table 9: The limit values for Cadmium and Mercury[10]

Parameter	Unit	Cement kiln	Hard coal power plant		Brown coal power plant	Fluidized bed technology (FBC)
			without grate cooling	with grate cooling		
Cd	mg/MJ	6.90	1.21	0.25	0.42	0.63
Hg	mg/MJ	0.08-0.33	0.065	0.034	0.085	0.028

The limit valuesare approximate, because air emissions dependonsingle boiler technological properties and must be determined based on measurements.

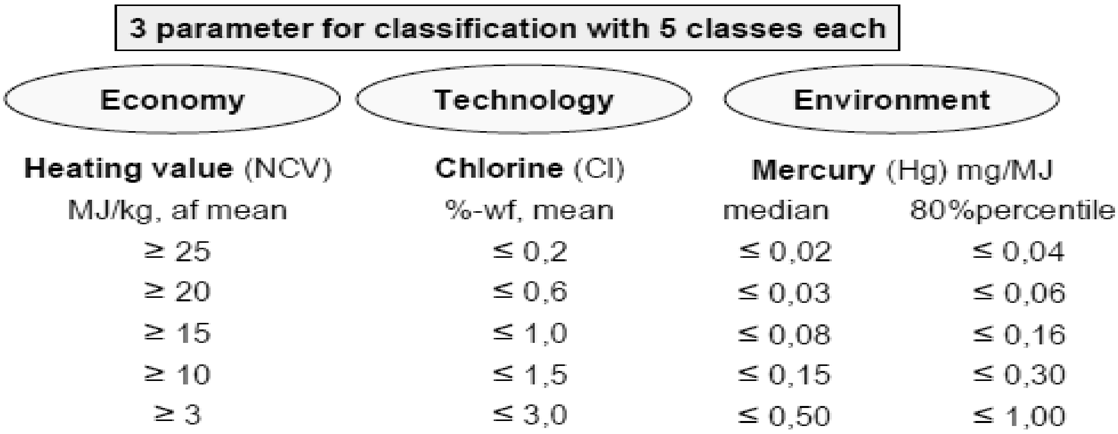
4 EUROPEAN STANDARDISATION OF SOLID FUELS FROM WASTE

The standards based on the resultsof the experimentaldata ofco-incineration of the SRFin Europehave been created within the Technical Committee CEN/TC343 of European Commission. They cover the areaof alternative fuelsfrom waste. There are the following working groups:

CEN/TC 343/WG 1	Terminology and Quality Assurance
CEN/TC 343/WG 2	Specifications and Classes
CEN/TC 343/WG 3	Sampling, sample selection and auxiliary testing methods
CEN/TC 343/WG 4	Physical, mechanical tests
CEN/TC 343/WG 5	Chemical tests

Threebasic aspects(economic,technological and environmental) are in place in Europefor the classification ofsolidwaste fuelsinto classesand Table 10 specifies them.

Table 10: Classification criteria for the SRF



3 parameter for classification with 5 classes each

Economy	Technology	Environment	
Heating value (NCV)	**Chlorine** (Cl)	**Mercury** (Hg) mg/MJ	
MJ/kg, af mean	%-wf, mean	median	80%percentile
≥ 25	≤ 0,2	≤ 0,02	≤ 0,04
≥ 20	≤ 0,6	≤ 0,03	≤ 0,06
≥ 15	≤ 1,0	≤ 0,08	≤ 0,16
≥ 10	≤ 1,5	≤ 0,15	≤ 0,30
≥ 3	≤ 3,0	≤ 0,50	≤ 1,00

The EN standard in use across Europe cover all areas of SRF production and testing, but are generally not obligatory. Some of them are stated in literature ([12][13][14][15][16][17][19][20][21][22][23]).

5 PRODUCTION AND CONSUMPTION OF SRF WITH THE PROGNOSIS OF THE PRODUCION BY THE YEAR 2020

The production of solid fuels in Europe has in the last 15 years experienced a great progress. From the beginning of production and the adoption of the legal bases which were first adopted Germany as part of an association of producersand users of SRF called »Die Gütegemeinschaft Sekundärbrennstoffe und Recyclingholz e. V», which includes solid fuel from waste and biomass, the organized and quality controlled process started also in other countries.

Today the productionof solid fuelsis becoming increasingly interesting and provides long-term economic perspective. The Figure 4 shows the prognosis of production and consumption of solid fuels in Europe by 2020.[10] There are 3 scenarios based on the optimism of end users. The production industry also has its waste source limits as the most interesting sources like packaging waste must first follow Packaging [18] and Waste [11] directive in terms of material recycling and can only later be utilized as fuel. The most optimistic scenario 3 has 2 alternations mostly alternating in the sector utilizing the SRF (cement industry vs. heating or thermal power plants).

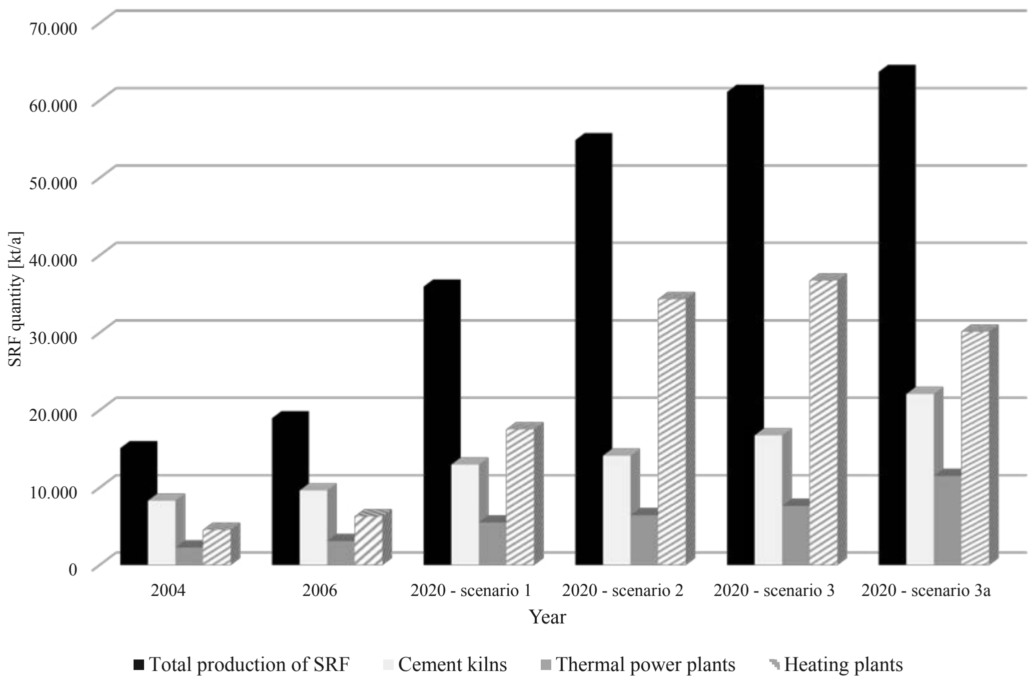


Figure 4: Prognosisof production and consumptionof solid fuelsin Europeby 2020

6 RESULTS OF EXPERIMENTAL STUDY OF SRF PRODUCTION IN SLOVENIA

The research done by the authors on waste sources and their quality in term of SRF production was already partly presented. [24]

Some differences can be found in the classification system for solid recovered fuels (SRF) between Slovenia and other European countries (Italy, Finland, Germany, Austria and Switzerland). In Slovenia, the classification system for SRF limits five most important fuel properties: the mean value of net calorific value (NCV), the mean value of chlorine content, the mean and 80th percentile values of mercury content, the mean value of cadmium content and the mean value of sulphur content. These were the parameters closely followed through the research.

