

STEAM ACTIVATION OF PELLETIZED COAL FINES

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الخلاصة :

يُعنى هذا البحث بتحضير حبيبات فحم منشط من بودرة فحم حجرى ناتجة من أحد مصانع الفحم المحلية. تم أولاً تنقية الفحم الحجرى من الشوائب ثم طحنه وتشكيله على هيئة حبيبات قطرها حوالي 2.5 ملليمتر باستخدام المولاس كمادة لاصقة. وتم تفحيم هذه الحبيبات عند درجة حرارة 600°م لمدة ساعتين ثم تنشيطها البخار الجاف عند درجات حرارة عالية ومعدلات مختلفة لمرور البخار ولأزمنة مختلفة. أوضحت النتائج العملية أن أنسب ظروف للتنشيط هي : 800°م عند سرعة مرور البخار 54 كيلو غرام في الساعة لكل كيلو غرام من الفحم ولمدة ثلاث ساعات. والفحم المنشط الناتج عند هذه الظروف له مساحة سطح 820 متر مربع لكل غرام وقوة مقاومة للتكسير 180 غرام لكل حبيبة.

ABSTRACT

Waste coal fines were crushed, ground and then processed into 2.5 mm diameter pellets using sugar-cane molasses as a binder. These pellets were charred at 600°C for two hours and then activated by dry superheated steam at different temperatures, steam flow rate and duration. Specific surface area and crushing strength of the produced active carbon pellets were experimentally measured.

Optimum activation conditions were found to be: 800°C, 3 hours, and steam flow rate of 54 kg/hr.kg of coal. Under these optimum operating conditions, the produced pellets have a specific surface area of 820 m²/gram and crushing strength of 180 grams/pellet.

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INTRODUCTION

Large quantities of waste coal fines normally occur in any industrial coking plant, mainly during transportation, storage and processing, and contain coals of different origins and grades. The literature cites many processes for the purification of such coal fines. Sanders *et al.* [1] applied hydrometallurgical leaching and flotation. Different dispersants were tested to render coal fines hydrophilic [2–5]. Selective agglomeration of coal fines with oil was proposed as a promising method for the recovery of coal fines from water slurries [6–9]. Activated carbon was prepared from different sources, such as coconut shell [10] or anthracite [11], by activation with steam [12] or carbon dioxide [13].

The aim of this work was to prepare pelletized activated carbon from waste coal fines collected from El-Nasr Coke & Chemicals Co. coking plant. The plant utilizes imported coals from different locations, mainly Russia, Australia, Canada, and the United States, which have different geological histories and grades.

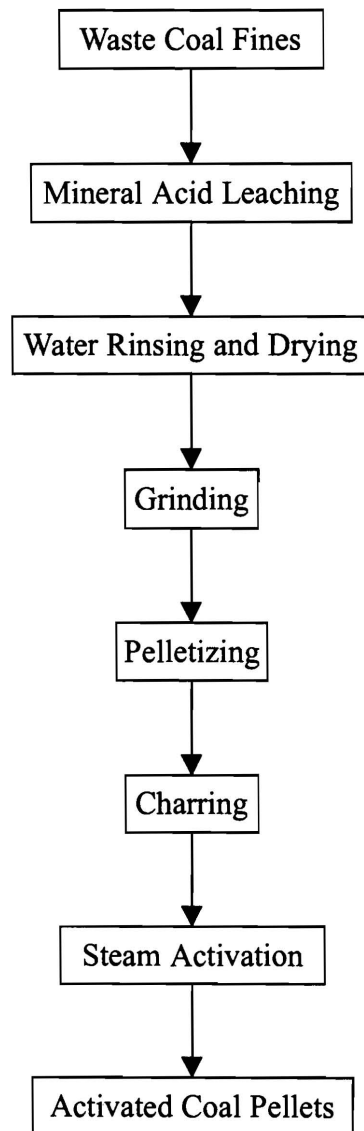


Figure 1. Flow diagram of the experimental work.

EXPERIMENTAL

Figure 1 illustrates the successive steps carried out in the experimental work to produce activated carbon pellets from waste coal fines. These were visually inspected and foreign materials were removed. The mass was then classified into four cuts of different particle size ranges. The obtained cuts were analyzed; Table 1 lists the main characteristics of these cuts. It is clear that carbon content decreases slightly with increase of particle size; on the other hand the amount of impurities such as SiO_2 and CaO increases slightly with decrease of particle size. Due to the fact that particle size has no major effect of the characteristics of the coal, the original mass was used for the preparation of coal pellets.

Coal fines were leached with dilute HCl, washed with water, dried and then ground to $> 47 \mu\text{m}$. This ground material was pelletized using sugar-cane molasses as a binder to form pellets of about 2.5 mm diameter. The pellets were then charred at 600°C for two hours in an inert atmosphere (nitrogen).

