EFFECT OF ORGANIC BINDERS ON THE QUALITY OF MANGANESE ORE SINTER FINES BRIQUETTES

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ABSTRACT:

Sinai Manganese Company imports the manganese ore sinter from abroad for ferromanganese alloy production. Large quantities of manganese ore sinter fines are produced in this process. These fines must be agglomerated to a suitable size in order to be reused for charging the electric arc furnace. The aim of this work is studying the briquetting ability of these fines using organic binders such as starch and bitumen. The results showed that, the suitable briquettes were produced with the addition of 5 % of starch and 20% H_2O under pressure 3 ton/cm^2 or 8 % bitumen under pressure 4 ton/cm^2 and 3 days curing time.

KEY WORDS:

Briquetting, Manganese ore, Recycling, Mechanical properties

1. INTRODUCTION:

Large quantities of manganese ore sinter fines are produced in Sinai Company during handling and storage the imported manganese sinter. Economically, these fines must be agglomerated to a suitable size and reasonable mechanical properties for smelting in the electric arc furnace. Briquetting is one of agglomeration process, which converts the ore fines into blocks of suitable size and shape. Binders are important for holding the fine particles together during the briquetting process. Either organic or inorganic binders can be used. Addition of inorganic binders changes the chemical composition of the indurated briquettes, and influences the metallurgical behavior during further treatment. On the other hand, organic binders burn or volatilize during of the firing. Consequently they do not change the chemical composition of the fired briquettes to a large extent. There are different types of organic binders such as lignin liquor, starch, petroleum bitumen, molasses …etc. Due to the comparatively high prices of such substances, there is an interest only in waste products of other industries such as bitumen that is both cheap and widely available [1-4].

The aim of this investigation is briquetting the manganese ore sinter fines using starch and bitumen as organic binders. The effect of different amounts of both types of binders on the mechanical properties of green and dry briquettes was investigated. The production of ferromanganese alloy from briquettes having optimum mechanical properties, for each binder, with characterization of the produced alloy was also studied.

2. MATERIALS AND EXPERIMENTS:

2.1. Materials:

The sample of manganese ore sinter fine used in this study was delivered from Sinai Manganese Company. The chemical composition and screen analysis of this sample were published elsewhere [5].

Starch was obtained from Starch and Glucose Co. where, bitumen was delivered from Egyptian Coke Co.

2.2. Apparatus and Experiments:

Compressor MEGA KSC-10 was used in this investigation for the production of briquettes with diameter 14 mm and thickness 15 mm. For the briquetting process, about 200 gm of manganese ore sinter fine was mixed with different percentages of both binders. In case of starch, its amount was dissolved in different percentages of water and the starch solution was heated for 5 min to 100 ^{o}C before the mixing process. Bitumen is sufficiently fluid at 80-90 ^{o}C to wet the solid surfaces readily on mixing with fine particles.

The mechanical properties tests (dropping damage resistance test) for the produced green briquettes were carried out by dropping about 10 green briquettes from a height of 30 cm onto a steel plate until breakage. The average dropping damage resistance gives the mean value of the test. The green briquettes were dried at room temperature for 3 days, and then it subjected to dropping damage resistance.

Determination of bulk density for green and dried briquettes was carried out by completely filling the open pores of briquette sample with a paraffin wax then weighing it in both air and immersed in distilled water [5,6].

The smelting experiments for ferromanganese alloy production were produced in a 100 KVA laboratory submerged electric arc furnace.

3. RESULTS AND DISCUSSIONS:

3.1. Effect of starch addition:

3.1.A. Effect of changing starch amount:

Figures (1 & 2) show the effect of different percentages of starch addition on the dropping damage resistance and bulk density of the green and dried briquettes, produced under pressure 3 ton/cm^2 with constant amount of water (20%).

From these figures, it is clear that as the amount of starch increases the dropping damage resistance and bulk density of both green and dried briquettes increase. This is due to the increase of plasticity of the briquettes, because of the fact that the starch is a colloidal material having a higher surface area [7,8].

Also, these figures show that at any constant value of starch the dropping damage resistance and bulk density increase from green briquettes to dried briquettes, which is due to the improvement of plasticity [9].

3.1.B. Effect of briquetting pressure:

The effect of briquetting pressure on the dropping damage resistance and bulk density of green and dried briquettes was studied at constant amount of starch (5%) and water (20%) and the results are shown in figures (3 & 4).

From these figures, it is clear that as the briquetting pressure increases both the dropping damage resistance and bulk density of green and dried briquettes increase. This is due to an increase in the Vander Waal`s forces between particles as a result of reducing the distance between them.

3.1.C. Effect of water added:

Figures (5 & 6) illustrate the effect of amount of water with starch (5%) on the dropping damage resistance and bulk density of green and dried briquettes, produced under pressure 3 ton/cm^2. From these figures, it is clear that as the amount of water increases from 5-20 % both the dropping damage resistance and bulk density of green and dried briquettes increase. This fact is due to the ability of starch to absorb water, which plays as a binding agent. Addition of 25% water leads to decrease in both dropping damage resistance and bulk density due to the formation of muddy materials.

3.2. Effect of bitumen addition:

3.2.A. Effect of changing bitumen amount:

Figures (7 & 8) show the effect of different amounts of bitumen added (4-10%) under constant pressure (2 ton/cm^2), on the drop damage resistance and bulk density of green and dried briquettes.

It is clear that increasing the bitumen amount added causes an increase in the drop damage resistance and bulk density of green and dried briquettes. This is due to the bitumen-ore bond increase.

Also, from these figures it is clear that, at any constant amount of bitumen added the dropping damage resistance and bulk density increase from green to dry briquettes. This is due to the occurrence of mechanical interlocking of particles causing a significant strength increase in the briquettes.

3.2.B. Effect of briquetting pressure:

Effect of different briquetting pressure (2, 3, 4 and 5 ton/cm^2) on the dropping damage resistance and bulk density of green and dried briquettes mixed with 8% bitumen is shown in figures (9 & 10). It is clear that, as the briquetting pressure increases the dropping damage resistance and bulk density of both green and dried briquettes increase. This is because during compaction rearrangement of particles takes place and solid particles approach each other closely, resulting in strong bonds [10].