The requirements for the final SRF quality are set based on technical and legal requirements of the end user. Based on this demands the various waste materials from municipal solid waste and industrial waste were analysed (textiles, residual industrial waste, yellow bags, residuals after sorting, ground bulky waste and combustible fraction waste of household waste).

The waste material was processed on full-scale technological system. It was first grounded to small size and homogenized. The final material mixture (6 samples) laboratory analyses were carried out after the materials were mixed in calculated shares from different waste streams as presented in Figure 5.

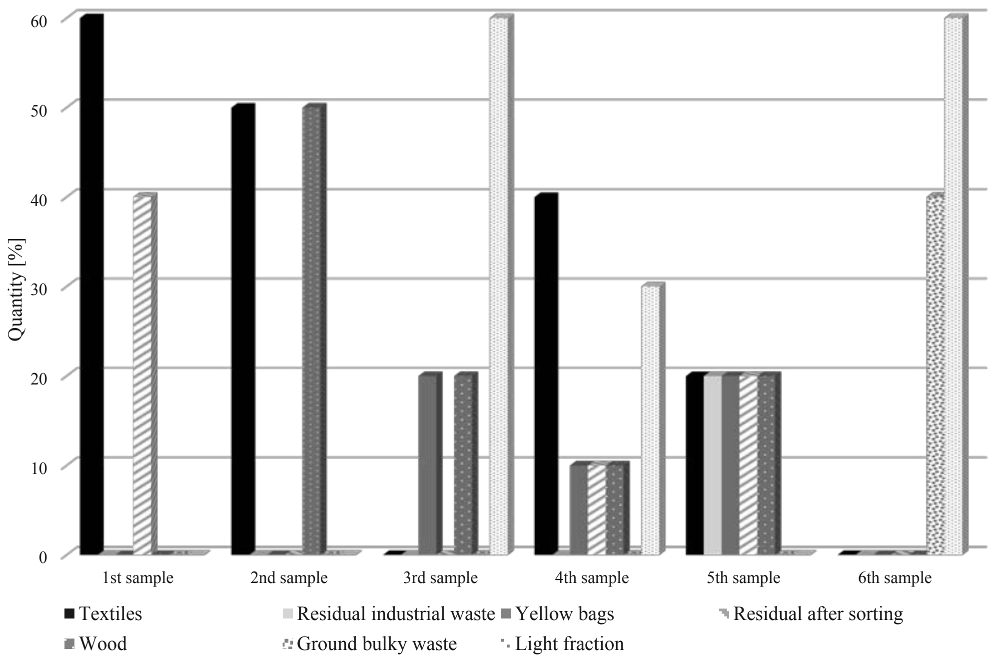


Figure 5: Waste material sources used for preparing testing samples

Different samples were prepared based on available waste sources in Slovenia that actually exist, their quantity is big and presents real material source for SRF production. The testing of mixtures (samples) has to show the possibilities for final utilization in terms of environment and technology.

Concerning the environment the chlorine content was measured in samples and is presented in Figure 6. The second sample had the lowest share and the sixth sample had the highest share. This concentration is a consequence of input streams that compose the sample and chlorine content in there.

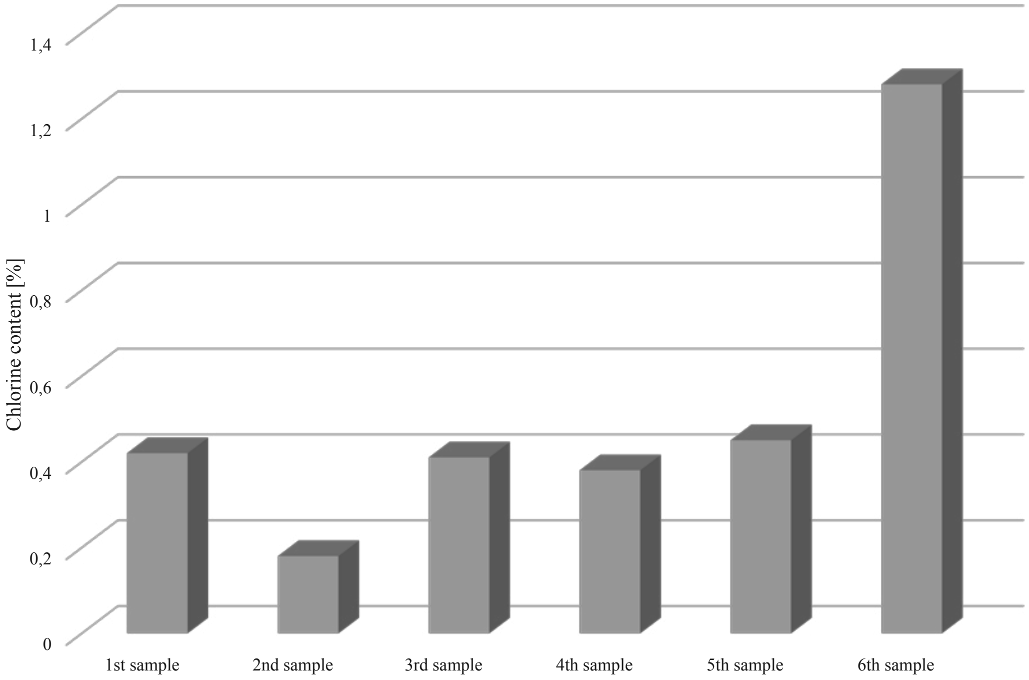


Figure 6: Chlorine content of prepared samples

The calorific value of the samples is very important from the technological and economical point of view and isdepictedonFigure 7. The first sample had the highest calorific value and the third sample had the lowest calorific value.All samples had relatively high calorific value that is comparable to brown or even hard coal. From this prospective are these SRF samples very attractive as alternative fuel.

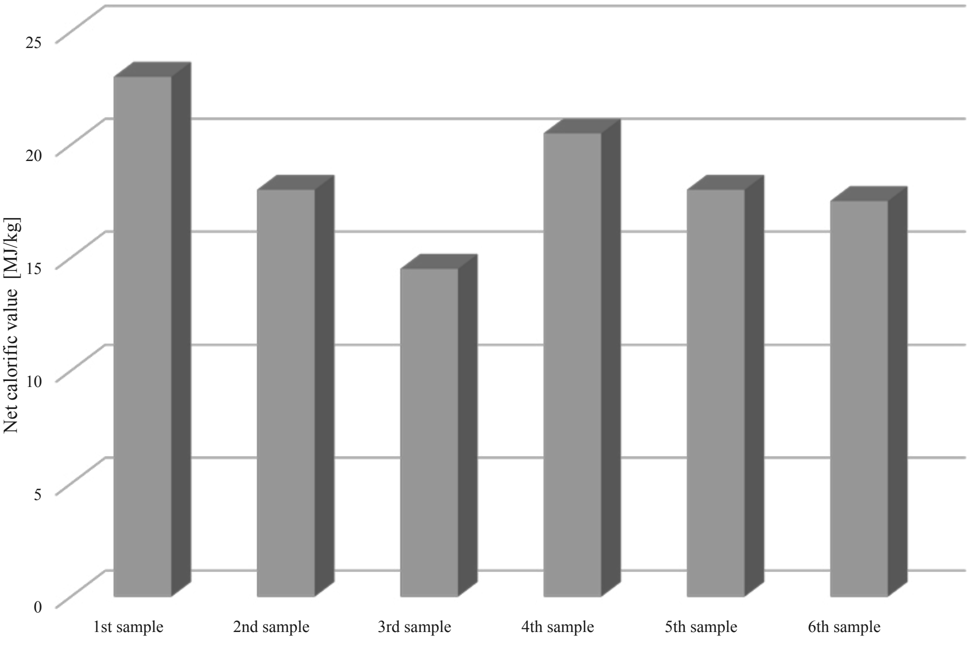


Figure 7: Calorific value of prepared samples

Later all 6samples underwent incineration tests with complete environmental and technical measurements. The results show that those samples with the highest share of plastic burned very intensively due to high calorific value. Consequently,very intensive combustion even produced increased emissions of products of incomplete combustion due to unstable process. The concentration of chlorine in the fuel was reflected in gaseous inorganic chlorine compounds and the input material with highest chlorine content produced the highest emissions.

