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ABSTRACT

TRIAL PRODUCTION OF CONDOM FROM IRRADIATED NATURAL RUBBER LATEX IN FACTORY SCALE. Irradiation of latex was carried out using gamma rays from ^{60}Co at 20 kGy in the presence of 1 phr (part hundred ratio of rubber) of normal butil acrylate (nBA), and 1 phr of carbon tetrachloride (CCl_4). A straight dipping process for producing condom with various processing condition, i.e. total solid content of irradiated latex (50, 51, 52%), and speed of production (45, 46, 47 gross/hour) was applied. The results show that by increasing total solid content or speed of production, the thickness and weight of condom increase. Condom from irradiated latex has low modulus, high elongation at break and high bursting volume. The condom from irradiated latex can satisfy the standard requirement.

ABSTRAK

UJI COBA PEMBUATAN KONDOM LATEKS ALAM IRADIASI DALAM SKALA PABRIK. Lateks alam yang diiradiasi dengan sinar gamma ^{60}Co pada dosis iradiasi 20 kGy dengan menggunakan 1 psk (per seratus bagian berat karet) normal butil akrilat (nBA) dan 1 psk karbon tetraklorida (CCl_4), digunakan dalam percobaan ini. Beberapa kondisi proses pencelupan secara langsung untuk memproduksi kondom yaitu kadar padatan (50, 51, dan 52%), dan kecepatan produksi (45, 46, dan 47 gros/jam) telah dicoba. Hasilnya menunjukkan bahwa dengan naiknya kadar padatan dan kecepatan produksi, tebal dan berat kondom meningkat. Kondom dari lateks alam iradiasi mempunyai modulus rendah, perpanjangan putus tinggi dan daya rekat tinggi. Kualitas kondom lateks alam iradiasi memenuhi persyaratan standar.

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INTRODUCTION

It has been reported earlier that radiation vulcanization of natural rubber latex can be sensitized by normal butil acrylate (nBA) and carbon tetrachloride (CCl_4). The irradiated latex can be used for producing rubber goods, such as ballon, and industrial gloves (1-3).

Several scientists reported that RVNRL or irradiated natural rubber latex is not cytotoxide and free from nitrosamines (4-5), so irradiated natural rubber latex will be an alternative to conventional basic substance especially for the production of consumer goods being in contact with human body, such as surgical gloves, and condom.

A condom plant in Indonesia is in operation since 1987. The designed capasity of this plat is 900.000 gross/year, using three lines of molding systems (6).

This paper presents the results of trial production of condom from irradiated natural rubber latex in factory scale, for preparation of commercial production of condom from irradiated latex.

EXPERIMENTAL

Materials. High ammonia type centrifuged natural rubber latex from Pasir Waringin Rubber Plantation. PTP XI, West Java, Indonesia was used (Table 1). Carbon tetrachloride and normal butil acrylate were used as sensitizer. Nocract 300 was used as antioxidant. All the chemicals were technical grade witout further purification.

Apparatus. A latex irradiator with activity 110 kCi ^{60}Co was used for producing the irradiated natural rubber latex. Automatic dipping condom machine with capacity 45-50 gross/hour was used for producing condom. Apparatus for testing latex and condom were pH meter, Inston tester type 1122, etc.

Method. One hundred and fifty kg of natural rubber latex emulsion containing 1 phr of nBA, and 1 phr of CCl_4 were pumped into a mixing tank (Figure 1). After mixing it was pumped into a reaction vessel, and irradiated with total irradiation dose of 20 kGy. The average dose rate measured using red perspex dosimeter was 1.21 kGy/h. An antioxidant 0.5 phr of Nocract 300 was then added into the irradiated natural rubber latex. Condoms were made using automatic dipping machine at Banjaran Comdom Fctory. Glass former were used for dipping into the irradiated natural rubber latex with various total solid content (50, 52, and 52%) and various production capacity (45, 46, and 47 gross condom/hour). The whole procedure is illustrated in Figure 2. The physical and mechanical propertis of condom produced were measured according to ASTM, JIS, or BS standards (7-9).