The pellets were then activated using superheated dry steam at different temperatures: $600\text{--}1000^\circ\text{C}$; for different periods; up to 4 hours; and at various steam flow rates: 2.5–5.5 grams/min. The specific area and crushing strength of the activated carbon pellets produced were experimentally measured. The pellet was suspended in a steel container in a muffle furnace. Steam was produced by evaporating water, then superheated by allowing it to pass through a steel coil in a tube furnace, before being allowed to pass over the pellet. During heating up of the pellet, nitrogen gas was allowed to flow instead of steam until the operating temperature was reached.

Figure 2 shows the weight loss values as a function of activation temperature, time, and steam flow rate. The results show that percentage weight loss increases with increasing temperature and steam flow rate. The weight loss was found to increase

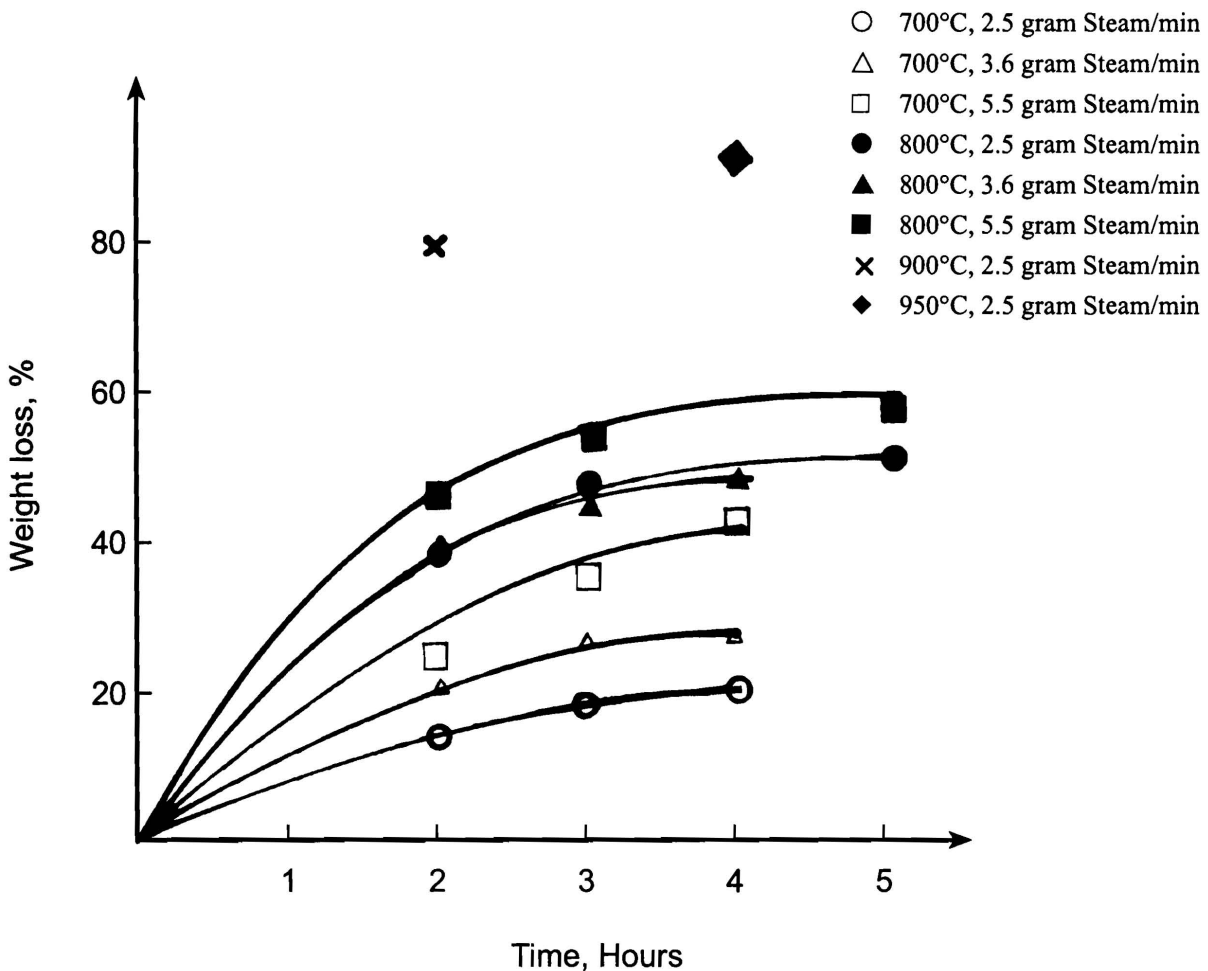


Figure 2. Weight loss at different temperatures, steam flow rates, and time.

steadily with activation time up to three hours, after which it starts to level off, so optimum activation time is three hours. The diameter of the activated pellet remains nearly the same as for the original one at temperatures of 700 and 800°C. Loss in weight in this range can be attributed to the formation of pores. The loss in weight becomes great and the pellet starts to decrease in size 900C; this can be attributed to attack on the outside surface of the pellet. Accordingly, the optimum operating temperature and steam flow rate were 800C and 3.6 grams/min, respectively.