7 POTENTIALS FOR SRF PRODUCTION IN MONTENEGRO

Todays and future energy potential of MSW in Montenegro has already been estimated. [25] The findings there show the possibility for refuse derived fuel (RDF) production through mechanical – biological treatment (MBT) of MSW. The results of that research indicateimmense quantities of this alternative fuel.

RDF production is not the standard process and the technological equipment depends on the type of residual waste treated and the further usage of the produced fuel. RDF is the combustible fraction of residual wastes with high calorific value. It is mostly composed of plastic, paper and textiles.

Figure 8shows the estimated potential for RDF production during the period 2011 – 2035 regarding the regions in Montenegro.This research presented a possibility to produce by the year 2020 around 100.000 tons of RDF per year. [25]

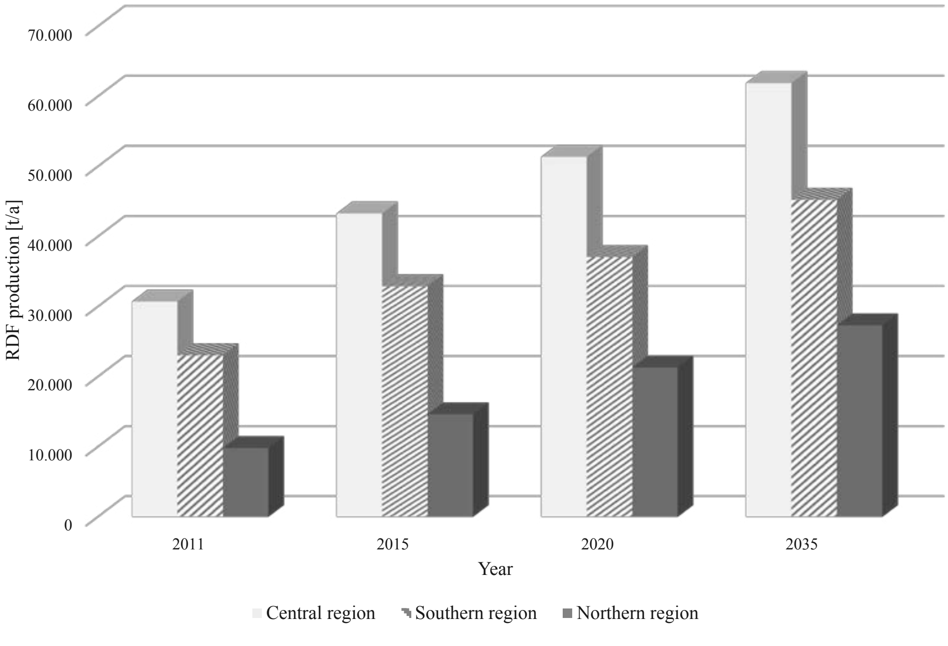


Figure 8: Estimated quantity of RDF production regarding the regions in Montenegro[25]

The main difference between SRF and RDF is in its input waste streams, production and the fuel quality. Most of the RDF in Europa is produced directly from MSW and the fuel quality is very dependent of the input waste stream quality, thus varies quite much. The SRF is mainly produced from more or less homogenous waste fractions with known composition and pollutant concentrations.

This enables more precise production process in order to produce end user desired product. The fuel quality assurance in such process is much easier achieved. The production of RDF is usually more simple and robust.

The countries that want to follow EU waste directive [11] and fully oblige waste treatment hierarchy but are without waste-to-energy plants should look into the direction of producing the SRF instead of RDF to produce a fuel that can be utilized in big thermal or industrial plant and at the same tine do not pose any treat for the environment.

The Montenegro has the potential to produce at least 50.000 tons per year of SRF. This can be produced partially from MSW fractions and partly from high calorific industrial and commercial waste. This would decrease the production of RDF but produce higher quality alternative fuel that is much easier to utilize without harmful environmental influence.

8 CONCLUSION

The work has presented the general development and trends in Europe in the sector of SRF. It is completely clear that the developed countries recognized the opportunity of this alternative fuel utilization. The research activities have proved that the fuel is adequate fuel alternative without bigger negative impact compared to standard fuels. To be able to use this fuel the producers must ensure constant production of agreed SRF quality.

To assure quality fuel production it is very important to undertake multiple parameter analysis of the input materials brought into the production process. This is assured only with continuous sampling of waste in accordance with the valid technical specifications and laboratory analysis. The analysis data is the basis for mixing different waste streams to produce desired quality SRF. Testing and production procedures should follow either EN or national standard, agreed by the producer and SRF end user.

Presented experimental work shows the possibilities to produce good quality SRF from industrial waste and MSW fractions. Samples were tested and expected results in terms of energy utilization and impact to the environment were measured.

The potentials in Montenegro for SRF production are great since so far no fuel production from waste takes place. They should be exploited as this is domestic energy source that saves other energy sources.

The SRF is a relatively low-cost form of alternative energy with a large potential for future expansion. It is possible to use it in adequate devices with the proper organization of an integrated waste management system and if done correctly, does not have any negative impact on the environment.

SRF from waste represents an important source of renewable energy and gives a major contribution to low-carbon society.

