Formulár ZK

Záverečná karta projektu

Názov projektu

Dvojstupňové splyňovanie zmesného tuhého odpadu s katalytickou redukciou dechtov

Evidenčné číslo projektu **APVV-15-0148**

Zodpovedný riešiteľ **doc. Ing. Juma Haydary, PhD.**

Príjemca **Slovenská technická univerzita v Bratislave - Fakulta chemickej a potravinárskej technológie**

Názov pracoviska, na ktorom bol projekt riešený

Fakulta chemickej a potravinárskej technológie Slovenskej technickej univerzite v Bratislave

Názov a štát zahraničného pracoviska, ktoré spolupracovalo pri riešení

neboli

Udelené patenty/podané patentové prihlášky, vynálezy alebo úžitkové vzory, ktoré sú výsledkami projektu

Prototyp: prototyp jednotky dvojstupňového splyňovania laboratórnych rozmerov

Najvýznamnejšie publikácie (knihy, články, prednášky, správy a pod.) zhrňujúce výsledky projektu – uveďte aj publikácie prijaté do tlače

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Uplatnenie výsledkov projektu

V septembri 2020 sme podpísali ZoD s priemyselným partnerom so zámerom vyvinúť priemyselnú pilotnú jednotku dvojstupňového splyňovania odpadu a biomasy na základe laboratórneho prototypu, ktorý bol vyvinutý v rámci tohto projektu. Dňa 16.09.2020 bol na neformálnej návšteve nášho laboratória predseda vlády SR pán Igor Matovič a zaujímal sa výlučne o výsledky nášho výskumu v oblasti termo-katalytického spracovania odpadov kvôli jeho zapracovaniu do zámeru vlády SR pre zelenú ekonomiku. V poslednom roku je veľký záujem o výsledky projektu zo strany priemyselných partnerov. S najväčšou pravdepodobnosťou v blízkej budúcnosti budeme svedkami výrobnej jednotky postavenej na základe výsledkov dosiahnutých v rámci tohto projektu.

Súhrn výsledkov riešenia projektu a naplnenia cieľov projektu v slovenskom jazyku (max. 20 riadkov)

Cieľom tohto projektu bolo skúmanie termicko-katalytického rozkladu vysokomolekulových látok syntetického a prírodného pôvodu v dvojstupňovom pyrolýzno-splyňovacom zariadení. Predmetom skúmania boli rôzne zmesné polymérne odpadové materiály a lignocelulózovej odpadovej biomasy. Projekt riešil otázky súvisiace so znižovaním obsahu dechtov v produkovanom plyne, so zvyšovaním konverzie uhlíka a s heterogenitou suroviny. Takisto projekt skúmal matematické modelovanie uvedených procesov vrátane materiálovej a energetickej integrácie. Termicko-katalytický rozklad odpadu sa realizoval v dvojstupňovom pyrolyticko-splyňovacom systéme použitím lacno dostupných katalyzátorov a parciálnej oxidácie v druhom stupni.

V prvej etape projektu sme charakterizovali viac ako 30 komponentov tuhého odpadu z hľadiska ich termického rozkladu, elementárneho zloženia, výhrevnosti a reakčného tepla. V nasledujúcich etapách v dvojstupňovom splyňovacom zariadení sme skúmali vplyv zloženia suroviny, procesových parametrov a typu použitého katalyzátora v sekundárnom stupni na množstvo a zloženie plynu a obsah dechtu v plyne. Vybudovali sme prietokovú laboratórnu jednotku, umožňujúcu premenu rôznych typov heterogénnych odpadov na plyn s nízkym obsahom dechtu a vysokým obsahom CO a H2. Procesy termického rozkladu odpadu a biomasy sme študovali aj pomocou matematického modelovania. Vyvinuli sme matematické modely jednotlivých stupňov procesu a kompletný počítačový model jednotky. Medzi čiastkové vyriešené úlohy v tomto smere patrí rovnovážny model dvojstupňového splyňovania biomasy a RDF, model výpočtu vlastností zmesí na základe vlastností jednotlivých komponentov, kinetika termického krakovania ropných zvyškov, modelovanie čistenia plynu, modelovanie výroby metanolu zo syntézneho plynu, modelovanie procesu sušenia, modelovanie sieti ohrevnej pary a detailný model skrutkového pyrolýzneho reaktora.