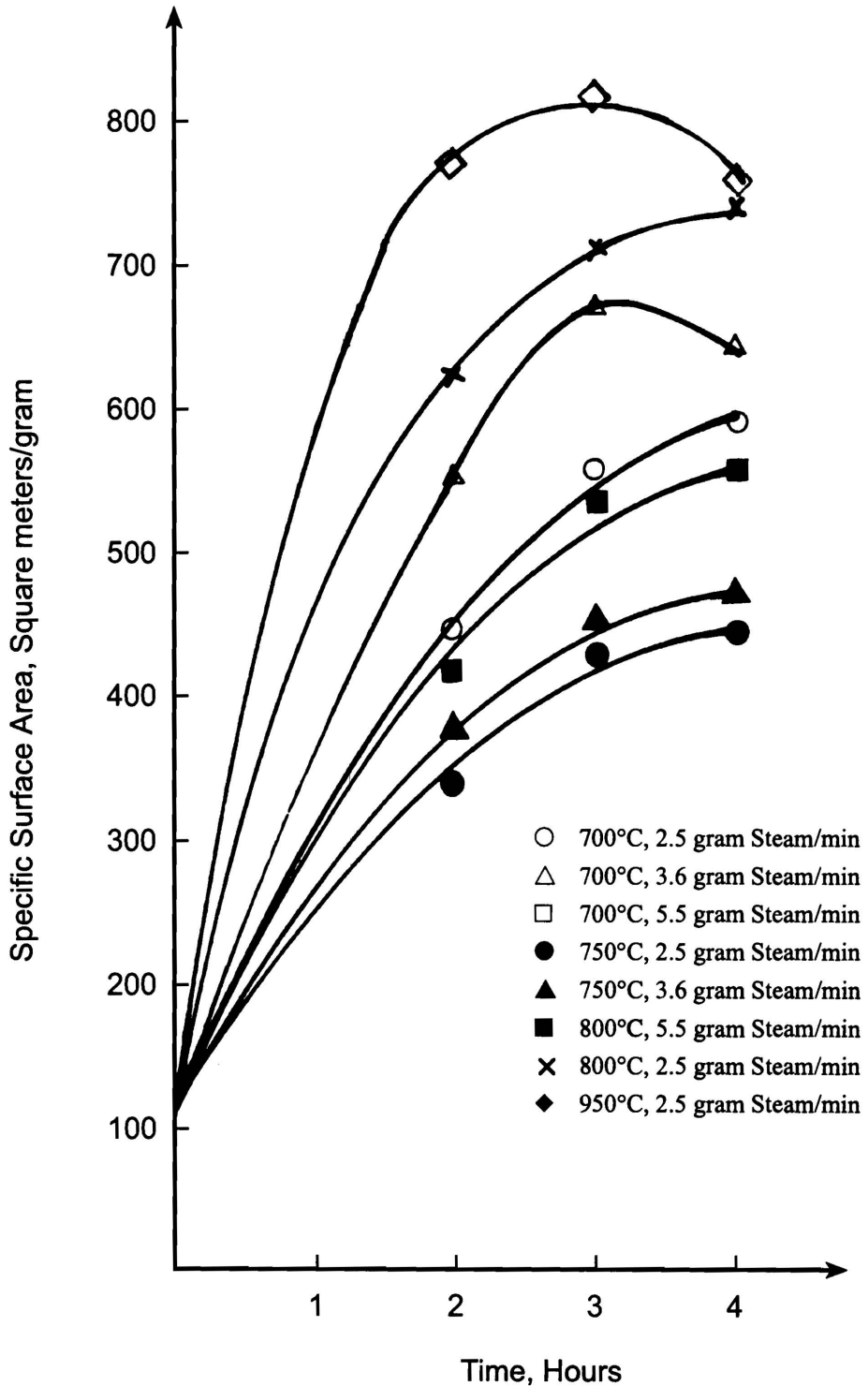


Figure 3. Surface area of pellets produced at different temperatures, time, and steam flow rates.