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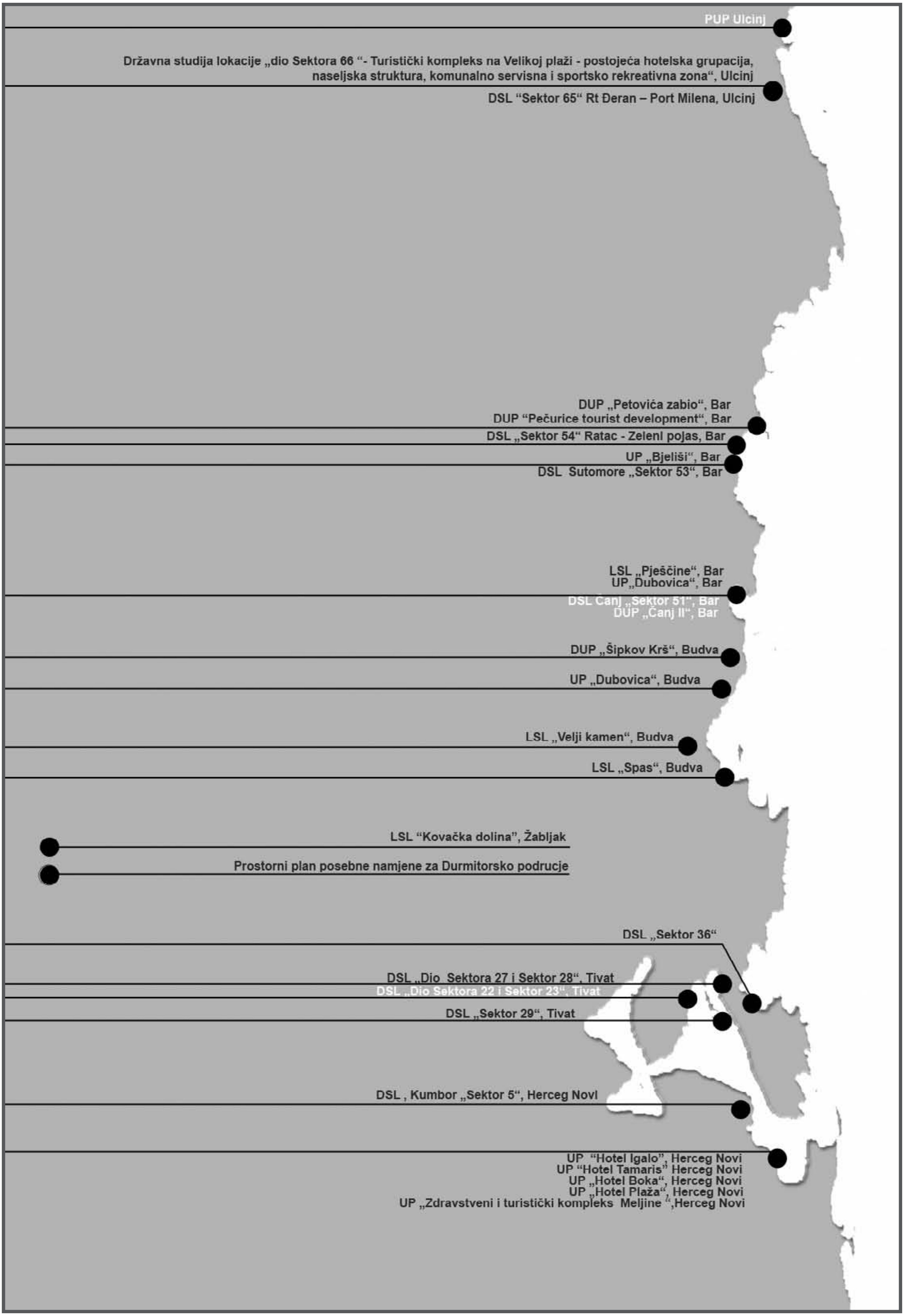
PUP Ulcinj
Državna studija lokacije „dio Sektora 66 “- Turistički kompleks na Velikoj plaži - postojeća hotelska grupacija, naseljska struktura, komunalno servisna i sportsko rekreativna zona“, Ulcinj
DSL “Sektor 65“ Rt Đeran – Port Milena, Ulcinj
DUP „Petovića zabio“, Bar
DUP “Pečurice tourist development“, Bar
DSL „Sektor 54“ Ratac - Zeleni pojas, Bar
UP „Bjeliši“, Bar
DSL Sutomore „Sektor 53“, Bar
LSL „Pješčine“, Bar
UP„Dubovica“, Bar
DSL Čanj „Sektor 51“, Bar
DUP „Čanj II“, Bar
DUP „Šipkov Krš“, Budva
UP „Dubovica“, Budva
LSL „Velji kamen“, Budva
LSL „Spas“, Budva
LSL “Kovačka dolina”, Žabljak
Prostorni plan posebne namjene za Durmitorsko podrucje
DSL „Sektor 36“
DSL „Dio Sektora 27 i Sektor 28“, Tivat
DSL „Dio Sektora 22 i Sektor 23“, Tivat
DSL „Sektor 29“, Tivat
DSL , Kumbor „Sektor 5“, Herceg Novi
UP “Hotel Igalo”, Herceg Novi
UP “Hotel Tamaris” Herceg Novi
UP „Hotel Boka“, Herceg Novi
UP „Hotel Plaža“, Herceg Novi
UP „Zdravstveni i turistički kompleks Meljine “,Herceg Novi

Centar za arhitekturu i urbanizam - CAU je nastao kroz proces intenzivne, međunarodne, intelektualne i profesionalne saradnje na razmjeni ideja između pojedinaca koji su okupljeni oko zajedničkih ciljeva.Pokazalo se da u uslovima globalizacijena i vrijednosti informacije, timski rad umreženih pojedinaca sa raznih krajeva svijeta postaje trend u ozbiljnim projektima.U sveukupnoj klimi prostornog planiranja u Crnoj Gori danas, regionalna i međunarodna saradnja,multidisciplinarnost, nesmetan protok znanja i kapitala, studiozan pristup, zaštita životnog okruženja, održivi razvoj, obnovljiva energija i sl. samo su neke od ‘ključnih riječi` za definisanje ispravnog pristupa ovoj ozbiljnoj disciplini. CAU posjeduje licence za izradu prostorno-planske dokumentacije.

AKTIVNOSTI

- prostorno planiranje i urbanizam
- arhitektura i uređenje pejzaža
-saobraćaj i infrastruktura
- investicioni projekti
- studijska istraživanja

CAU

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Poliex

NOVO!!! NOVO!!! NOVO!!!

AD "POLIEX", BERANE

Izgrađen kao fabrika namjenske industrije za potrebe Vojske AD "POLIEX" je prvobitnu proizvodnju minsko-eksplozivnih sredstava je 1991. godine dopunio proizvodnjom inicijalnih sredstava, a tri godine kasnije usvojena je i proizvodnja eksploziva za civilnu upotrebu.

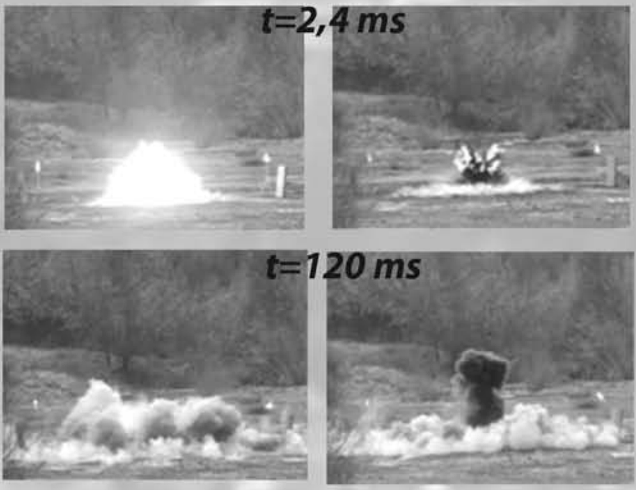
Fabrici je uveden ISO 9001 standard- Sertifikovani sistem menadžmenta i svi proizvodi su usklađeni sa evropskim standardima tj. posjeduju CE znak po tipu Modula B i Modula D.

Fabrika se takođe bavi uslugom minerskog servisa, kao i delaboracijom minsko-eksplozivnih sredstava i ima obučeni kadar i mogućnost da ovu oblast dodatno usavršava.

