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REZULTATI PRIMJENE ADITIVA ZA POBOLJŠANJE IZGARANJA TEŠKOG LOŽIVOG ULJA U RADU GENERATORA PARE ENERGANE RAFINERIJE NAFTE RIJEKA

Sažetak

Generatori pare Energane Rafinerije nafte Rijeka koriste teško loživo ulje neujednačene kvalitete i rade konstantno cijelu godinu s promjenljivim opterećenjem.

Problemi koji nastaju tijekom rada uzrokovani su taloženjem neizgorenih čestica i teških metala, čađom, viskotemperaturnom i niskotemperaturnom korozijom. Sve to skraćuje neprekidni rad zbog čišćenja ili popravaka, pogoršava prijelaz topline, kapacitet i stupanj iskoristivosti te povećava potrošnju goriva što dovodi do ekonomskih gubitaka i povećanja emisije u okoliš.

Navedeni problemi pokušavaju se izbjeći ili umanjiti primjenom aditiva za poboljšanje izgaranja loživog ulja.

UVOD

Početkom devedesetih godina u Energani RNR obavljena su ispitna, dvomjesečna korištenja različitih aditiva za poboljšanje izgaranja teškog loživog ulja radi odabira najprikladnijeg za potrebe parogeneratorskog postrojenja

Na temelju kompleksnih analiza odabran je višenamjenski organometalni aditiv na osnovi bakra (djeluje kao katalizator izgaranja, analiza taloga ukazuje na inhibitorsko djelovanje protiv korozije, nastali talozi su rahli, slabo prianjaju uz ogrjevne površine i lakše se ukljanjaju). (Lit. 3)

U radu je prikazandio sadržaja periodičnih izvještaja autora nastalih tijekom sedmogodišnjeg korištenja i praćenja utjecaja aditiviranja.

PRAĆENJE UTJECAJA ADITIVIRANJA

Postavljeni zahtjevi na aditiv za teško loživo ulje u specifičnim uvjetima rada generatora pare Energane RNR su slijedeći:

1. smanjenje izlaznih gubitaka topline dimnih plinova
2. smanjenje troškova čišćenja ogrjevnih površina
3. povećanje raspoloživosti generatora pare povećanjem razdoblja između dva čišćenja
4. smanjenje djelovanja korozije na ogrjevnim površinama
5. smanjenje emisije štetnih sastojaka u okoliš

Kao pokazatelji utjecaja aditiviranja uzeti su u obzir:

- temperature izlaznih dimnih plinova u ovisnosti o opterećenju (proizvodnji)
- vizualni pregled ložišta i iskustva prilikom čišćenja ogrjevnih površina
- analiza taloga
- analize teškog loživog ulja

Korisnost aditiviranja utvrđivala se analizom pokazatelja i usporedbom s nultim (početnim) stanjem ili razdobljem bez korištenja aditiva.

Doziranje aditiva izvedeno je preko ugrađenog sustava za direktno dodavanje u ulazni cjevovod spremnika teškoga loživoga ulja.

Izmjena topline kroz ogrjevne površine znatno ovisi o njihovoj čistoći, odnosno o tome ima li na njima naslaga, taloga i razne druge nečistoće.Čađa je dobar izolator topline jer ima malu toplinsku vodljivost pa znatno utječe na ekonomičnost rada. Smanjujući prijelaz topline prouzrokuje višu temperaturu izlaznih dimnih plinova, a time i veće izlazne gubitke. Budući da se ona taloži s dimne strane cijevi, smanjuje temperaturu stijenki cijevi, ali postaje opasna kada su naslage deblje jer može doći do njezinog zapaljenja i ozbiljnih oštećenja materijala.Na temelju poznatih relacija za prijelaz topline dolazi se do pokazatelja o nužnosti održavanja čistoće ogrjevnih površina zbog učinkovitijeg korištenja energije, ali i zbog sprječavanja oštećenja materijala. (Lit. 2.)

U suvremenim paroproizvodnim postrojenjima važan podatak za ocjenu kvalitete postrojenja je i vrijeme neprekidnog rada. Za ovo vrijeme od presudnog je značaja intezitet prljanja i mjere predviđene za njegovo sprječavanje. Povišenje temperature izlaznih dimnih plinova uz neminovno smanjenje kapaciteta siguran je znak da su površine zaprljane.(Lit. 1.)

Kao glavni praktični i dovoljni pokazatelj utjecaja aditiviranja uzeta je temperatura izlaznih dimnih plinova u ovisnosti o opterećenju generatora pare (proizvodnji vodene pare), tj. uspoređuju se isključivo temperature po istim opterećenjima.