RESULTS AND DISCUSSION

Effect of Heating Process. The physical properties of condom made of irradiated NRL with various heating temperature before leaching, and various heating time at 80° C after leaching are shown in Table 2. The modulus increases with increassing temperature or heating time, but the tensile strength decreases, while the elongation at break does not change so much. The increasing modulus is caused by the increase of crosslink density among polyisoprene molecules. The decreasing of tansile strength is caused by prolongation of heating time. So, by using the drying temprature 50° C for condom before leaching, and heating time of condom after leaching 1.5 hour at 80° C, the highest tensile strength can be obtaind.

Effect of Total Solid content. The correlation between total solid content and thickness of condom and viscosity of irradiated NRL is shown in Figure 3. It is appears that by increasing the total solid content of irradiated NRL, the viscosity and the thickness of condom increase, but the bursting strength and pinhole of comdom decrease (Figure 4), while modulus 600%, tensile strength and elongation at break are not so much effected (Table 2). It is clear that physical properties of comdom made of irradiated NRL do not affected by the total solid content. So, for producing condom with normal thickness, i.e.

around 0.05 mm the total solid content of latex should be around 51%.

Thickness of Condom. The thickness distribution and weight of condom obtained from irradiated latex with different total solid content are shown in Figures 5 and 6. Figure 5 indicates that for obtaining a stable weight of condom, it needs about 4 hours after starting the operation. The normal thickness distribution of condom is shown in Figure 6. Figure 7 indicates that the thickness of condom increase with distance of the open end.

Effect of Producing Capacity. Figure 8 shows the effect of dipping speed of condom former on the thickness and weight of condom. It indicates that by increasing the speed of dipping, the thickness and weight of condom increase. Maybe it is because by increasing the speed, the posibility of latex for going down becomes shorter. Consequently, the irradiated latex with was caught by the glass former was coagulated by air, so the condom produced becomes thicker.

Effect of Storag Time. Table 3 shows the effect of storage time of irradiated NR latex on viscosity, wet tensile strength, and stickness among condom. There is an indication that by increasing storage time of latex, the viscosity increase, while wet tensile strength and stickness among sondoms decrease. For instance, by increasing the storage time from 0 to 3 months the viscosity increases from 60 to 67 cp, and the wet tensile strength decreases from 6.0 to 4.3 MPa, which can reduce the percentage of sticky from 100 to 96%. By using 0.025% antitack Quartamin D 86 P, percentage of sticky decreased from 94 to 87%, then the sticky will become 6%, if antitack G was used.

Quality of Condom. The quality of condom from irradiated NR latex with was produced in factory scale meets the ASTM, BS, and JIS standards requirements (Table 4).

CONCLUSSION

Irradiated NR latex can be used directly to produce condom in factory scale. The condoms produced have low modulus, high elongation at break and high bursting volume. The overall quality meets the standard requirements.

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9. BSI, Specification for Rubber Condom, BS 3704 (1979).

Table 1. Properties of centrifuged natural rubber latex for the experiment

Properties	Value	Condom Spect.
Total Solid Content (TS), %.	62.40	61.5
Dry Rubber Content (DRC), %.	60.90	60.5
TS-DRC	1.5	1.5**
Total NH_3, % weight of latex.	0.7	1.0-2.0
Viscosity, Cp.	100	120**
VFA number	0.018	0.02**

** maximum

Table 2. Mechanical properties of condom from irradiated latex using various processing condition

Total Solid Content, %.	Heating temp. of condom before leaching, °C.	Heating time of condom after leaching, at 80°C, hr.	Modulus 300%, MPa.	Tensile Strength, MPa.	Elongation at break, %.
50	50	1.5	4.1	24.0	950
		3.0	4.8	23.1	950
	90	1.5	5.7	21.0	890
		3.0	6.8	20.8	800
51	50	1.5	4.2	25.0	990
		3.0	4.8	24.0	990
	90	1.5	5.5	21.2	880
		3.0	6.6	20.9	800
52	50	1.5	4.0	24.0	975
		3.0	4.9	23.5	890
	90	1.5	5.0	22.5	846
		3.0	5.9	21.0	800

Table 3. Effect of storage time on viscosity, wet tensile strength, and percentage of sticky