TERMOBARIK

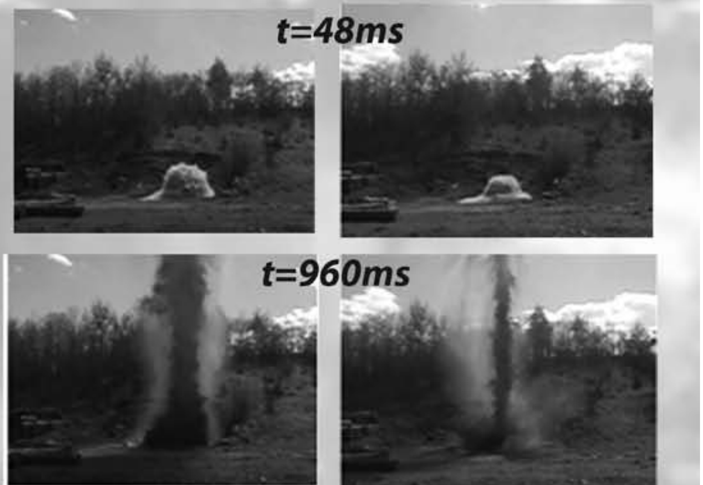
- Moćnija eksplozivna akcija!!!
-U velikom se opsegu čuvaju svojstva dodatnih razornih činilaca - šrapneli i brizantnost.
-Termobarik municija je fatalna za život u vještačkim i prirodnim skloništima.
-Dizajn termobarik municije blago se razlikuje od konvencionalne municije.
-Veliki broj municije može se pretvoriti u termobarik bez mijenjanja dizajna (avio-bombe).

Uporedni testovi mine 82 mm napunjene sastavom TBS i TNT



TBS 1 **TNT**

Uporedni testovi punjenja TBS 1 i TNT mase 2 kg u vodi na dubini od 1 m TNT ekvivalent TBS-1 minskog dejstva 2.5



TBS 1 **TNT**

Poliex

NOVO!!! NOVO!!! NOVO!!!

AMONIJUM PERHLORAT NH_4ClO_4

Bijeli kristalni prah.Zbog svojih svojstava masovno se koristi u proizvodnji kompozitnih raketnih goriva, a takodje i u pirotehnici.

KALIJUM PERHLORAT $KClO_4$

Bijeli kristalni prah.Zbog svojih svojstava koristi se eksploziva,posebno u proizvodnji privrednih eksploziva, kao i u pirotehnici.

KALIJUM HLORAT $KClO_3$

Bijeli kristalni prah.Veoma jak oksidans, koji nalazi široku primjenu u pirotehnici.

KALIJUM NITRAT KNO_3

Bijeli kristalni prah.Veoma široka primjena u mnogim oblastima, posebno u pirotehnici i proizvodnji mineralnih đubriva.

BARIJUM NITRAT $Ba(NO_3)_2$

Bijeli kristalni prah.Nalazi primjenu u pirotehnici, naročito za bojenje plamena.

BARIJUM HROMAT $BaCrO_4$

Žuti kristalni prah.Široka primjena u mnogim granama, naročito u pirotehnici.

BARIJUM PEROKSID BaO_2

Sivobijeli kristalni prah.Zbog izraženih oksidacionih svojstava koristi se u pirotehnici, ali i za dobijanje kiseonika.

OLOVOFEROCIJANID $Pb_2[Fe(CN)]_6$

Svijetložuti kristalni prah.Osnovna primjena je pirotehnika.

OLOVO HROMAT $PbCrO_4$

Žuti do žutocrveni kristali.Upotrebljava se u pirotehnici, ali i u proizvodnji mineralnih boja.

STRONCIJUM NITRAT $Sr_2(NO_3)_2$

Bijeli kristalni prah.Upotrebljava se u pirotehnici, ali i u mnogim drugim granama industrije.

SREBRO JODID AgJ

Svijetložuti kristalni prah.Upotrebljava se u fotografiji i kod izrade protivgradnog reagensa, kao aktivna komponenta.

AMONIJUM JODID NH_4J

Bijeli kristalni prah.Upotrebljava se u fotografiji,medicini, a takođe kod izrade protivgradnog reagensa.

HI "POLIEX" AD Berane, Crna Gora,
Police bb
Tel/Fax 382 (0)51 241-634
Mob.+382 (0)69 318-211 ; +382 (0)67 444-999

TÜV - 1008

poliex@t-com.me www.poliex.me

Centar za ekotoksikološka ispitivanja Podgorica DOO (CETI) je osnovala Vlada Crne Gore za vršenje poslova ispitivanja svih segmenata životne sredine: vazduha, vode, mora, zemljišta, flore i faune, klimatskih promjena, jonizujućeg i nejonizujućeg zračenja, buke i vibracije, izrade posebnih toksikoloških studija, analiza i programa za potrebe državnih organa, naučnoistraživačkih ustanova, privrede i građana, kao i poslova kontrole zdravstvene ispravnosti životnih namirnica i predmeta opšte upotrebe.

CETI vrši:

- ekotoksikološka i ispitivanja kvaliteta (fizičko-hemijska ispitivanja i ispitivanje sadržaja radionuklida) svih segmenata životne sredine (vode, vazduha, zemljišta, sedimenta, mora...);
- kategorizaciju otpada;
- ispitivanje otpadnih gasova - emisija;
- ispitivanje radona;
- snimanje „nultog“ stanja potrebnog za izrade studija lokacija i elaborata o procjeni uticaja na životnu sredinu;
- izradu toksikoloških studija, analiza i programa za potrebe državnih organa, naučnoistraživačkih ustanova, privrednih društava i drugih subjekata;
- dozimetrijska mjerenja, osiguranje i kontrola kvaliteta (QA/QC);
- kontrolu i izdavanje sertifikata za promet roba (hrane i predmeta opšte upotrebe) u uvozu, izvozu i proizvodnji;
- ispitivanje radne sredine (komfor-mikroklimatski uslovi, hemijske i fizičke štetnosti);
- ispitivanje buke i vibracije u radnoj i životnoj sredini;
- pripremu i izradu akta o procjeni profesionalnih rizika zaposlenih sa predlogom mjera za njihovo otklanjanje.

CETI se trudi da neprestano unapređuje kvalitet svojih usluga kako bi obezbijedio ispunjenje zahtjeva i očekivanja korisnika, održava na vrhunskom nivou sistem etaloniranja za svu opremu koju koristi za kontrolisanje i ispitivanje, sprovodi sistem međulaboratorijskih ispitivanja i kontrolnih i funkcionalnih proba u cilju provjere i obezbjeđenja tačnosti i preciznosti laboratorijskih rezultata i kompetentnosti rada Laboratorije i stalno podiže nivo obrazovanja i povećava motivaciju i zadovoljstvo zaposlenih.

CETI je institucija koja pored visoke stručnosti posjeduje i višegodišnje iskustvo u djelatnosti ekotoksikoloških ispitivanja svih segmenata životne sredine. Od osnivanja je postigao da svoju djelatnost proširi po obimu, vrsti ispitivanja, broju analiza što je rezultiralo i širenjem liste klijenata tj. korisnika usluga. Danas može da ponudi široki spektar analiza koje se rade po savremenim, svjetski priznatim metodama i sa najkvalitetnijom i najpouzdanijom laboratorijskom opremom.

Osnovni cilj djelovanja CETI je kreiranje i realizacija uspješne strategije zasnovane na konkurentskim prednostima sopstvene organizacije i uvažavanju potreba i interesa klijenata s ciljem širenja liste klijenata i jačanja i osvajanja povjerenja korisnika usluga na domaćem i tržištu regiona. Ostvarenje ovih zadataka podrazumijeva prije svega veliku angažovanost zaposlenih, odgovarajuću instrumentalnu opremu, finansijska sredstva i vrijeme. Temelj uspjeha ujedno i prednost CETI jeste angažman svih zaposlenih, spremnost na nove izazove, a sve sa ciljem ostvarivanja zajedničke vizije – da CETI bude institucija prepoznata, u regionu i šire po stručnosti, pouzdanosti analiza, uvijek raspoloživa na tržištu uz konkurentne cijene.

