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**FLUIDIZED-BED DRYING OF PARBOILED RICE USING ENERGY  
FROM RICE HULL FLUIDIZED-BED COMBUSTOR**

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หัวข้อวิทยานิพนธ์	การอบแห้งข้าวหนึ่ง ในฟลูอิโดซ์เบดโดยใช้พลังงานความร้อนจากเตาเผาไหม้แกลบแบบฟลูอิโดซ์เบด
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บทคัดย่อ

การอบแห้งข้าวหนึ่ง ในฟลูอิโดซ์เบดโดยใช้พลังงานความร้อนจากเตาเผาไหม้แกลบแบบฟลูอิโดซ์เบดนี้ เป็นการศึกษาเกี่ยวกับการรวมระบบการอบแห้งข้าวหนึ่งที่อาศัยเทคนิคทางฟลูอิโดซ์เบดกับระบบการผลิตความร้อนจากเตาเผาไหม้แกลบแบบฟลูอิโดซ์เบด โดยมีวัตถุประสงค์ที่จะนำเอาแกลบที่ได้จากการสีข้าวหนึ่งกลับมาใช้เป็นแหล่งพลังงานความร้อนในการอบแห้งข้าวหนึ่ง

จากการทดลองเผาไหม้แกลบในคอลัมน์ขนาดเส้นผ่านศูนย์กลาง 15 เซนติเมตร อัตราการป้อนแกลบ 2.825 กรัมต่อชั่วโมง และป้อนอากาศ 30 ลูกบาศก์เมตรต่อชั่วโมง แล้วนำพลังงานความร้อนไปใช้ร่วมกับอากาศร้อน 170 ลูกบาศก์เมตรต่อชั่วโมง ที่มาจากเครื่องอุ่นอากาศสำหรับการอบแห้งข้าวหนึ่งในเครื่องอบแห้งแบบฟลูอิโดซ์เบด ขนาดกว้าง 6 เซนติเมตร ยาว 60 เซนติเมตร ด้วยอัตราการป้อนข้าวหนึ่ง 6.5 กิโลกรัม (น้ำหนักแห้ง) ต่อชั่วโมง โดยปรับอุณหภูมิของอากาศที่เข้าสู่เครื่องอบแห้งที่ 120, 130, 140 และ 150 องศาเซลเซียส ตามลำดับ แต่ละอุณหภูมิปรับความสูงของเบดเป็น 3, 3.5, 4 และ 4.5 เซนติเมตร ตามลำดับ พบว่า เตาเผาไหม้แกลบนี้สามารถให้พลังงานกับเครื่องอบแห้งได้ประมาณร้อยละ 50-55 ปริมาณแกลบที่คำนวณได้จากปริมาณข้าวหนึ่งถ้านำมาใช้เป็นเชื้อเพลิงให้ความร้อนได้ร้อยละ 66 ของความร้อนจากเตาเผาไหม้ ประสิทธิภาพรวมของการอบแห้งเป็นร้อยละ 7-11 ในการอบแห้งช่วงแรก และร้อยละ 2-4 ในการอบแห้งช่วงที่สอง ความร้อนส่วนใหญ่ประมาณร้อยละ 90 สูญเสียไปกับอากาศร้อนที่ออกจากคอลัมน์



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#### ABSTRACT

In the study on Fluidized-Bed Drying of Parboiled Rice Using Energy from Rice Hull Fluidized-Bed Combustor; the fluidized-bed drying system was combined with the fluidized-bed combustor in order to use rice husk from the milling yield of parboiled paddy as a source of energy in parboiled rice fluidized-bed dryer.

From the experiments, rice husk was combusted in a 15 cm column at rice husk feed rate of 2,825 g/hr and air feed rate of 30 Nm<sup>3</sup>/hr. Hot flue gas from the combustor together with hot air from the air heater of 170 Nm<sup>3</sup>/hr was used for drying of parboiled paddy in the fluidized-bed dryer of 6 cm width and 60 cm length with the parboiled paddy feed rate of 6.5 kg/hr. The temperature of inlet air to the dryer was set at 120, 130, 140, and 150 °C respectively. The height of bed of parboiled paddy was set at 3, 3.5, 4 and 4.5 cm respectively for each temperature. It was found that heat from the combustor was able to supply approximately about 50-55 % of heat required to dryer. Rice husk from parboiled paddy could generate only 66 % of energy from the combustor. The overall efficiency of drying was 7-11 % for the first stage drying and 2-4 % for the second stage drying. The major heat, about 90 %, was lost with air from the drying column.



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## NOMENCLATURE

$A_c$	=	Cross-sectional area of tube or bed, $m^2$
$A_s$	=	Surface area of bed, $m^2$
$A_t$	=	Cross-sectional area of tube or bed, $m^2$
$C$	=	Empirical constant of Eq. (9), dimensionless
$c_{p,a}$	=	Heat capacity of air, Joule/kg $K$
$d_p$	=	Diameter of sphere having the volume of the paddy, $m$
$E_m$	=	Void fraction in a random packed bed, dimensionless
$E_{mf}$	=	Void fraction in a bed at minimum fluidizing
$g$	=	Acceleration of gravity, $9.80 \text{ m/sec}^2$
$g_c$	=	Conversion factor, $980 \text{ gm.cm/(gm-wt)(sec)}^2$
$h_p$	=	Heat transfer coefficient between hot air and particles, $\text{Joule-sec.m}^2.K$
$L$	=	Height of fixed bed, $cm$
$L_{mf}$	=	Height of bed at minimum fluidizing conditions, $cm$
$m$	=	Empirical constant of Eq. (9), dimensionless
$M$	=	Moisture content (dry basis), %
$M_d$	=	Mass of dry material, $kg$
$Nu_p$	=	$h_p d_p / k_a$ , Nusselt number for hot air parboiled paddy heat transfer, dimensionless
$\Delta P$	=	Pressure drop across bed, $cm.H_2O$
$Q_H$	=	Rate of heat transfer, Joule/sec
$Q_o$	=	The volumetric flow rate of air, $m^3/sec$
$R$	=	$dM/dt$ , rate of drying, $gm.H_2O \text{ evaporated/gm.dry}$
$Re$	=	Reynolds number, dimensionless
$Re_p$	=	$d_p U_o \rho_a / \mu_a$ , parboiled paddy Reynolds number, dimensionless
$R_w$	=	Rate of drying; $gm.H_2O/hr.kg \text{ dry solid}$

$t$	=	Drying time, min
$T_{ab}$	=	Temperature of air in bed, °C
$T_{a1}$	=	Temperature of air inlet, °C
$U_o$	=	Superficial air velocity through a bed of parboiled paddy, m/sec
$u_o$	=	Velocity of particle, m/sec
$W$	=	Weight of bed, kg
$W_d$	=	Moisture-content (dry basis), %
$W_w$	=	Moisture-content (wet basis), %
$\rho_p$	=	Density of paddy, kg/m <sup>3</sup>
$\rho_a$	=	Density of air, kg/m <sup>3</sup>
$\phi_p$	=	Sphericity of paddy, kg/m <sup>3</sup>
$\mu_a$	=	Viscosity of air, kg/m.sec.
$\theta$	=	Total drying time, hr