3.3. Production of Ferromanganese alloy:

From the previous results it is clear that the most suitable briquettes which have reasonable mechanical properties to be safely charged in the electric arc furnace, are those produced under pressure 3 ton/cm^2 with 5% of starch with 20% water and curing time 3 days at room temperature.

In case of bitumen addition the suitable briquettes were those produced under pressure 4 ton/cm^2 with 8% of bitumen and curing time 3 days at room temperature.

Table (1), illustrate the chemical analysis of the produced ferromanganese alloys from the briquettes, that were produced at the optimum condition of the briquetting process for both binder materials.

Table.1. The chemical analysis of ferromanganese alloys

Components	Percentage, %		
	Standard alloy	**For starch**	**For bitumen**
Mn	75-79	79	78.7
Fe	16-12	14.6	14.2
P	<0.2	0.035	0.024
Si	<1.2	1.1	1.05
C	<7.5	3.95	4

From this table, it is clear that the produced alloy from briquettes contain both binders under the optimum operating condition for the briquetting process lie in the standard ferromanganese alloy.

Figure (11) shows the x-ray diffractograms of the produced ferromanganese from such briquettes.

CONCLUSIONS:

The optimum operating condition of the briquetting process for manganese ore sinter fine for ferromanganese production in electric arc furnace are as follows:

1- For starch binder, 5% of starch with 20% of water under pressure 3 ton/cm^2.

2- For bitumen binder, 8% bitumen under pressure 4 ton/cm^2.

3- The produced ferromanganese alloy from briquettes that contain both binders under the optimum condition of briquetting process lie in the range of the standard alloy.

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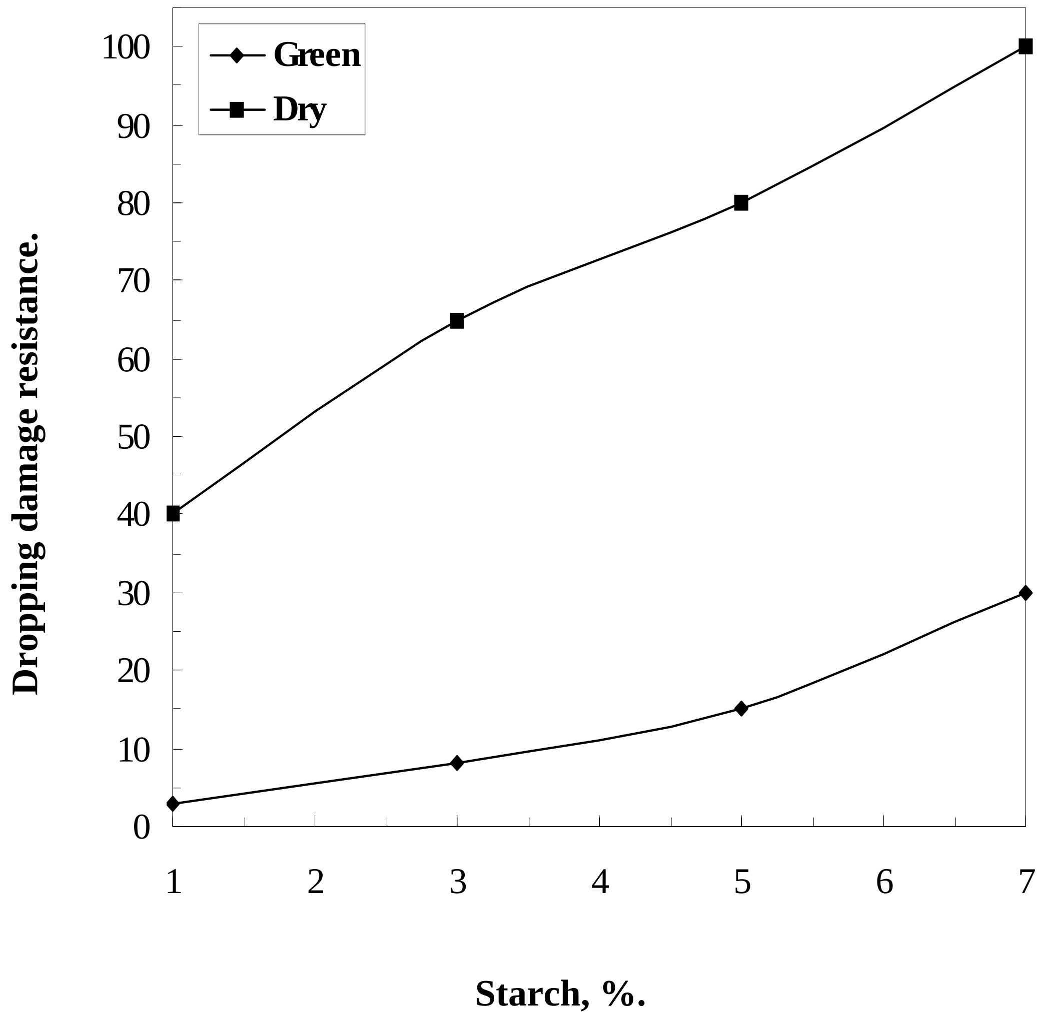


Fig. 1. Effect of percentage of starch added on the dropping damage resistance of green and dried briquettes at 3 ton/cm^2 and 20-percentage water.