Naši klijenti cijene implementaciju standardnih metoda analiza EN, MEST ISO, ISO, DIN, pridržavanje najviših profesionalnih standarda i dobre laboratorijske prakse, primjenu poznatih i priznatih metoda ispitivanja, obezbjeđenje tačnosti i preciznosti laboratorijskih rezultata i kompetentnosti rada Laboratorije, visoke sposobnosti i mogućnosti CETI, kratko vrijeme realizacije posla, konkurentne cijene, potpuno osiguranje kvaliteta rezultata i kontrolu sistema kvaliteta.

LABORATORIJSKE TEHNIKE

- *gasna hromatografija – masenomasena spektrometrija (GC-MSMS)*
- *gasna hromatografija - masena spektrometrija (GC-MS)*
- *gasna hromatografija (GC – ECD, FID, NPD, TCD, PID,FPD)*
- *tečna hromatografija visokih performansi (HPLC - UV, RF, DAD,RID)*
- *tečna hromatografija sa masenim spektrometrom LC- MS*
- *induktivno spregnuta plazma - optička emisijska spektrometrija (ICP-OES)*
- *atomska apsorpciona spektrofotometrija (AAS)-plamena i sa grafitnom kivetom*
- *spektrofotometrija i spektroskopija (UV, VIS, FTIR)*
- *Analizator žive*
- *TOC analizator*
- *analizatori emisija izduvnih gasova*
- *analizator gasova po VDI za mjerenje emisije iz velikih ložišta preko 3 MW*
- *γ - spektrometri sa 40% i 38% efikasnosti*
- α *- spektrometar*
- *scintilacioni brojač, scintilaciona sonda*
- α, β *- counter*
- *Oprema za kontrolu Rentgen aparata*
- *Oprema za mjerenje radona i njegovih potomaka*
- *Oprema za mjerenje buke i vibracija, mikroklime, temperature, vlažnosti i brzine strujanja vazduha (anemometar)*
- *Automatske monitorske stanice za praćenje kvaliteta vazduha*
- *Automatske stanice za kvalitet riječne i morske vode*
- *Uzorkivači vazduha za određivanje PM 10 i PM 2,5*
- *Uzorkivač vazduha za dioksine*
- *Uzorkivači za vode, sediment, zemljište i opasne materije*

Tokom 15 godina uspješnog poslovanja najznačajniji klijenti CETI su: Elektroprivreda Crne Gore, Kombinat aluminijuma, Termoelektrana Pljevlja, Luka Bar, Brodogradilište Bijela, Kliničko bolnički centar, Agencija za zaštitu životne sredine, Novi Volvox, Cerovo, 16 Februar, Porto Montenegro, Tradeunique, Okov, Nivel i dr.

MEDIX
d.o.o.
P.C."KRUŠEVAC"
PODGORICA

- ***O preduzeću***

Preduzeće „MEDIX“ d.o.o. Podgorica osnovano je u oktobru 1998. godine. Zapošljava 4 radnika koji su u stalnom radnom odnosu, a u honorarnom odnosu ima 15-tak radnika.

- ***Djelatnost***

Osnovna djelatnost preduzeća je izrada Elaborata procjene uticaja na životnu sredinu, Strateških procjena uticaja, Studija izvodljivosti i Projekata iz oblasti životne sredine.

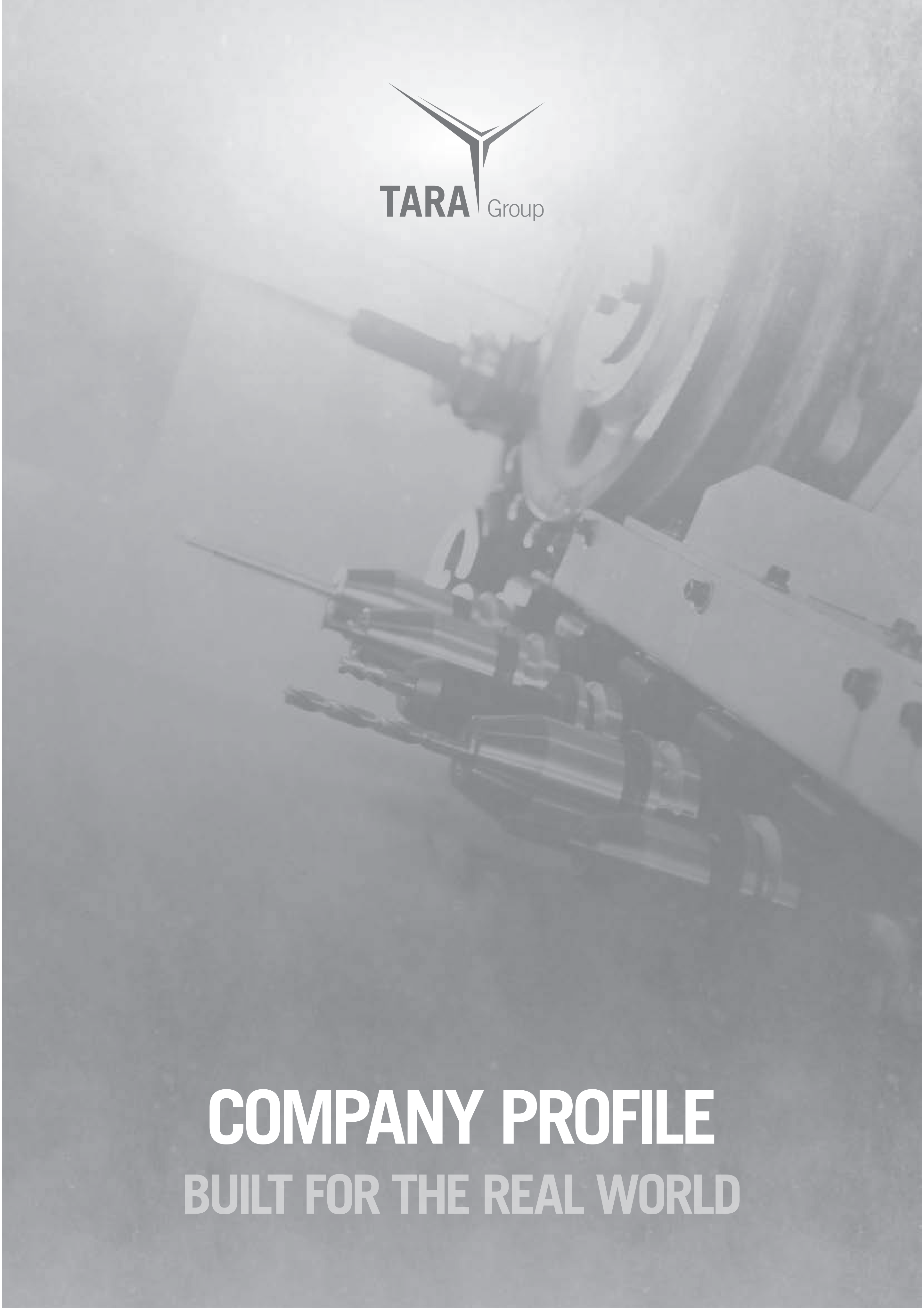
U svom dugogodišnjem radu ovo preduzeće je uradilo preko 500 Elaborata procjene uticaja, kao i značajan broj Strateških procjena uticaja i Studija izvodljivosti.

Preduzeće okuplja veliki broj stručnjaka iz različitih oblasti koji za pojedine poslove čine multidisciplinarni tim. Svi angažovani stručnjaci imaju veliko iskustvo u izvršavanju poslova iz oblasti životne sredine, tako da je ovo preduzeće jedno od vodećih u pružanju usluga koje se odnose na sferu njegove djelatnosti.

Osim saradnje sa domaćim institucijama i preduzećima, jedan dio aktivnosti preduzeća je vezan i za saradnju sa inostranim partnerima koji se bave problemima životne sredine.