Všetky vytýčené ciele a výsledky projektu boli dosiahnuté nad očakávanú úroveň. Vďaka projektu vzniklo doteraz celkom 17 publikácií v karentovaných časopisoch, 9 publikácií v recenzovaných časopisoch registrovaných v databázach Web of Science alebo SCOPUS, 2 kapitoly v knihách vydaných v medzinárodných vydavateľstvách a 53 konferenčných príspevkov. Témy dizertačných prác troch doktorandov súviseli s riešením projektu. Témy 11 diplomových, 4 bakalárskych prác a 8 technologických projektov súviselo s riešením projektu. Bol vyvinutý a testovaný laboratórny prototyp jednotky dvojstupňového splyňovania odpadu a biomasy a komplexný matematický počítačový model procesu priemyselných rozmerov. Projekt vyvolal štyri medzinárodné spolupráce a štyri nové projekty výskumu a vývoja, z ktorých dve úspešne získali financie. Výskum problematiky pokračuje novým projektom APVV (Výroba plynu s parametrami kvality plynného paliva, splyňovaním tuhého odpadu a biomasy -APVV -0170) so zámerom konverzie zmesného odpadu na plyn spĺňajúci parametre kvality plynného paliva.

Súhrn výsledkov riešenia projektu a naplnenia cieľov projektu v anglickom jazyku (max. 20 riadkov)

The aim of this project was to investigate the thermal-catalytic decomposition of high-molecular substances of synthetic and natural origin in a two-stage pyrolysis-gasification unit. The subject of the research was various mixed polymeric waste materials and lignocellulosic waste biomass. The project addressed issues related to reducing the tar content of the produced gas, increasing carbon conversion and dealing with raw material heterogeneity. The project also examined mathematical The aim of this project was to investigate the thermal-catalytic decomposition of high-molecular substances of synthetic and natural origin in a two-stage pyrolysis-gasification unit. The subject of the research was various mixed polymeric waste materials and lignocellulosic waste biomass. The project addressed issues related to reducing the tar content of the produced gas, increasing carbon conversion and dealing with raw material heterogeneity. The project also examined mathematical modeling of these processes, including material and energy integration. The thermal-catalytic decomposition of the waste was carried out in a two-stage pyrolysis-gasification system using low-cost catalysts and partial oxidation in the second stage.
In the first stage of the project implementation, we characterized more than 30 components of solid waste in terms of their thermal decomposition, elemental composition, calorific value and heat of reaction. In the following stages, we investigated the influence of the composition of the raw material, process parameters and type of catalyst used in the secondary stage of a two-stage gasifier on the amount and composition of gas and gas tar content. We have built a continuous laboratory unit, enabling the conversion of various types of heterogeneous waste into a gas with low tar content and high CO and H2 content. We also studied the processes of thermal decomposition of waste and biomass using mathematical modeling. The models of individual process stages and a complete computer model of the unit were developed. Partial solutions solved in this direction include equilibrium model of two-stage gasification of biomass and RDF, model of calculation of properties of mixtures based on properties of individual components, kinetics of thermal cracking of oil residues, modeling of gas purification, modeling of methanol production from synthesis gas, modeling of drying process, heating steam network modeling and a detailed model of a screw pyrolysis reactor.
All set goals and results of the project were achieved above the expected level. Thanks to the project, a total of 17 publications in SCI peer-reviewed journals, 9 publications in peer-reviewed journals registered in Web of Science or SCOPUS databases, 2 chapters in books published by international publishers and 53 conference papers have been published. The topics of the dissertations of three PhD. students were related to the solution of the project. The topics of 11 diploma theses, four bachelor's theses and 8 technological projects were related to the project solution. A laboratory prototype of a two-stage waste and biomass gasification unit and a comprehensive mathematical computer model of an industrial-scale process were developed and tested. The project has given rise to four international collaborations and four new research and development projects, 2 of which have successfully received funding. The research will continue with a new APVV project (Production of fuel quality gas by solid waste and biomass gasification - APVV-19-0170) with the intention of converting mixed waste into gas meeting the parameters of gaseous fuel quality.