Item	Storage time of latex, month			
	0		3	
	I	II	I	II
Antitack				
- Antitack G	0	0	0	0.025
- Quartamin D 86 P	0.005	0.025	0.005	0.025
Viscosity, Cp.	60	60	67	67
Wet tensile strength, MPa.	6.000	6.000	6.000	6.000
Sticky, %.	100	97	97	6

I = first operation
II = second operation

Table 4. The quality of condom from irradiated latex, which was produced in factory scale, and ASTM, BSI, JIS standards

Properties	Condom from RVNRL	ASTM	BSI	JIS
Length, mm.	185	180+10	-	-
Width, mm.	49	52+2	-	-
Thickness, mm.	0.058	0.04-0.09	-	-
Weight, gram.	1.0+05	1.7**	-	-
Tensile strength, MPa.	22-28	24	20*	20*
Elongation at break, %.	900-1000	750	650*	650*
Blowing strength, liters.	35	-	-	25*

* minimum
** maximum

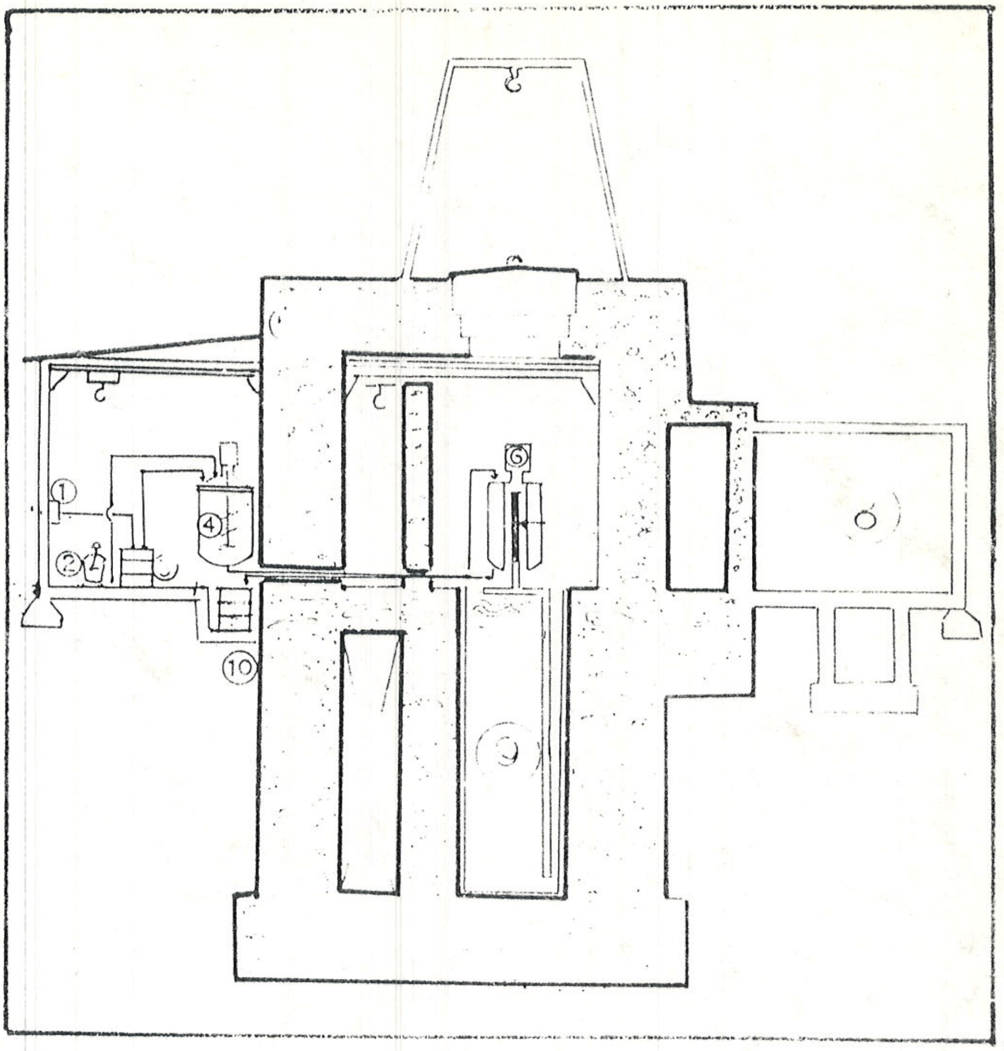

Figure 1. Cross-section of latex irradiator pilot plant at PAIR-BATAN.