- ***Osposobljenost***

Preduzeće „Medix“ je u svakom pogledu osposobljeno za obavljanje svoje djelatnosti.



TARA Group

COMPANY PROFILE

BUILT FOR THE REAL WORLD

TARA AEROSPACE AND DEFENCE PRODUCTS A.D.

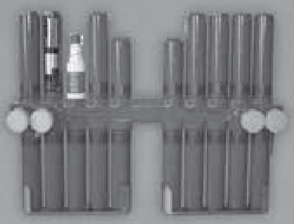
PYROTECHNICAL PROPULSION CARTRIDGES AND ROCKET ENGINES

The development and manufacturing of Pyrotechnical Activation and Propulsion Cartridges for Pilot Ejection Seats of Western and former Soviet design is the core expertise of Tara Aerospace and Defence Products A.D.

Certified by Martin Baker and accredited by many Air Forces and Aviation Repair and Maintenance Factories around the world, Tara Aerospace and Defence Products A.D. are acknowledged as the leading independent manufacturer of Pyrotechnical Aviation Cartridges. Being equipped with modern environment testing facilities and by conducting 100% performance and conformity tests, Tara is ensuring OEM specifications and the highest quality of its products.

Pyrotechnical Activation Charges and Rocket Engines are used in the following products:

- Pyrotechnical Activation Charges and Rocket Engines for all Russian design Ejection Seats type KM-1, KM-1M,K36L and K36DM, used in various Aircraft types, MIG21, MIG23, SU25, SU27, MIG29, L39
- Pyrotechnical Activation Charges and Rocket Engines for Martin Baker Ejection Seats Mk-9, Mk-10 and Mk-11 as well as Folland Mk-1 used in Aircraft types, Tornado, F4 Phantom, F5 Tiger, F16 and others as well as Galeb and Super Galeb
- Pyrotechnical Blasting Caps for firing initiation type PPL, PPL-T, PP-9 and for Aircraft Machine Guns type Yak-B and Gsh-23 gun as well as TK-M71 for the D30 Howitzer
- Counter measure Infrared and Anti-Radar Chaff Flares type PPI-26, PPR-26 and PPI-50 and PPR-50
- Signal Flares 38/40mm and Personal Rescue Flare Kits for Pilots and other users
- Anti Riot Ammunition 37/38 and 38/40mm



RESEARCH AND DEVELOPMENT OF PYROTECHNICAL CHARGES

The extensive laboratories and experienced team of Engineers of Tara Aerospace are providing a wide range of possibilites for research and development of almost any type of pyrotechnical charges and rocket engines according to customer requirements and specifications.

FUSE PRODUCTION

Initially established in cooperation with the main Mortar Shell Manufacturer of former Yugoslavia, the company Krusik Valjevo, Tara Aerospace and Defence Products were the main suppliers of Mortar Shell fuses and other Artillery Ammunition and Rocket Fuses that were in production by the Yugoslavian Defence Industries. Also, Tara is manufacturing several types of Fuses for Mines and Fuses for Aviation Bombs.

- Mortar Shell Fuses Calibers 60mm, 80mm, 81mm, 82mm and 120mm
- Hand Grenade Fuses for Hand Grenades type M-75 and ARGES
- Fuses for various types of Mines

DEMILITARIZATION OF OBSOLETE MUNITIONS

Tara Aerospace and Defense Products A.D. is offering the knowledge and safe infrastructure to disassemble all types of Munitions and Rocket engines. Because of the expertise and experience in working with Fuses, Pyrotechnics and Explosives, Tara has recently been selected by the Ministry of Defense of Montenegro under the MONDEM Project as a partner for the professional disassembly and ecologic disposal of various types of obsolete Large Caliber Ammunitions. Further projects and expansion of the demilitarization projects are in preparation.

AVIATION AND AIRCRAFT SERVICES

In cooperation with other Aviation Servicing Companies, Tara Group is offering specific expertise in support of aviation and aircraft maintenance services and components supply. Maintenance, Overhaul and Upgrade of Russian pattern aviation platforms such as:

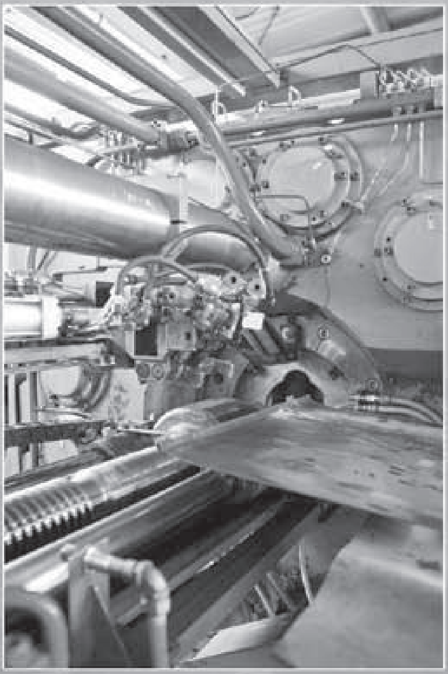
- MIG-21, MIG-23 MIG-29, SU-25, SU-27, MI-8, MI-17, MI-24, MI-26

Maintenance, Overhaul and Upgrade of Western pattern helicopters and aircrafts such as:

- Bell and Bell Augusta 204, 205, 206, 412
- Rotor Blades from Composite materials for most types of Helicopters
- Overhaul and Supply of Aviation Rockets 57mm S5 and 80mm S8

TARA PERFECTION D.O.O.

FIREARM TECHNOLOGY - QUALITY STANDARDS, PRECISION AND DURABILITY



TARA Perfection D.O.O. became a member of the TARA GROUP, situated in the “Wild Beauty” of Montenegro in 2009 and leads the Small Arms Division of the Concern. Although all processes within the GROUP are strongly related, each section concentrates in special fields to guarantee maximum efficiency and autonomy.

Together with Tara Precision Works and Tara Aerospace, the factory can offer complete solutions to modern Law Enforcement and Military customers around the world. The Services of the Group include the production and sale of new products entirely produced in Montenegro, as well as system-upgrades for individual customers and the selection and procurement of related material for our partners.

The development and production of the TM-9 standard size service pistol and the TM-4 assault rifle with a polymer lower receiver and a short-stroke piston system are only the first step towards the introduction of a complete and consistent weapon family, comprising all relevant sizes and calibers in the small-arms world. All future developments and product launches shall follow the vision and company philosophy of employing latest technologies and best materials only to provide new technical solutions to professional users.

TM-9 PISTOL

The TM-9 semi-automatic service pistol combines the latest developments and features of cutting edge firearm technology not only with regards to quality standards, precision and durability but also considering the strictest safety requirements. The extremely hard and anticorrosive slide can be disconnected from the Polymer Lower Receiver without the need to pull the trigger. This can be considered an additional passive safety – just like the pistol’s ability to allow consecutive striker actions (real double action) without the need to rack the slide.

State-of-the-art characteristics like anti-corrosive surface protection, high capacity double stag magazines and piccatinny rails to mount tactical lights are the answer to the requirements of modern forces. In addition the TM-9 features an ambidextrous magazine release button and a special lanyard connection point to cover all possible scenarios. The DARE-Trigger system allows for a fast and simple training of new users and for a smooth transition for those who come from old conventional systems, in order to reach maximum safety and effectivity with minimum effort and costs.