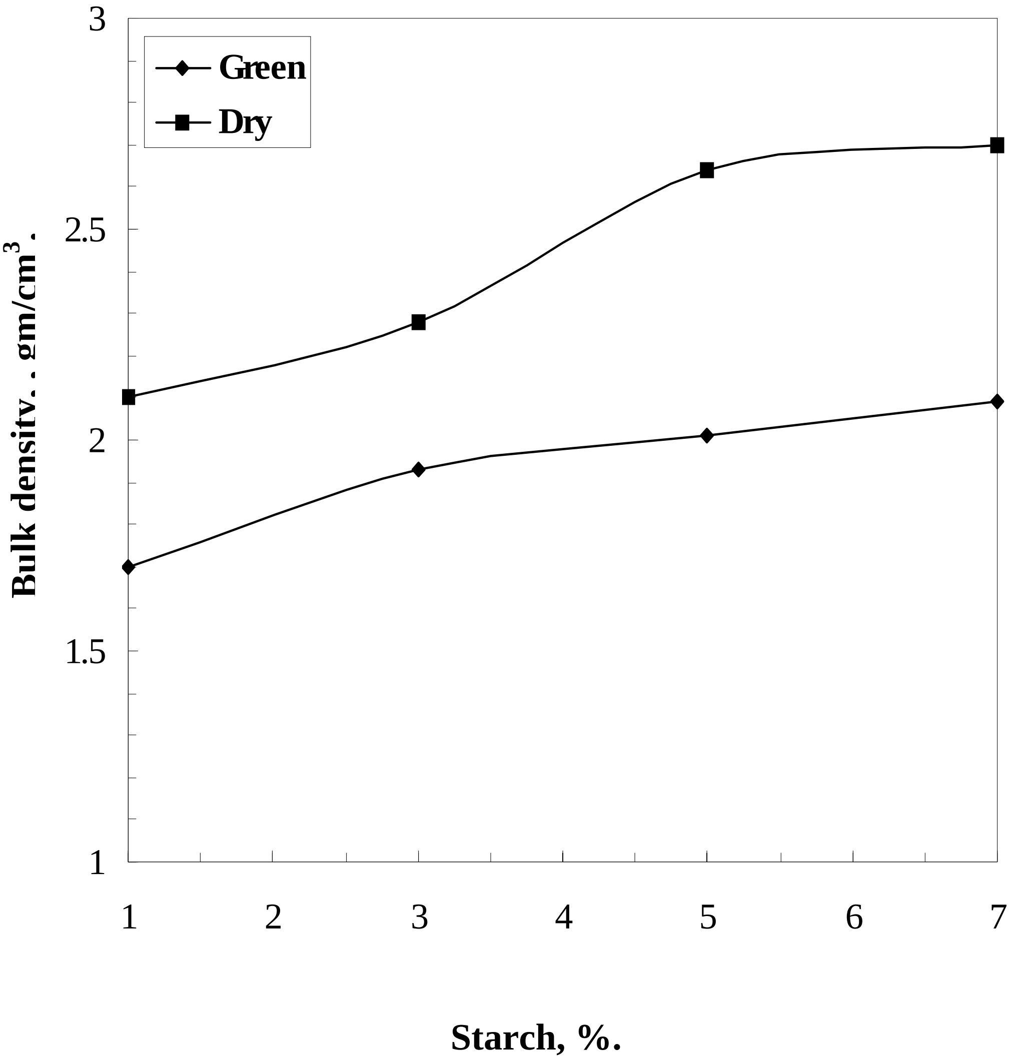


Fig. 2. Effect of starch added on the bulk density of the briquettes produced under pressure of 3 ton/cm^2 with 20-percentage water

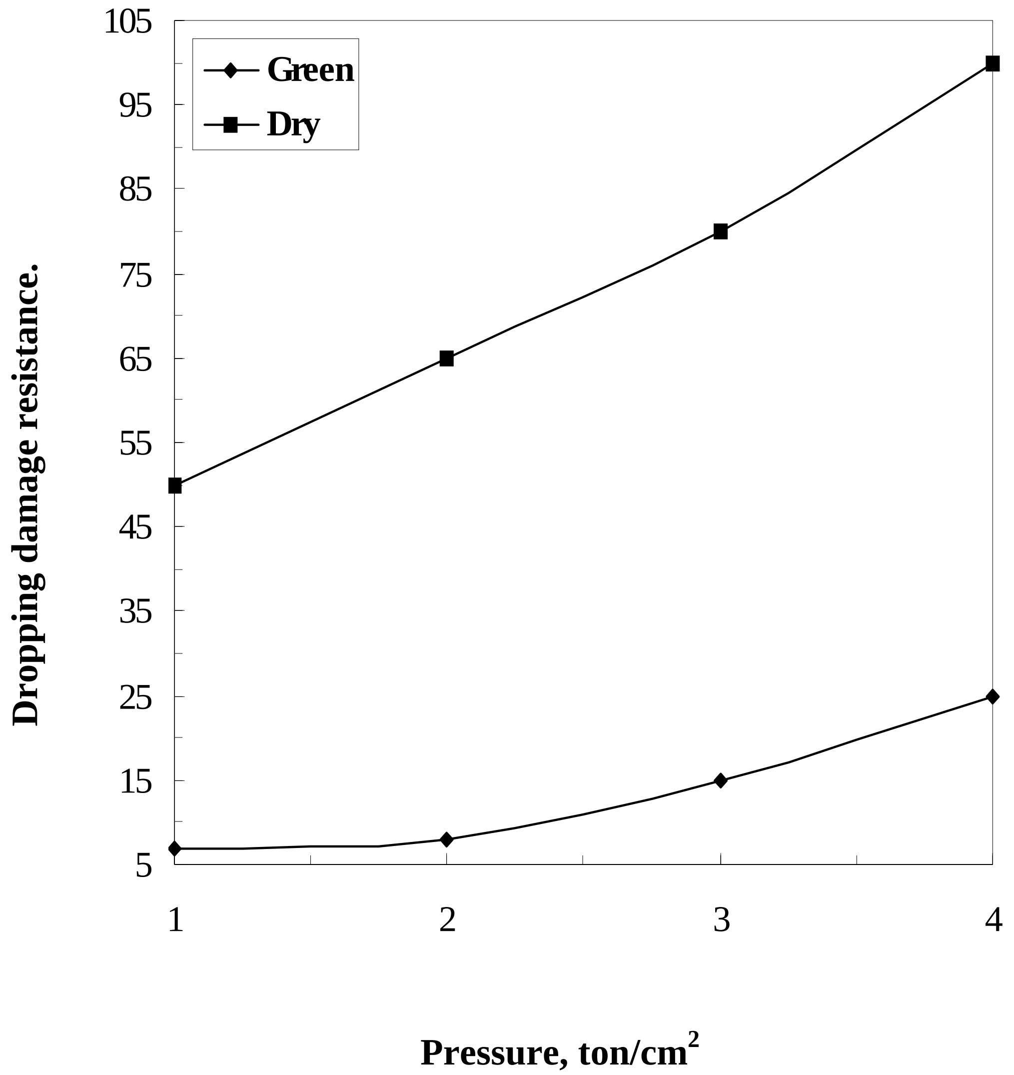


Fig. 3. Effect of pressure on the dropping damage resistance of briquettes produced with 5 percentage of starch and 20 percentage of water