1. Compression pump
2. Sensitizer tank
3. Latex before irradiation
4. Mixing tank
5. Concrete shield
6. Reaction vessel
7. γ ^{60}Co.
8. Water treatment room
9. Water pool
10. Irradiated latex.

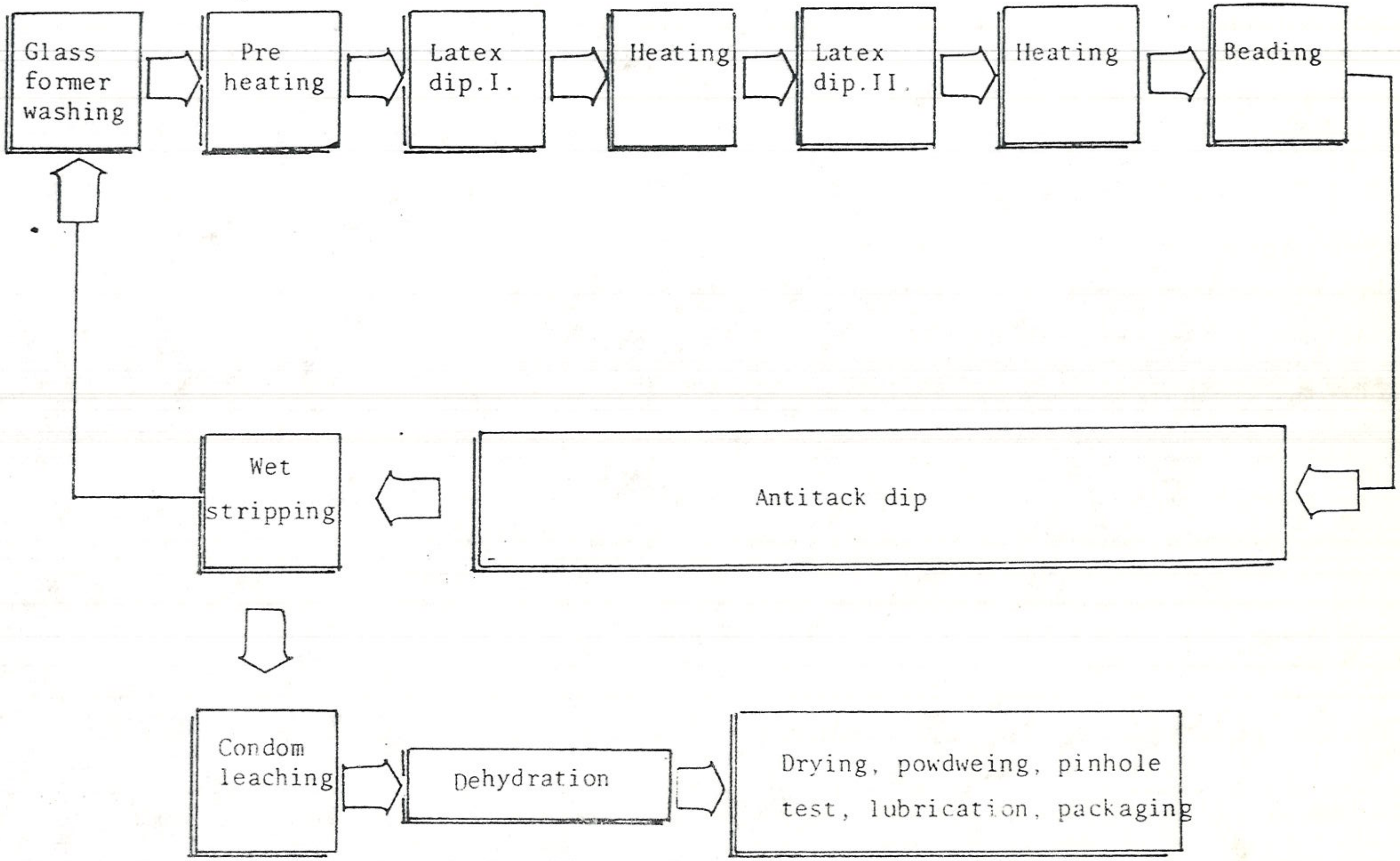

Figure 2. Schematic diagram of trial production of condom.

