Labthink Instruments Co., Ltd.
144 Wuyingshan Road, Jinan, P.R.China
Phone: +86 531 85068566
FAX: +86 531 85812140

Overview the Relationship between Pressure Difference and Gas Penetration Property of Material Scientifically

Abstract: This paper analyzed the mistaking point of view that believed the existence of pressure difference in differential-pressure method would affect the result of gas penetration property test and demonstrated that pressure difference between two sides of specimen would not affect the gas penetration property of material (gas penetration amount and gas penetration coefficient) by plenty of testing data.
Key Words: pressure difference, differential-pressure method, compressive strength, gas penetration amount, gas penetration coefficient

Many believe that the existence of gas pressure difference in differential-pressure method would affect the structure of macromolecule polymer of flexible packaging and further affect the result of gas penetration test: gas penetration amount and gas penetration coefficient (the multiply of gas penetration amount and thickness of film). However through a year's experiments and investigations, we found that this point of view was not right and demonstrated that the evidence was insufficiency, unscientific and incorrect.

1. Definition of Gas Penetration amount

The misunderstanding of the definition of gas penetration amount is a key factor which led to the mistaking point of view that believes the existence of pressure difference would affect the gas penetration property of material by gas penetration amount. According to the definitions in standards GB/T 1038 and ASTM D1434, gas penetration amount (gas transmission rate) is the volume of gas penetration in unit area of specimen in unit time when gas penetration is stable under the constant temperature and unit pressure difference, the unit commonly used is **cm^3 / m^2·d·atm.** We can see from analysis that gas transmission rate defined in standard ISO 2556 is consistency with gas penetration amount. Gas penetration coefficient which represents material property, is the multiply of gas penetration amount and thickness of film.

Flows and currents may increase as hydraulic pressure and voltage increase. It is inclined to get the conclusion that gas penetration amount is affected by gas pressure difference, according to the pattern above, but "under the unit pressure difference" which defined in the gas penetration amount, demonstrated that the pressure difference in two sides of specimen is rigidly regulated when calculated gas penetration amount. This can be seen from formula that compute gas penetration amount, so gas penetration amount which gas penetration coefficient is derived from, would not be affected by the variation of pressure in concrete experimental procedure.

2. Pressure Difference and Material Structure

Film materials have been compared to sponge, it is considered that when pressure increases, the microstructure of film can be affected and would change from loose structure to close structure and increase the difficulty of gas penetration. If this point of view is correct, the thickness of film would reduce as the time goes by. Supposing the closeness of structure would increase the difficulty of gas penetration, the data of gas penetration test would decrease as the time of constant tests increases. Labthink designed a series of tests to validate this point of view. We selected aluminum foil composite film, PET film and PC film, the gas penetration properties of

which belong to the ranges of high barrier, middle barrier and low barrier respectively and test the gas penetration of the same specimen for many times to inspect the repeats of constant testing result and the changes of thickness before and after tests as illustrated in table 1. Testing results demonstrated that the data of gas penetration test was not changed basically and the thickness of specimen was not changed after experiment. This proved that the saying of gas pressure difference would change the structure of material from loose to close, was incorrect.

Table1. Data list of oxygen penetration amount and specimen thickness

specimen	Gas penetration test					Thickness test (μm)		
	Oxygen penetration amount ($ml/m^2 \cdot 24h \cdot 0.1MPa$)			temperature	CV (%)	Before test	After test[1]	Δd
aluminum foil composite film	0.150	0.202	0.179	27℃	14.72	97.9	97.9	0
PET film	58.467	58.770	60.291	30℃	1.65	25.6	25.7	0.1
PC film	521.122	536.198	529.115	30℃	1.43	128.3	128.3	0

Tips: 1. the measurement of thickness is done within the range of efficient test region, other regions which are polluted by vacuum ester, are not significant to be measured.