Pretičak zraka je uvijek održavan na granici dimljenja i vrijednosti su se kretale od 1,1 do 1,2 (2-3,5 % O_2).

Temperature izlaznih dimnih plinova ukazuju na kvalitetu prijelaza topline s dimnih plinova na ogrjevne površine. Povećanje temperatura pokazuje na slabiji prijelaz topline, pogoršani stupanj iskoristivosti, smanjenje kapaciteta, a uzrok je taloženje neizgorenih čestica na ogrjevnim površinama i njihovo zaprljanje što na kraju dovodi do povećanja potrošnje goriva, povećanja emisije u okoliš, nepotrebnog zaustavljanja zbog čišćenja.

Učinkovitost djelovanja aditiva kontrolirala se pregledima ogrjevnih površina prilikom stajanja generatora pare, iskustvima prilikom čišćenja ogrjevnih površina te analizom taloga.

Na temperature izlaznih dimnih plinova utječu također i odnosi korištenja loživo ulje-rafinerijski plin kao goriva te razdoblja između čišćenja ogrjevnih površina.

ANALIZA TEŠKOG LOŽIVOG ULJA

Pokazalo se da je teško loživo ulje neujednačene i pogoršane kvalitete u odnosu na prijašnja razdoblja, kada je navedeni aditiv i odabran, što je normalna tendencija maksimalnog iskorištavanja sirovine i smanjenja troškova pri proizvodnji goriva za vlastite potebe, ali direktno pogoršava kvalitetu izgaranja i ukazuje na nužnost uporabe aditiva radi poboljšanja izgaranja.

Npr. za 1999. godinu karakteristične vrijednosti kvalitete goriva su bile:

viskoznost (na 100^{0C}) se kretala od 22 do 59,2 mm^2/s (srednja vrijednost 32,2),

količina vanadija se kretala od 89 do 300 ppm (srednja vrijednost 185),

količina metala (sumarno) se kretala od 142 do 390 ppm (srednja vrijednost 242),

količina koksa se kretala od 7,57 do 17,14 % mas (srednja vrijednost 12).

U tim otežanim uvjetima aditiv je smanjio svoju korisnost ali i opravdao korištenje.

TEMPERATURA IZLAZNIH DIMNIH PLINOVA

Diagram prikazuje temperature izlaznih dimnih plinova na generatoru pare 341-G5 (80/100 t/h, 37 bar/450^0C, proizvodnja1982, ĐĐ) pri opterećenju od 70 t/h za razdoblje od 01.1999. - 05.2000. s pridodanim vrijednostima viskoznosti loživog ulja na 100^0C kao pokazatelju kvalitete goriva.

Uočljiv je porast temperature dimnih plinova u razdoblju neposredno prije čišćenja ložišta (01-04/99), kada i nije bilo aditiva te se nije aditiviralo.

Nakon čišćenja ložišta dolazi do pada temperature izlaznih dimnih plinova za 20-30^0C. Iz trenda porasta temperatura uočava se da je porast temperatura usporen u odnosu na razdoblje 01-04/99. iz čega se može uočiti djelovanje aditiva, pogotovo sagledavavši utjecaj povećanja viskoznosti loživog ulja čiji je maksimum bio na kraju 1999. Ložište je ponovno čišćeno u lipnju 2000. godine.

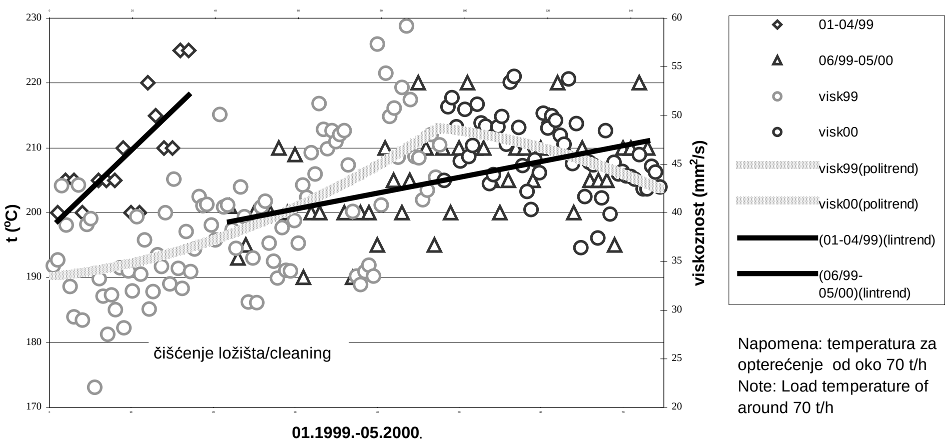
VIZUALNI PREGLEDI LOŽIŠTA I ISKUSTVA PRILIKOM ČIŠĆENJA OGRJEVNIH POVRŠINA

Svi vizualni pregledi ložišta generatora pare potvrdili su rahlost taloga te je time čišćenje prilikom stajanja bilo olakšano, ali to ukazuje da su i izlazni dimni plinovi ispuhivali rahliji dio taloga tijekom rada generatora pare.