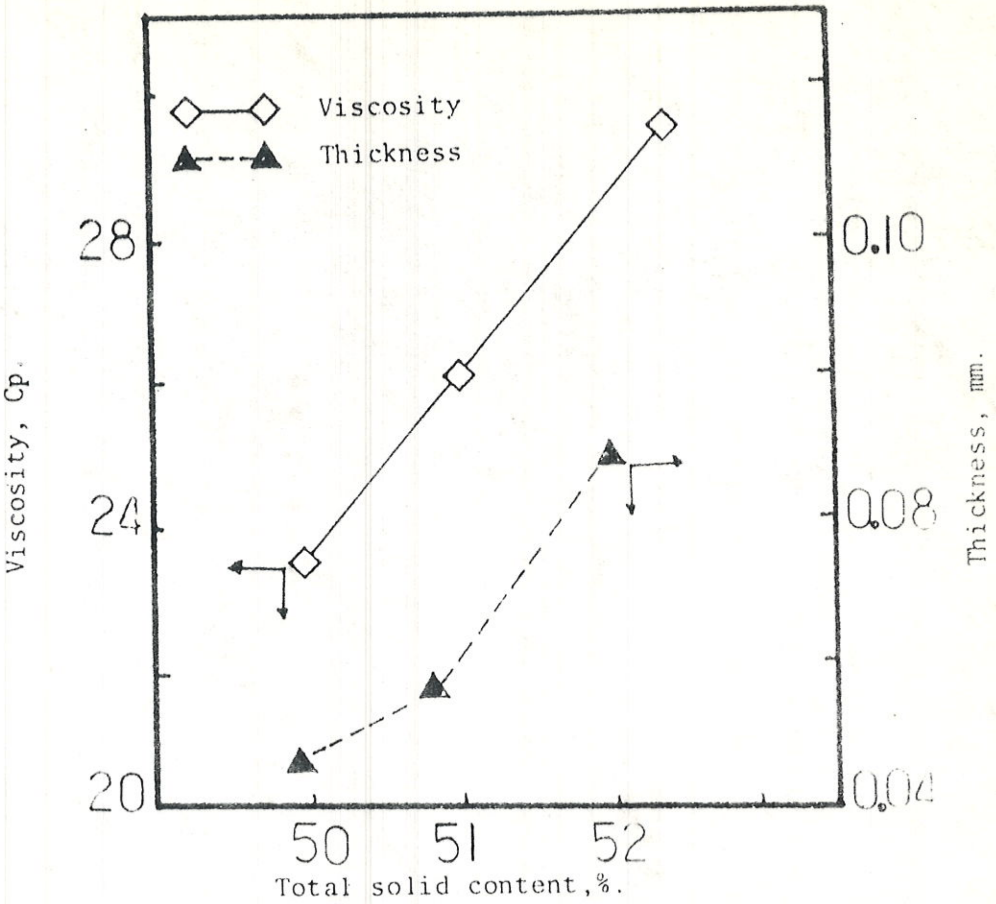

Figure 3. Effect of total solid content on viscosity and thickness of condom.