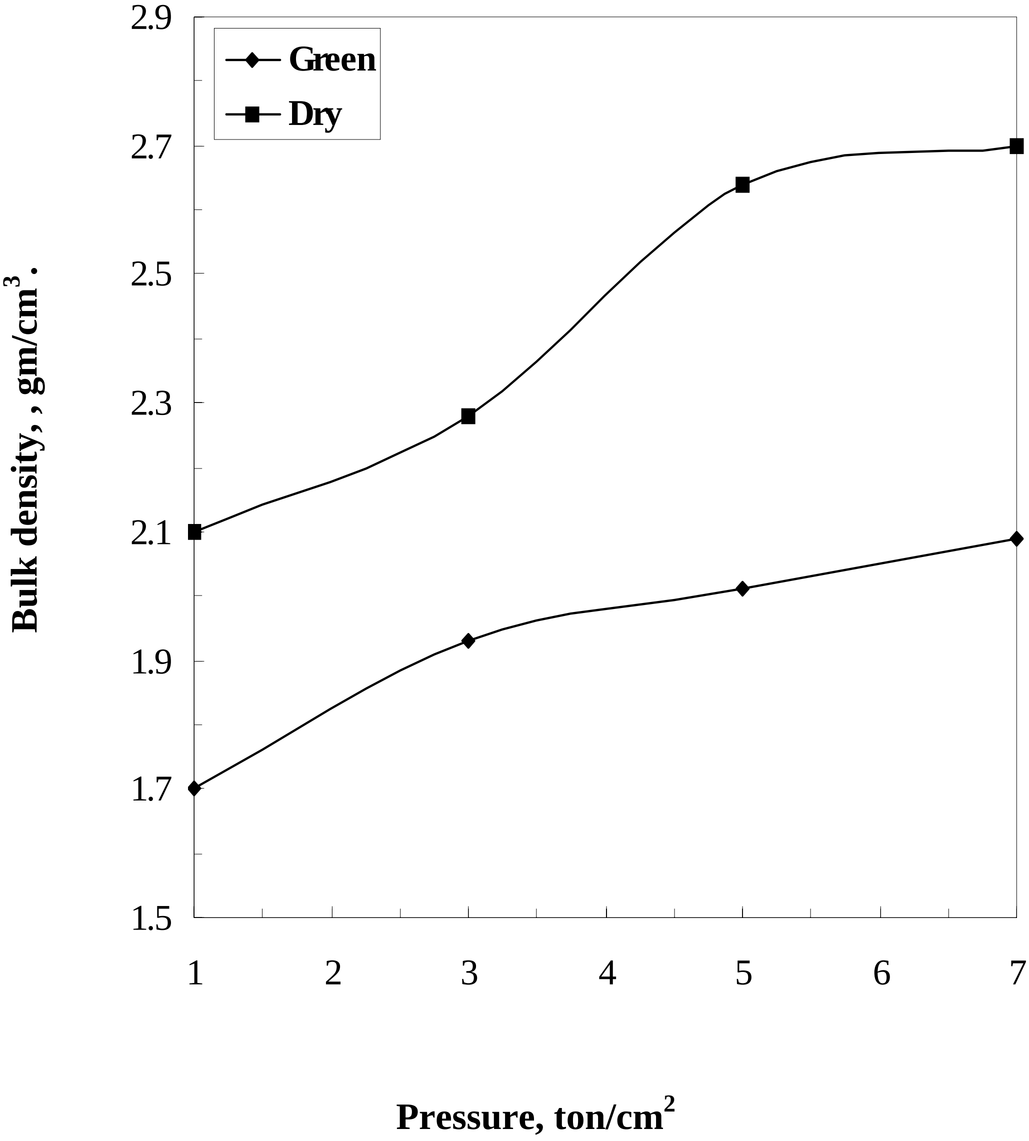


Fig. 4. Effect of pressure on the bulk density of briquettes produced with 5-percentage starch and 20 percentage of water