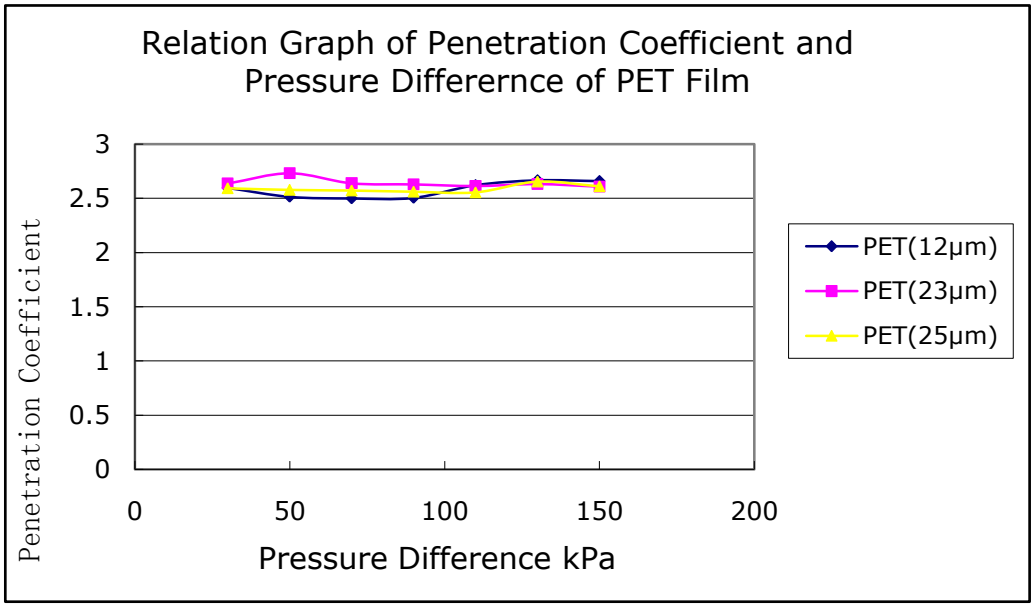
The mechanical properties of film materials are fairly well and are the basis of its abroad application. Compressive strength of film material is the max strength imposed on unit section when material is not destroyed under the slowly imposing of pressures. The compressive strength of PP is 39 MPa ~56MPa, ordinary PS is 80.5 MPa ~112MPa, modified PS is 28 MPa ~112MPa, PA-66 in dry condition achieves 120MPa, we can see that the compressive strength of film materials are hundreds to thousands times of the pressure differences imposed on specimen in differential-pressure test. And in the inspection of sealing property of flexible packaging, we found that the break points of flexible packages with break pressures about 0.1MPa as well as above 0.15MPa, are usually on the edge of hot sealing. Higher pressures are needed to make breaks in films, but perforated papers in the side of low pressures protest and support specimens well, so the existence of pressure difference would not affect the structure of specimen in differential-pressure test.

3. Pressure Difference and Gas Penetration Property of Material

Would the gas penetration property of material be affected by pressure difference? Even excluded the suspicious that pressure difference would affect material structure, many still believe that relations exist between pressure difference and gas penetration property. This point of view can be demonstrated through experiments, if the gas penetration amount and gas penetration coefficient do not change when pressure difference between two sides of material increases, it indicate that the existence of pressure difference do not affect the gas penetration property of materials.

Labthink had tested tens of specimen of eight kinds under different gas pressure differences for months. The test points of pressure differences is 0kPa、50kPa、70kPa、90kPa、110kPa、130kPa、150kPa, the gas penetration amount of testing materials are ranging from 1.5$cm^3/m^2 \cdot 24h \cdot 0.1MPa$ to 7000$cm^3/m^2 \cdot 24h \cdot 0.1MPa$. figure 1 is the

penetration coefficient testing curves of three PET materials of different thickness: PET（12μm）、PET（23μm）、PET（25μm）. Testing data demonstrated that the changes in pressure differences did not affect the gas penetration amount and penetration coefficient of specimen. Monograph based on the test had been published in IAPRI 2007, the conclusion that pressure differences did not affect gas penetration property of materials, was affirmed and agreed by professionals and specialists from many countries.



Fingure1 Relation Graph of Penetration Coefficient and Pressure Differernce of PET Film

Unit of penetration coefficient：(E-12)cm^3·cm/cm^2·s·cmHg

Some people may consider that the pressure difference in our test is not big enough and far from the limit of compressive strength of film material. Not to come singly but in pairs institutionary members from Chile did the similar research and came to the coincident conclusion with us. The research that is mentioned in the paper “INFLUENCE OF HIGH PRESSURE PROCESSING OVER MECHANICAL, THERMAL AND BARRIER PROPERTIES ON FLEXIBLE FOOD PLASTIC PACKAGING” which published in IAPRI 2007, enhanced the pressure to 400MPa that is 4000 times as high as the pressure in differential-pressure method and did special research to the barrier property of special coat material. The conclusion is that as to metallization materials and films plating silicon oxide, its barrier property is 40％ to 50％ affected, but as to PE/EVOH/PE and PET/PE material, the data from its barrier property tests did not change obviously. The pressure in the HPP is 4000 times as high as the pressure in differential-pressure test and beyond the limit of compressive strength of film materials. Coat material keeps good barrier property under high pressure, so the gas penetration property of materials won’t be affected by the existence of pressure difference in differential-pressure test.

4. Conclusion

Generally speaking, the point of view that believes pressure difference affect the gas penetration property of materials and includes mistaking understandings in parameter definition, do not stand practical test. Any lab would come to the same conclusion with labthink if it does the similar experiment. The whimsicality that data would not be affected in isopiestic method because absence of pressure difference but data would be affected in differential-pressure method because the existence of pressure difference, is absurdity and absolutely err from the scientific and religious attitudes toward research.