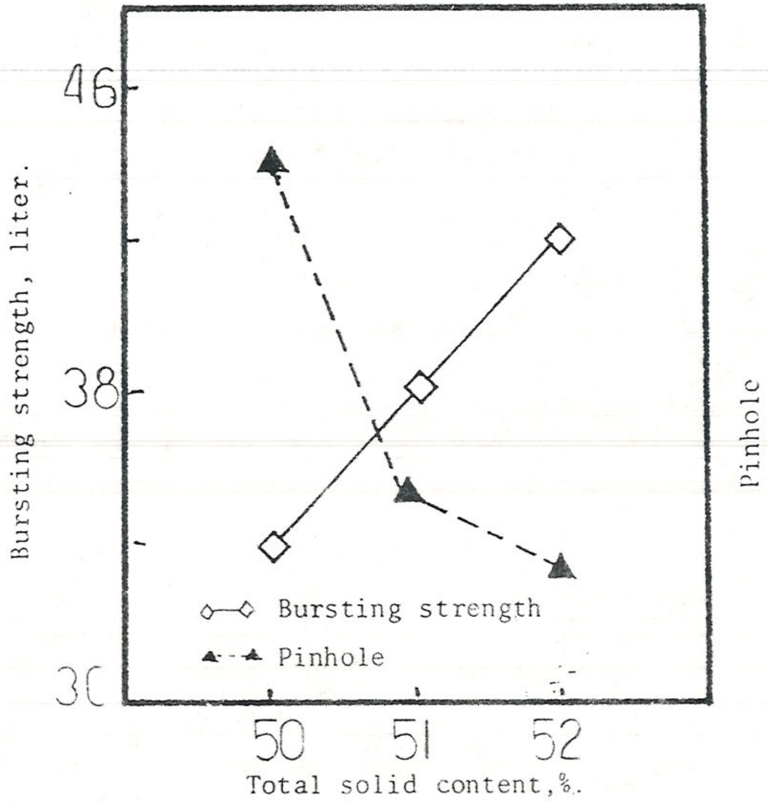

Figure 4. Effect of total solid content on bursting strength, and pinhole.

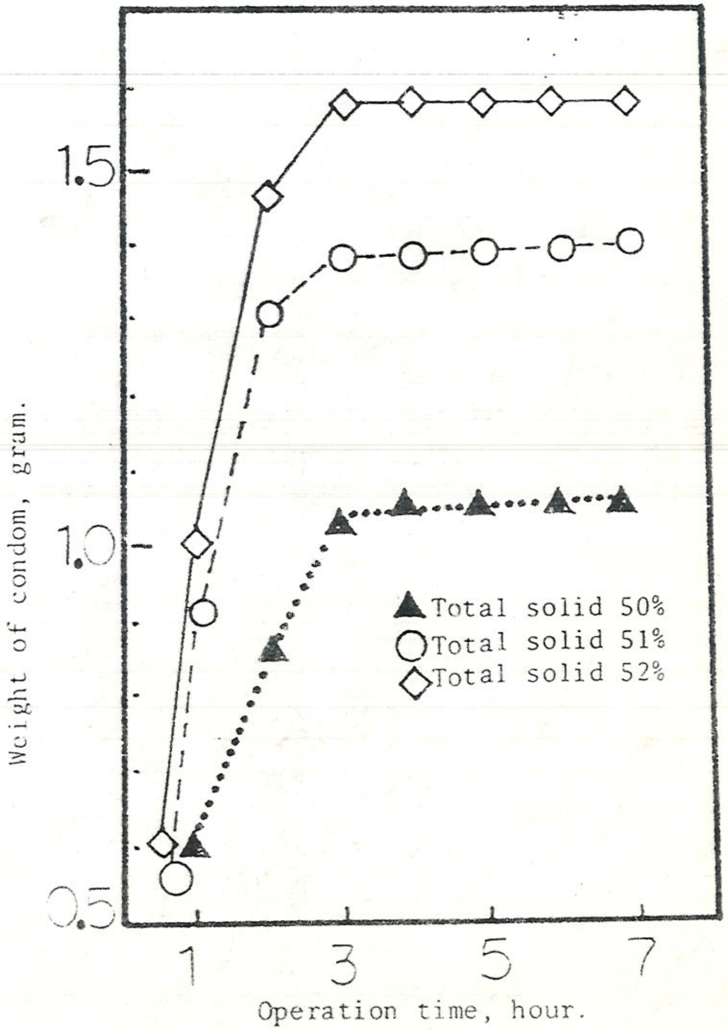

Figure 5. Correlation between operation time and weight of condom.