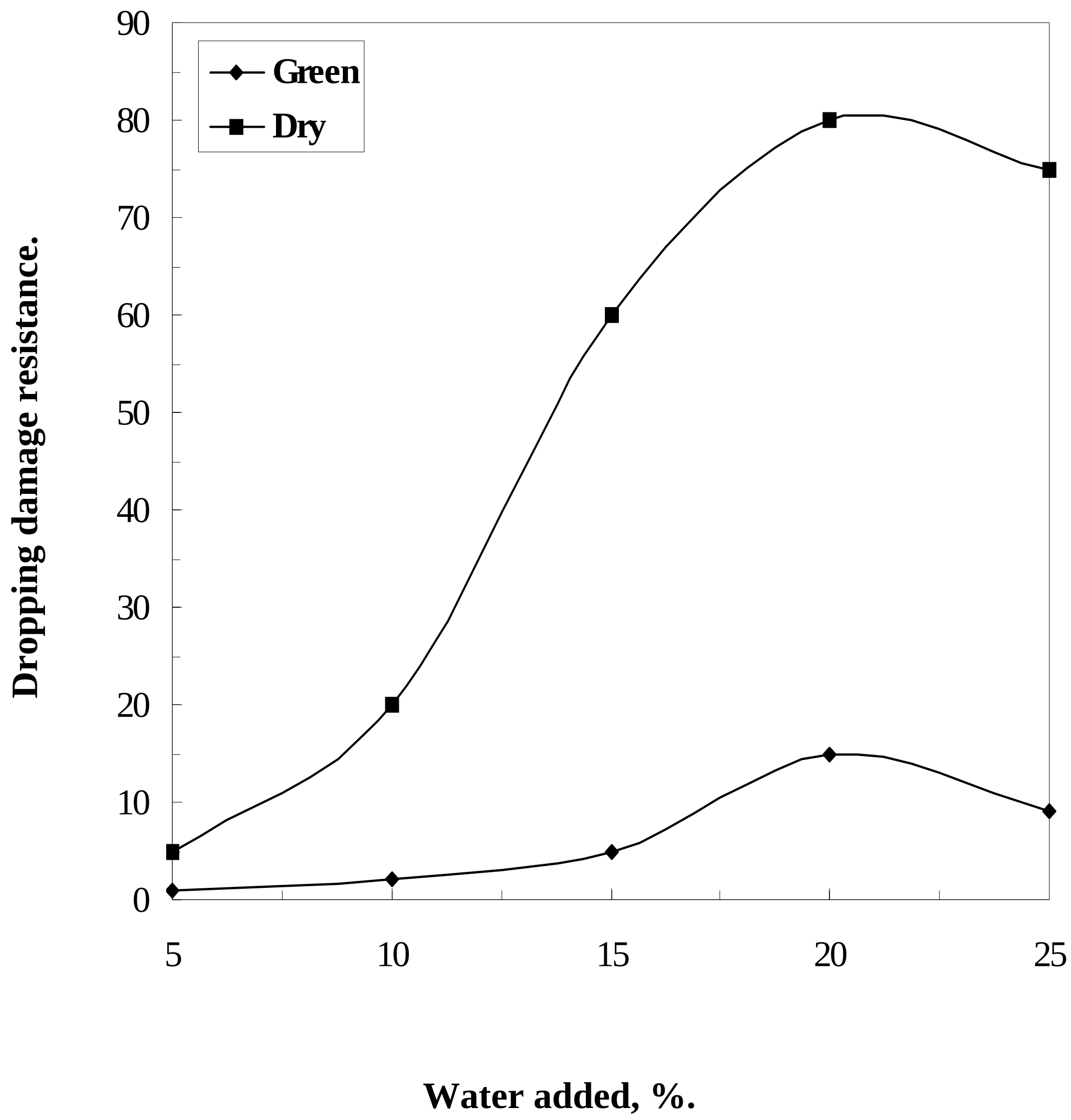


Fig. 5. Effect of water added on the dropping damage resistance of briquettes produced under pressure 3 ton/cm^2 with 5 percentage of starch.

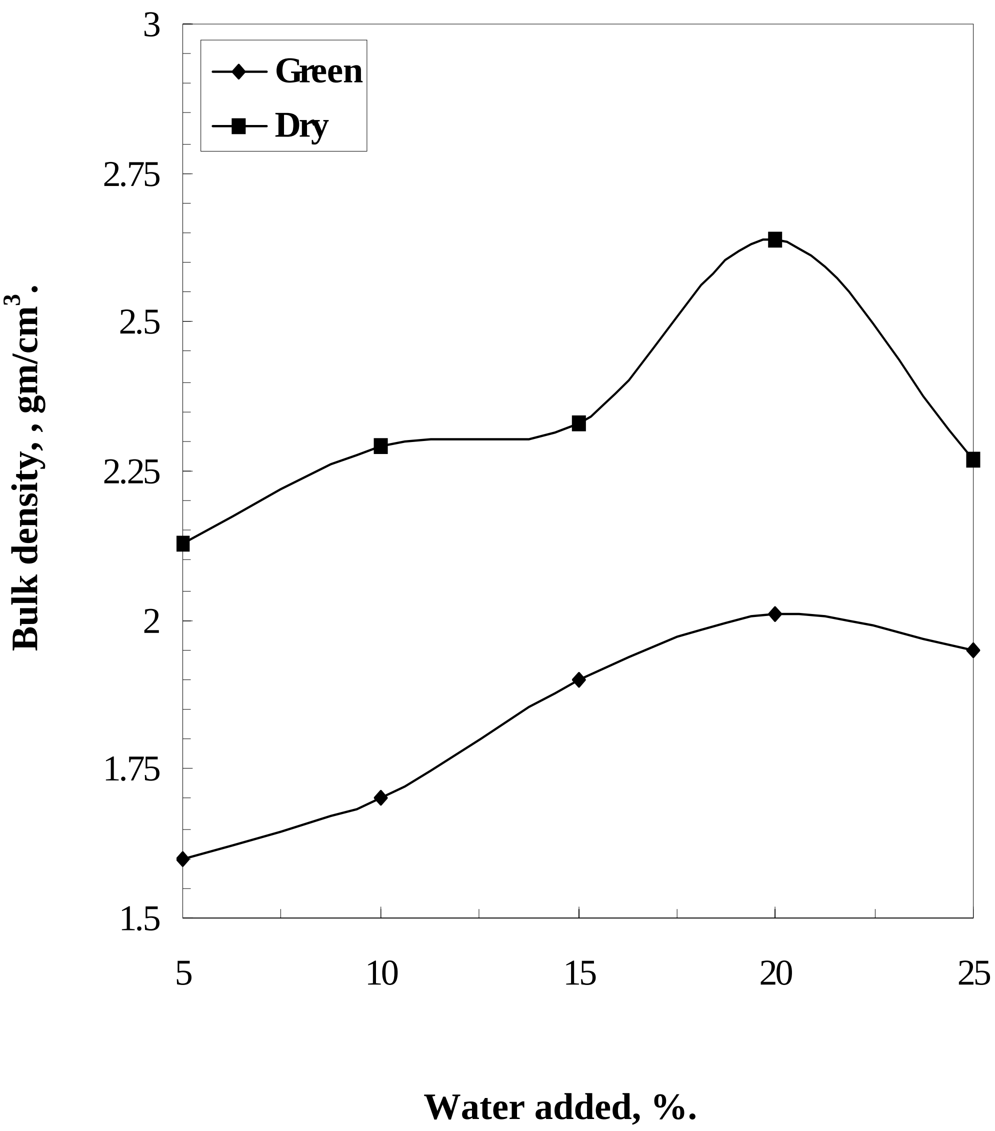


Fig. 6. Effect of water amount added on the bulk density of produced briquettes under pressure 3 ton/cm^2 and with 5 percentage of starch.