TM-4 ASSAULT RIFLE

The TM-4 Assault Rifle represents the ultimate evolution of the battle proven M16 Rifle design for the 21st Century. Without compromise, Tara Perfection has eliminated the weaknesses of the open gas system by designing a highly reliable and adjustable short stroke piston system, a revolutionary steel reinforced high strength polymer lower receiver with fully ambidextrous magazine release and fire selector lever.
The cold hammer forged and NITREX coated barrel guarantees the highest accuracy in all weather conditions and is ideal for tropical climates due to its total corrosion protection. This unique process increases the barrel life and reliability of the rifle.

The high number of compatible parts with existing M16A1, M16A2 and M4 Carbines allow Tara Perfection to offer existing users of the M16 Rifle Systems different types of refurbishments and upgrades to improve their current rifles to the unique TM-4 Standard.

The TM-4 Assault Rifle is the ideal choice for Military and Law Enforcement units that require an up-to-date weapon which provides the highest reliability, accuracy and great user facilities.

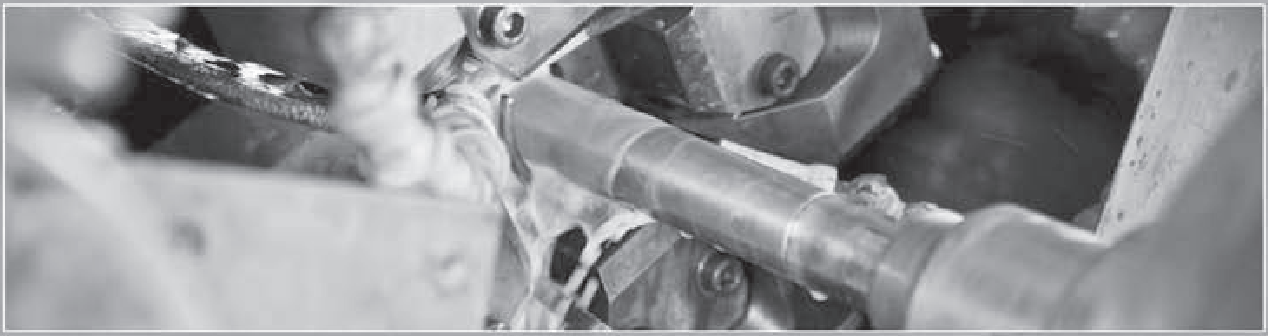
TARA PRECISION WORKS A.D.

PRODUCTION FACILITY

Tara Precision Works is a fully equipped production facility specializing in the execution of all processes required for developing, testing and manufacturing of up-to-date components of all types for the requirements of the Aviation, Aerospace, Defence and Automotive Industry.

The company has highly qualified personnel and production potential for:

- Machining, turning, milling, drilling and grinding
- Hammer forging of barrels for small caliber weapons
- mechanical treatment by deformation
- heat treatment
- surface coating and protection
- testing of products in the chemical laboratory
- testing of products in the test station
- 3d measurements in the metrology laboratory
- Assembly of specialized products.



COLD HAMMER BARREL FORGING

Tara Precision Works A.D. is equipped with a complete production line for Cold Hammer Barrel Forging made by GFM Austria. The process of cold hammer forging produces the best quality barrels featuring highest precision and lifetime. Tara Precision Works offers barrel blanks in most common Calibers to its customers as well as in various steel configurations. Tara Precision Works can offer machining and heat treatment of the barrels to individual customer requirements.

- Maximum hammering diameter of Barrel Blank up to 40mm
- Maximum Length after hammering is 580mm
- Barrel Steels available in Military Standards and Stainless Steel
- Caliber Range for all common Rifle, Handgun and Automatic Weapons

WEAPON SUPPORT AND MAINTENANCE SERVICES

Tara Precision works is offering a wide range of manufacturing capacities for manufacturing of specialized accessories and equipment for all types of armament. Based on customer requirements and focused on ultimate serviceability and quality, Tara is providing services in Design Studies, Rapid Prototyping, Testing Prototypes and Serial Production of almost any type of mechanical components.

- Rotating Vehicle Mounts for Light and Heavy Machine Guns such as PKM, MAG-58, M60, M2HB, NSV, DSHK
- Tripods for Heavy Machine Guns DSHK and NSV
- Optical Sight Mounts for Medium and Heavy Machine Guns and Mechanical Mortar Goniometers.

SURFACE TREATMENT, REFURBISHING AND REMANUFACTURING

Tara Precision Works is equipped with full line of surface treatment equipment for cleaning, preparation, coating and galvanization of ferrous and non ferrous steels. Phosphating (iron and steel), Chrome-plating (aluminum and Al alloys), Chrome-plating (copper and brass), Anodic oxidizing (aluminum and Al alloys), Cadmium-plating, Zinc-plating, Silver-plating, Tin-coating, Nickel-plating, Copper cyaniding, Hard chrome-plating, Shellac-varnishing, Burnishing.

Tara Precision Works is providing services for complete repair, refurbishment and remanufacturing for all types of Light and Medium Armament. Scope of work includes:

- Disassembly
- Cleaning, Sand Blasting, Surface polishing etc.
- Measuring and control of individual parts
- Surface coating
- Assembly and lubricating
- Function testing and certification
- Packing and storage services

TEST STATIONS

The Test Station is equipped with the most modern test equipment for environmental tests of various armaments and defence equipment and other products at all development stages:

- Chemical tests laboratory is authorized to issue test certificates (attests) certifying quality of surface protection based on tests conducted in salt and humidity test chambers
- Four-channel oscilloscope - NICOLET
- Vibrator with a random vibrations setting and control device – RANDOM
- Pressure and thrust test bench
- Conditioning chamber
- Jolting test equipment (verifying transport safety according to Russian and US standards)
- Transport Safety Testing station to NATO and Russian Standards
- Quality Control Standards (ISO 9001, ISO 1474)

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FOUNDATION & PEAK OF PRODUCTION

Founded in 1984 and build up until 1986 the Factory was established under the name “4th Novembar” by the Ministry of Defense of Former Yugoslavia. The mission of 4th Novembar was manufacturing and developing of mechanical fuses for Mortar Shells and Artillery Rockets in cooperation with the Krusik factory in Valievo, Serbia as well as manufacturing all types of Pyrotechnical Propulsion Cartridges, Pyrotechnical Activation Charges and Rocket Engines for Ejection Seats for Soviet Military Aircrafts and Helicopters as well as Pyrocartridges and Rockets Engines for the British Martin Baker Ejection seats.

During the peak of the production in the late 1980’s and early 1990’s the company was manufacturing up to 500’000 mortar fuses per year and the number of employees was over 500. 4th Novembar was the largest fuse and pyrotechnics manufacturer of the former Yugoslav Republic and cooperating strongly with all the other Military Factories.

PRIVATIZATION AND NEW TECHNOLOGIES

The hard years of the embargo times during the Balkan Conflicts as well as the lack of International co-operations has caused the bankruptcy of the company in the beginning of 2001. During the years 2002 to 2007 the company was held alive with subsidies from the Montenegro Government, who in due course came to the decision that only a privatization could bring the company back to life and would ensure the re-structuring of the company and allow fresh capital and new technologies to flow into the company.

On July 31st, 2007 the Swiss registered company BT International Ltd. won the tender for privatization and took over the operational management of the factories on December 20th, 2007. In the process of privatization, the company has been renamed and divided into two companies, Tara Precision Works A.D. which is the heart of the company with all the metal processing and treatment plant and, Tara Aerospace and Defence Products A.D. which is covering the military part of the factory and is responsible for assembly and marketing of the final products. New production lines and machinery have been installed, together with a team of highly qualified engineers to operate them.

CDKZM

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