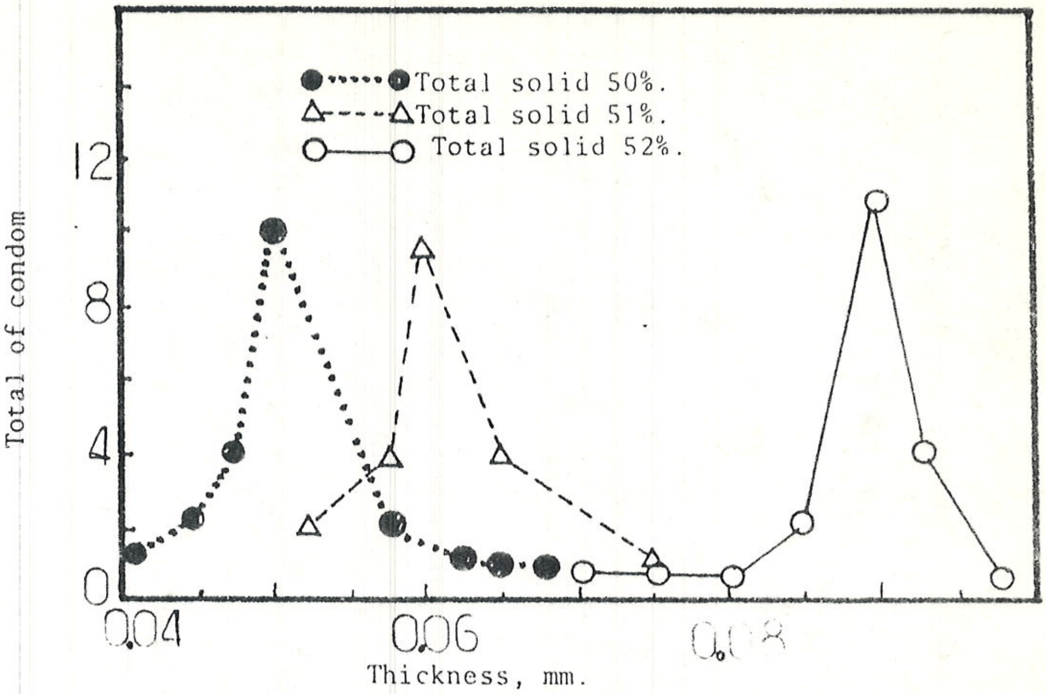

Figure 6. Thickness distribution of 50 condoms from irradiated natural rubber latex.