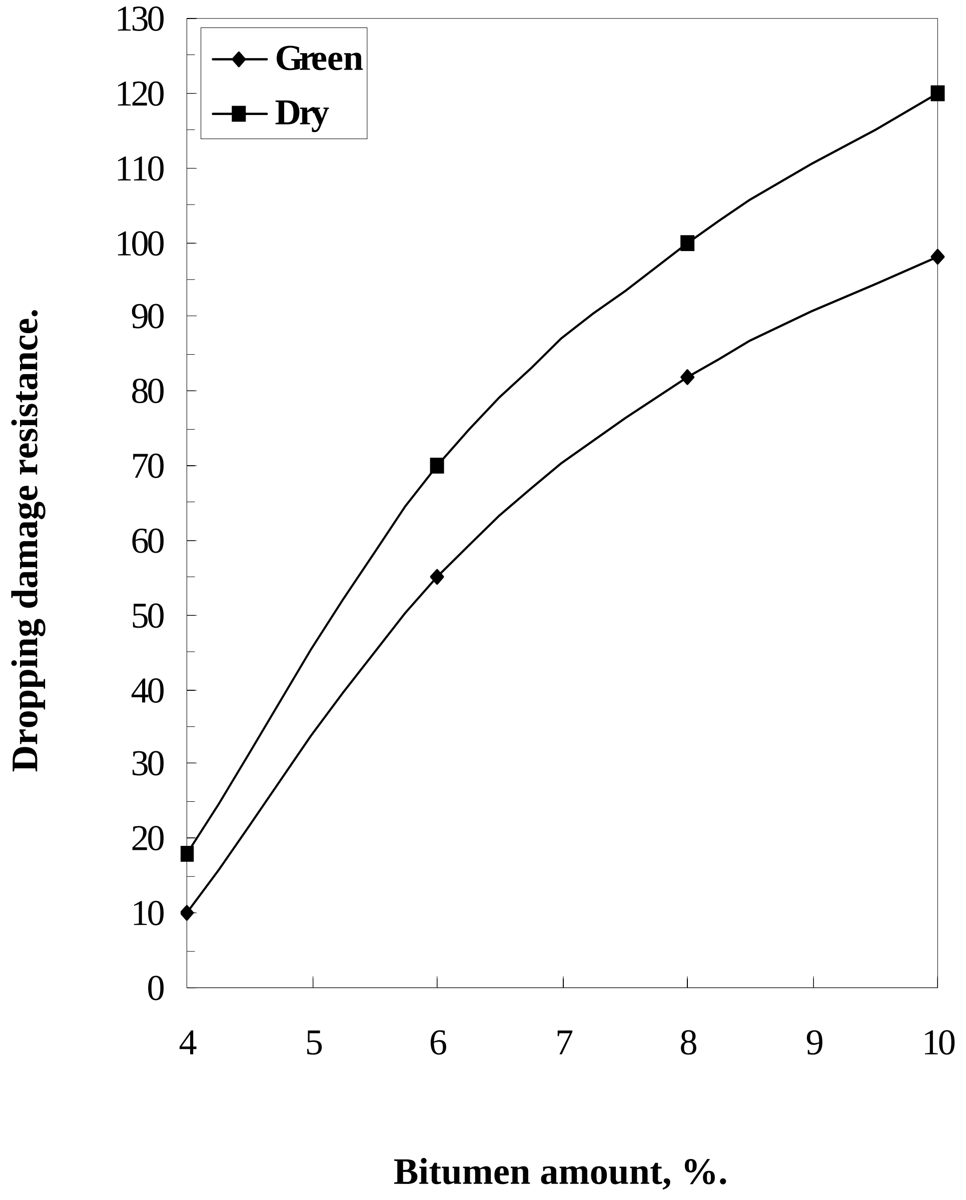


Fig. 7. Effect of bitumen amount on the dropping damage resistance on briquettes under 2 ton/cm^2.