U razdoblju od prosinca 2001. do generalnog remonta RNR u svibnju 2002. godine aditiv nije korišten šest mjeseci (problemi procedure javnog natječaja) i to je bilo najduže razdoblje nekorištenja aditiva. Prilikom remonta uočeno je veliko zaprljanje ogrjevnih površina generatora pare Energane koje su se teško i dugo morale čistiti što nije bio slučaj u prethodnim razdobljima.

Ovo je pravi dokaz svrhovitosti uporabe aditiva: smanjenje troškova čišćenja (samog čišćenja i broja čišćenja) i povećanje raspoloživosti generatora pare.

Temperature dimnih plinova/Flue gas temperatures
341-G5, razdoblje/period 01.99-05.00.



ANALIZA TALOGA

Uspoređujući analize goriva i analize taloga potvrdilo se smanjenje sadržaja Fe i Cr u uzorcima taloga što ukazuje na smanjenje korozivnosti, a vidljiv je također i porast pH vrijednosti taloga što također pokazuje inhibitorsko djelovanje aditiva protiv korozije.

ZAKLJUČAK

Ovaj rad nije reklama za korištenje navedenog aditiva, koji se pokazao učinkovit tijekom sedmogodišnjeg korištenja, već generalno za korištenje aditiva. Tamo gdje su problemi i potrebe drukčije (npr. izraženija niskotemperaturna korozija ili nešto drugo) upotrijebit će se drugi aditivi. Naravno, uz obveznu ekonomsku kalkulaciju. U opisanom primjeru uvijek se pazilo da odnos troška aditiviranja prema trošku za gorivo bude oko 1%.

RESULTS OF ADDITIVE APPLICATION FOR IMPROVING HEAVY FUEL OIL COMBUSTION IN THE OPERATION OF STEAM GENERATOR AT THE RIJEKA OIL REFINERY POWER PLANT

Abstract

The Rijeka Oil Refinery steam generators use heavy fuel oil of uneven quality and are operating constantly throughout the year with a variable load.

The problems occurring during operation are caused by the deposition of uncombusted particles and heavy metals, soot, high temperature and low temperature corrosion. All this shortens continuous operation due to cleaning or repair, impairs heat transfer, capacity and efficiency, and increases fuel consumption, which leads to economic losses and increased environmental emission.

Attempts are being made to avoid or lessen the above problems by applying additives for improving fuel oil combustion.

INTRODUCTION

Towards the beginning of the 90s, tests on two month use of various additives for improving the combustion of heavy fuel oil were performed at the Rijeka Oil Refinery power plant in order to select the most adequate one for the needs of the steam generator plant.

Based on complex analyses, a multipurpose organic-metal copper-based additive was chosen acting as combustion catalyst. The deposit analysis was performed pointing to the inhibition activity against corrosion. The deposits created were crisp, porely adhering to the heating surfaces and easier to remove. (Ref. 3)

The paper presents part of the contents of the authors' periodical reports created over the seven-year additive use and additive impact monitoring.

MONITORING ADDITIVE IMPACT

Requirements concerning heavy fuel oil additive under specific steam generator operating conditions at the Rijeka Oil Refinery power plant are as follows:

1. lowering flue gas heat output losses
2. lowering heating surface cleaning costs
3. increasing steam generator availability by extending periods between two consecutive cleanings
4. reducing corrosion on heating surfaces
5. reducing noxious components environmental emission

As additive impact indicators, we have taken into account the following:

- flue gas output temperature in dependence of load (production)
- visual fire-box inspection and experiences in cleaning heating surfaces
- deposit analysis
- heavy fuel oil analyses

Additive efficiency was being established through indicator analysis and comparison with the zero (initial) state or period without additive use.

Additive dosage was done through an in-built system for direct addition into the input pipeline of the heavy fuel oil tank.

Heat exchange through the heated surfaces depends considerably on their cleanliness i.e. on whether they contain any deposits, sludge, or other impurities. Soot is a good thermal insulator because it has low thermal conductivity and hence impacts the cost effectiveness of the operation. By decreasing heat transfer, it causes higher temperature of the output flue gases, and hence also losses. Since it is deposited on the flue gas part of the pipe, it lowers the temperature of the walls. However, it becomes dangerous when the deposits are thicker, because they may start burning and cause considerable material damage. Based on the known relations for heat transfer, we reveal the necessity of maintaining the cleanliness of the heating surfaces due to a more efficient energy use, but also in order to prevent damage of the material. (Ref. 2.)