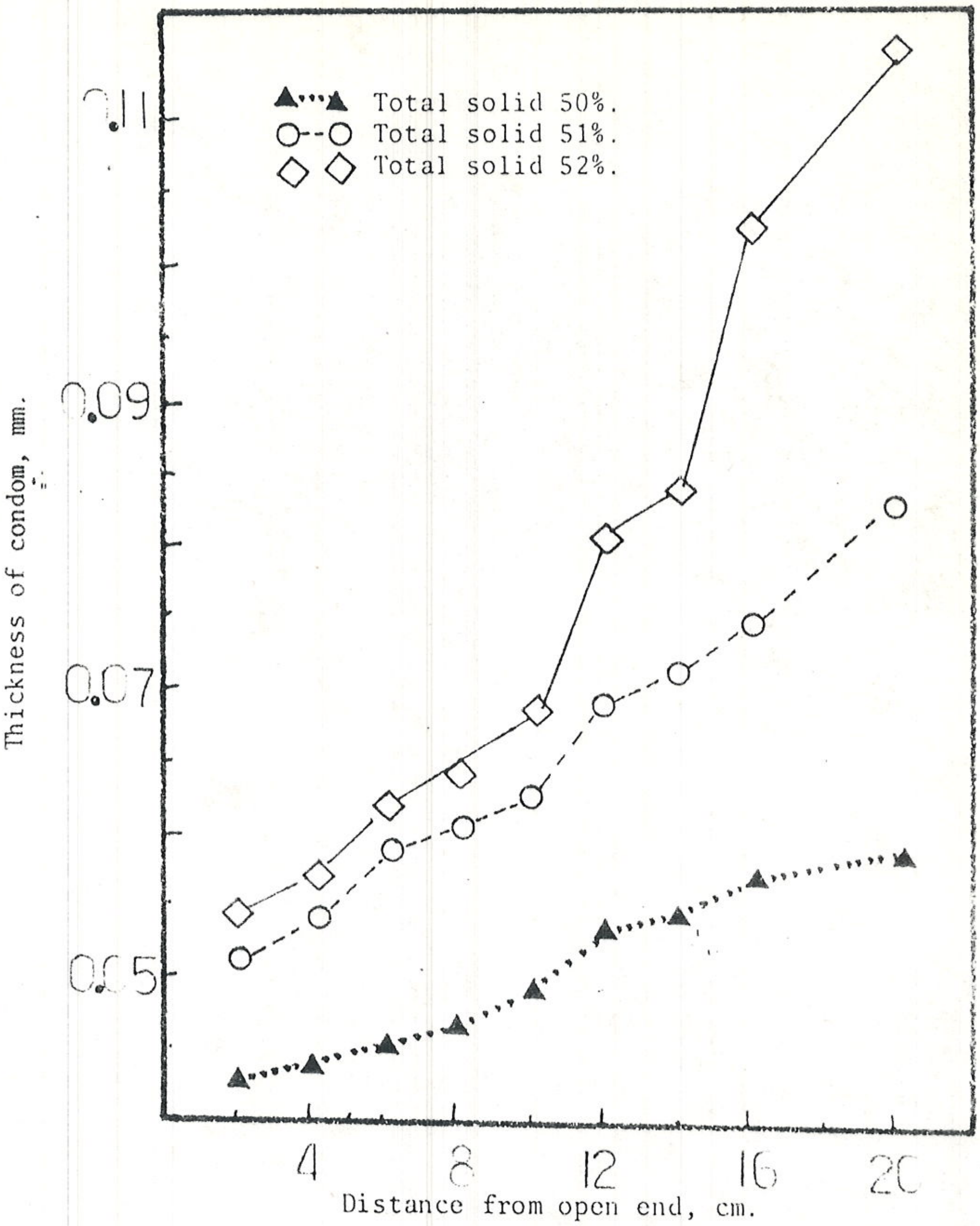

Figure 7. Correlation between distance from open end and the thickness of condom.

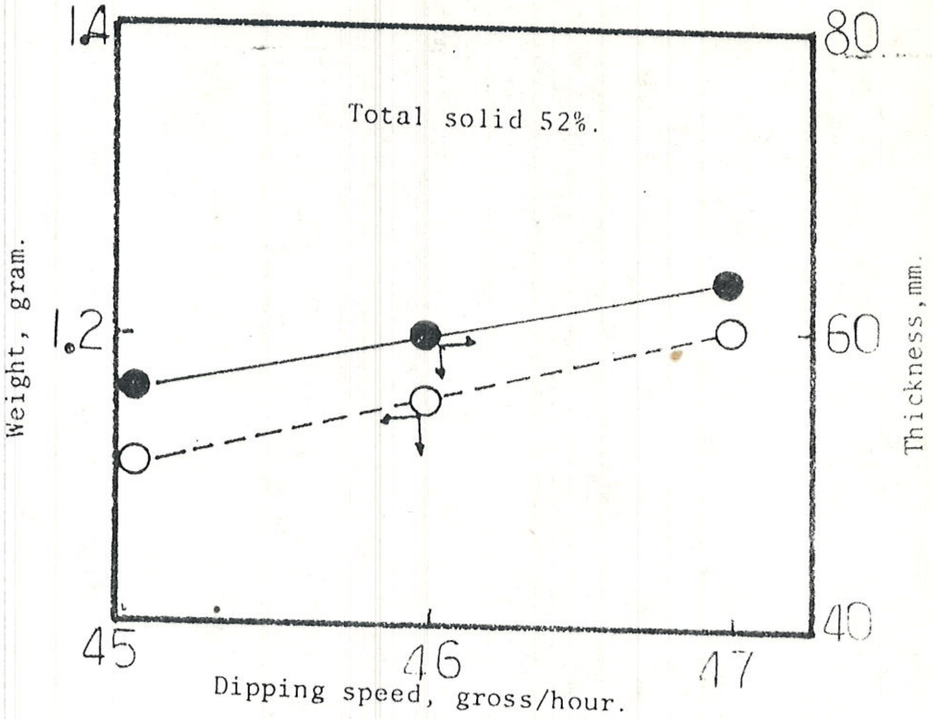

Figure 8. Effect of dipping speed/production speed on weight and thickness of condom.