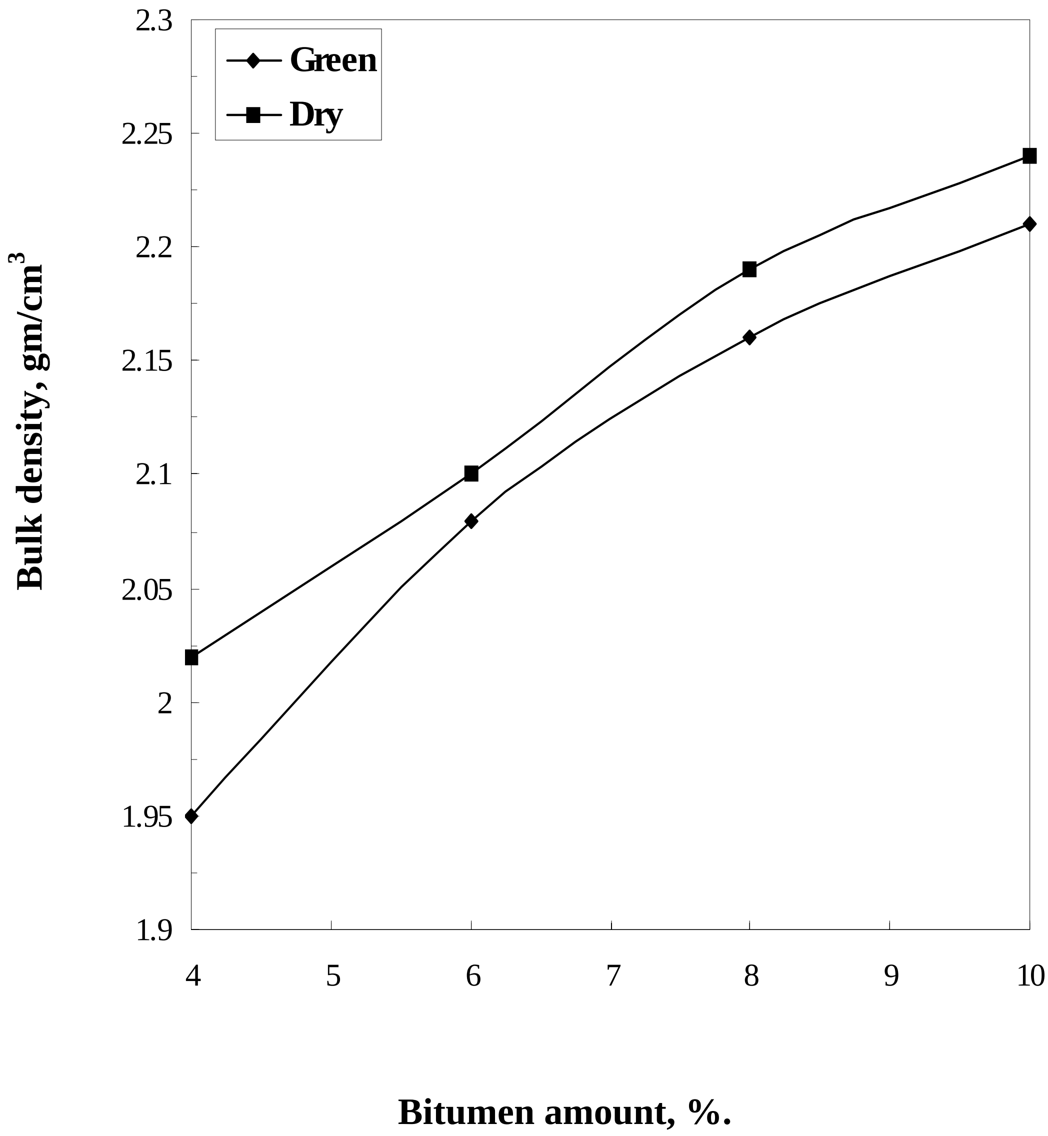
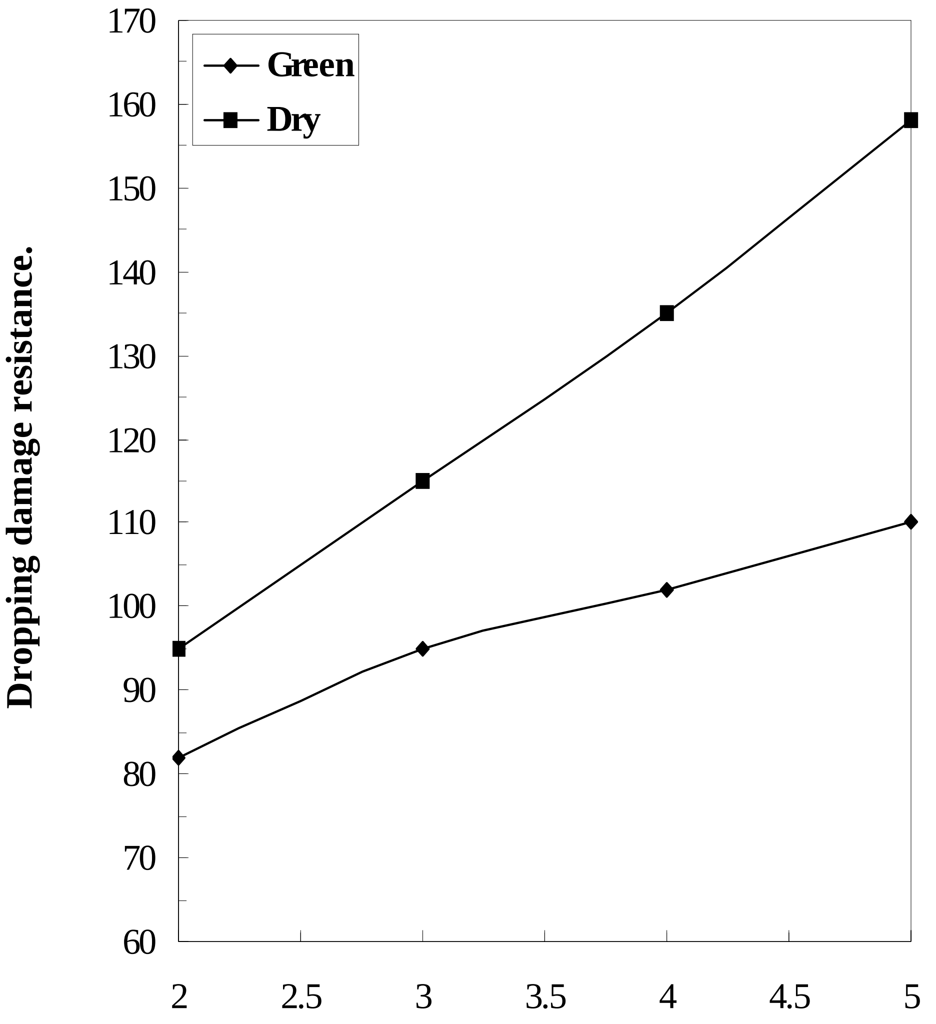


Fig. 8. Effect of bitumen amount on the bulk density of briquettes under 2 ton/cm^2



Briquetting pressure, ton/cm^2.

Fig. 9. Effect of briquetting pressure on the dropping damage resistance of briquettes with 8% bitumen.