In modern production plants, an important indicator for evaluating the plant's quality is its continuous operation time. This is in turn influenced by the intensity of collecting dirt and measures undertaken for its prevention. Increase of the output flue gas temperature accompanied by inevitable capacity lowering is a safe sign that the surfaces are dirty.(Ref. 1.)

As the main practical and sufficient indicator of additive impact the flue gas output temperature was considered in dependence of the steam generator load (steam production), i.e. solely the temperatures under the same loads are being compared.

Air surplus is always kept at the border of smoking and the values ranged from 1.1 to 1.2 (2-3.5 % O_2).

The flue gas output temperature points to the quality of heat transfer from flue gases to the heating surfaces. Temperature increase points to a poorer heat transfer, impaired efficiency, capacity lowering, the cause being the depositing of uncombusted particles on heating surfaces and their uncleanliness, ultimately leading to increased fuel consumption, higher environmental emission, unnecessary halts due to cleaning.

Additive efficiency was being controlled by inspections of heating surfaces during halts of the steam generator, by experience in cleaning heating surfaces, and deposit analysis.

The flue gas output temperatures are also impacted by the ratios between fuel oil and refinery gas as fuel during combustion, as well as periods between the cleaning of heating surfaces.

HEAVY FUEL OIL ANALYSIS

It turned out that the heavy fuel has an uneven and reduced quality with regard to former periods when the additive in question was selected, which is a normal tendency of maximum raw material use and cost reduction when producing fuel for one's own needs. This however directly impaires combustion quality and points to the need of using additives in order to improve combustion.

For instance, in 1999, the characteristic fuel quality values were as follows:

viscosity (at 100^{0}C) ranged from 22 to 59.2 mm^2/s (average value 32.2),

Vanadium content ranged from 89 to 300 ppm (average value 185),

metal content (summary) ranged from 142 to 390 ppm (average value 242),

carbon coke content ranged from 7.57 to 17.14 % mas (average value 12).

Under such difficult conditions, the additive reduced its efficiency, but also justified its use.

FLUE GAS OUTPUT TEMPERATURE

The diagram shows the flue gas output temperature on the steam generator 341-G5 (80/100 t/h, 37 bar/450^{0}C, manufactured in 1982 by ĐĐ) at the load of 70 t/h for the period from 01/1999-05/2000 with added fuel oil viscosity values at 100^{0}C as fuel quality indicator.

We may observe the increase of flue gas output temperature in the period immediately preeceding fire-box cleaning (01-04/99), when there were no additives used.

After fire-box cleaning the flue gas output temperature went down by 20-30^{0}C. From the temperature increase trend we may observe that temperature increase has been slowed down with regard to the 01-04/99 period, showing additive action, particularly if we consider the fuel oil viscosity increase impact reaching maximum at the end of 1999. Firebox was cleaned again in June 2000.

VISUAL INSPECTIONS OF THE FIRE-BOX AND EXPERIENCES IN CLEANING HEATING SURFACES

All visual inspections of the steam generator fire-box have confirmed deposit crispness, thus rendering cleaning during halts easier, but also showing that output flue gases have been blowing out the crisper part of the deposit during the steam generator operation.

In the period from December 2001 to the Rijeka Oil refinery overhaul in May 2002, the additive was not used for six months due to problems associated with the solliciting for tenders procedure, which was the longest period of not using the additive. During the overhaul, a major uncleanliness of the power plant steam generator heating surfaces was observed. The cleaning process was long and difficult, which was not the case in previous periods.

This is the real proof of the necessity to use additives: cleaning costs reduction (of the cleaning itself, as well as of the number of cleanings) and increased steam generator availability.

DEPOSIT ANALYSIS

By comparing fuel and deposit analyses Fe and Cr content reduction has been confirmed in deposit samples, which points to corrosion reduction, while the deposit pH value increase may also be observed, pointing to the inhibition activity of the additive against corrosion.

CONCLUSION

This paper is no commercial advertising for the use of the additive in question. Fuel oil additivation has shown to be efficient over the seven-year use, but rather for additive use in general. Where there are different problems and needs for instance a more pronounced low temperature corrosion or something else, other additives shall be used, with the necessary economic evaluation. In the example described, attention was always paid that the ratio between the additive consumption price and the fuel consumption price be around 1%.

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