Table 1. Characteristics of Coal Fines

Property	Grain Size, mm.+ 4.6			
	+4.6	-4.6 + 2.5	-2.5 + 0.125	-0.125
Fractional Weight, %	31.5	7.2	52.4	8.9
Chemical Analysis: wt%				
Moisture	1.14	1.10	1.05	1.18
Volatile matter	26.74	26.02	25.57	25.92
Fixed carbon	64.24	62.16	58.58	57.29
Sulfur	0.86	0.71	0.75	0.70
SiO ₂	4.6	5.45	6.92	7.4
Al ₂ O ₃	1.83	1.71	1.61	1.68
CaO	0.23	0.55	0.87	1.00
Balance	0.36	2.3	4.65	4.83

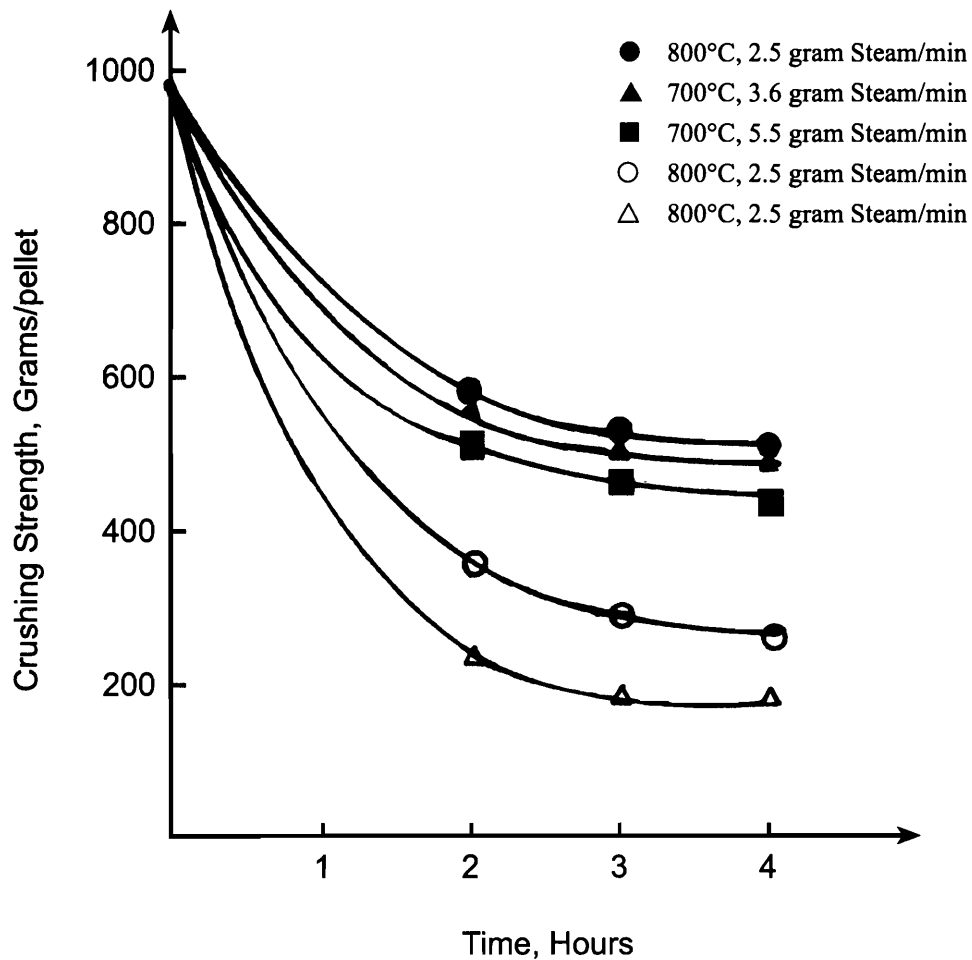


Figure 4. Crushing strength of pellets produced at different temperatures, steam flow rates, and time.

The effect of operating variables on the surface area of the produced pellets is shown in Figure 3. These data show that specific surface area increases with increasing temperature and steam flow rate. The optimum surface area was 820 m²/gram at 800C, achieved at a steam flow rate of 3.6 grams/min conducted for three hours. A drastic decrease in surface area at longer periods is an indication of the collapse of the pore structure, which in turn suggests that the optimum activation time is three hours.

Figure 4 shows the crushing strength as a function of time, temperature, and steam flow rate. These results show that crushing strength decreases with increasing time, temperature, and steam flow rate. Under the above-mentioned optimum activation conditions, the crushing strength was found to be 180 grams/pellet.

CONCLUSIONS

1. The proposed process proves ideal for the treatment of waste coal fines to produce active carbon pellets of significant specific surface area and suitable crushing strength.
2. The largest specific surface area was obtained at the optimum operating conditions, which are: 800C; 3 hours; and 3.6 grams steam/min (equivalent to 54 kg steam/hr. kg of pellet).
3. The pellets produced have a specific surface area of 820 m²/gram and 180 grams/pellet crushing strength.
4. The steam activation process has to be carefully controlled to achieve production of suitable active carbon pellets of a significant specific surface area and suitable crushing strength, without collapse of the built-in pores.

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