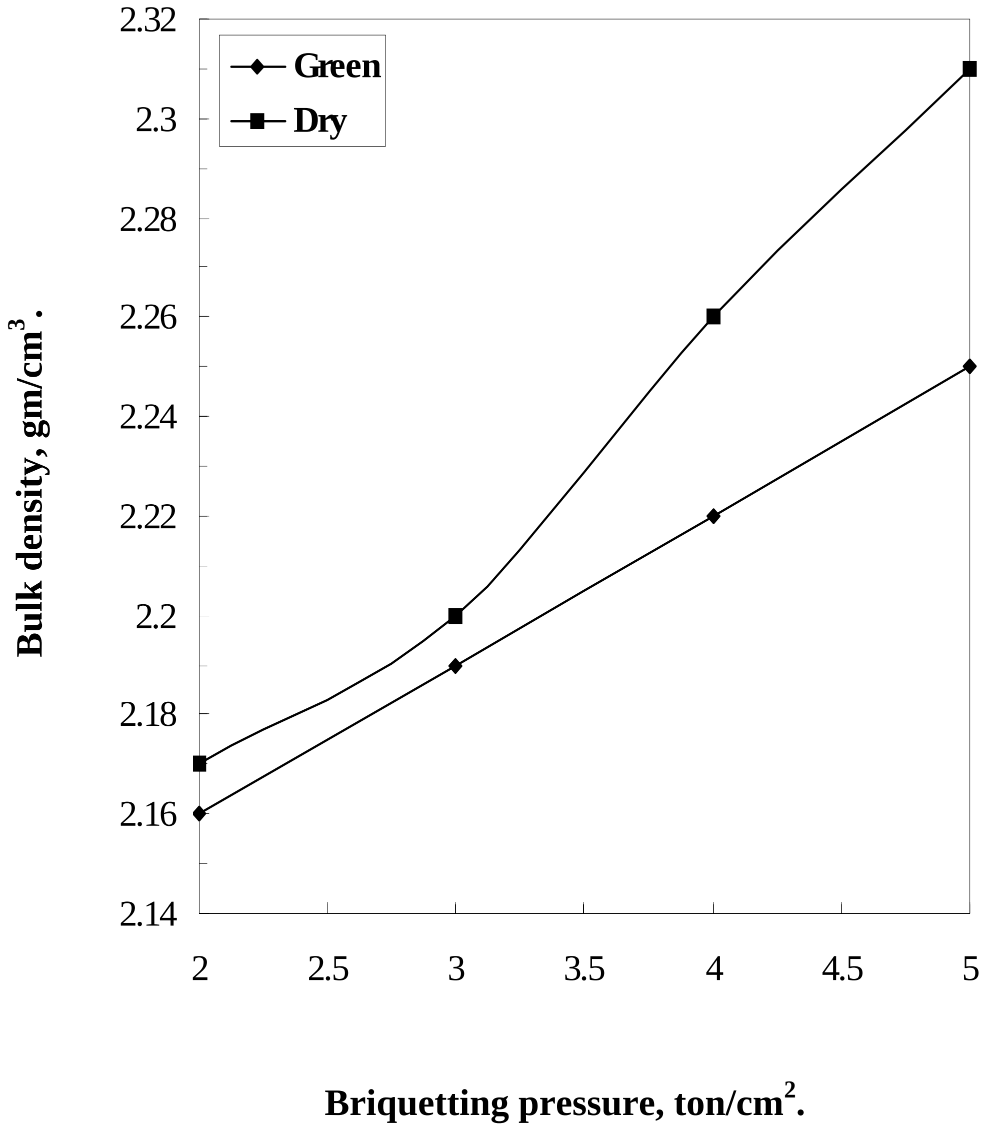


Fig. 10. Effect of briquetting pressure on the bulk density of briquettes with 8% bitumen.

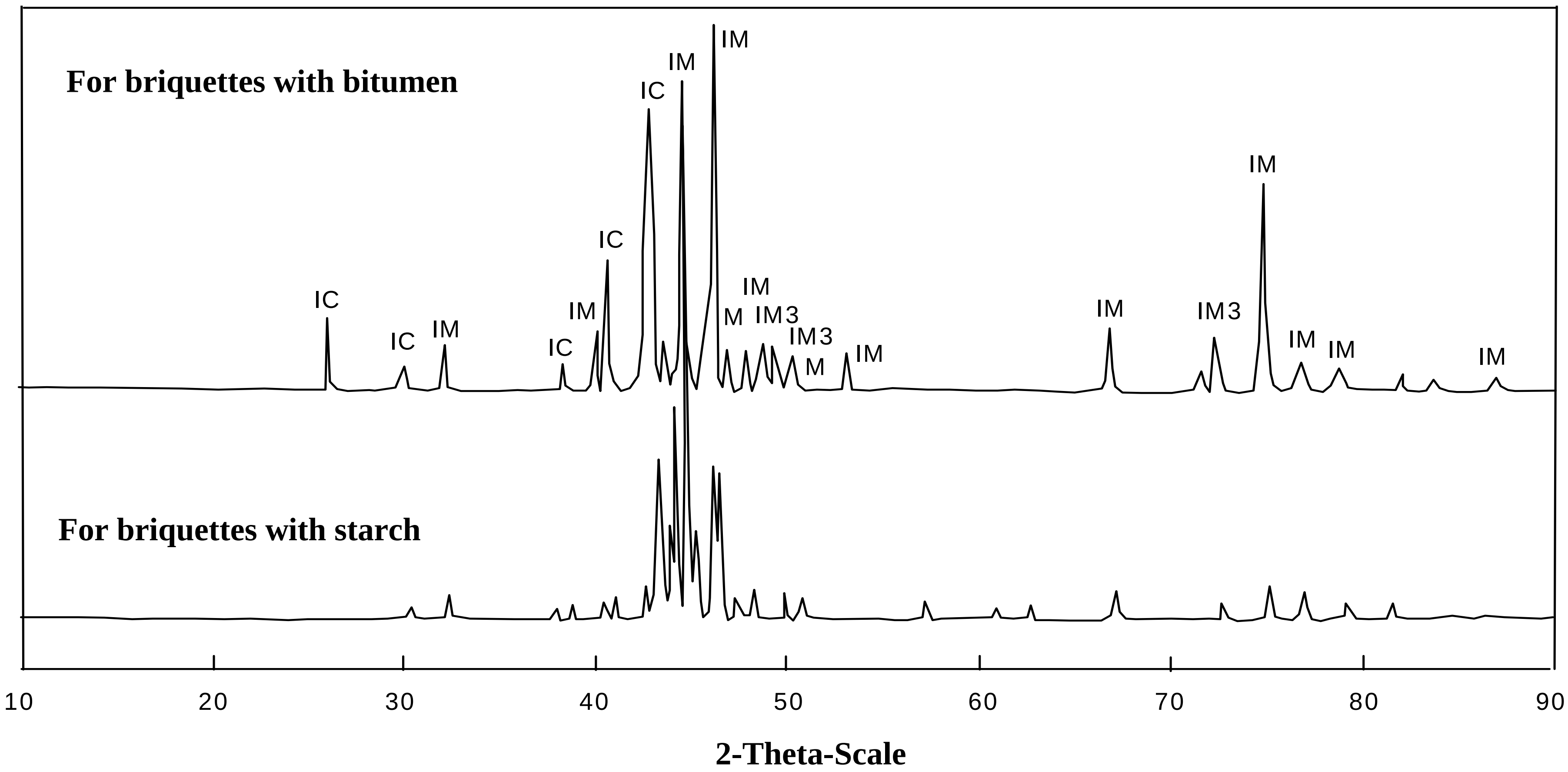


Fig. 11. XRD of ferromanganese alloy produced from smelting of briquettes made with addition of starch and bitumen.

Where; IM = Ferromanganese $FeMn_4$, IM3 = Ferromanganese $FeMn_3$, IC = Iron carbide and M = Manganese