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The Quality Evaluation of Korean Traditional Hanji by Different Sheet-making Processes

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ABSTRACT

It is well known that Korean traditional Hanji have lots of predominant physical and optical properties such as high density, high air permeability, long lasting quality and lightness. The paper-making raw materials of traditional Korean Hanji are the bast fibre cooked from the Korean paper mulberry as a fibrous materials and sticky aqueous material from the root of Hibiscus anihot L. as additives for good dispersion of stock. Additionally, the mechanical properties of Hanji varies according to the cooking methods of bast tissues of Korean paper mulberry, the treatment methods of fibrous raw materials such as bleaching and refining, the wet formation types of sheet-making such as "Oebal-chiji" and "Ssangbal-choji", and the finishing treatment like stamping. This study was carried out to investigate and evaluate the quality properties of Korean traditional hand-made Hanji, and compared with commercial machine-made paper and modified prepared sheets. The physical quality comparisons of different kinds of Hanji were focused on the methods of hand-sheet making, the types of raw materials, the treatment of stamping, and the properties of ink reception and spreading.

Keywords: Korean traditional hand-made paper, Hanji, quality property, handsheet-making, stamping, ink reception

1. Introduction

Korea has a long history in traditional papermaking technology. It is well known that paper was firstly invented in China, and then next succeeded to Korea. Additionally, Korea has developed the traditional Korean hand-made papermaking technology from bast plant fibres as a raw material of papermaking. Korean traditional hand-made paper, Hanji, therefore, has been over thousand year's history, and developed for its high strength, high whiteness, high gross, excellent ink reception and long periods of preservation properties. The main fibrous component of Hanji is from the bast fibre of the Korea Paper

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Mulberry (Broussonetia kazinoki). The fibres obtained from Paper Mulberries have long fibre length and high content of cellulosic material with high degree of polymerization. The pulping method of Paper Mulberry fibre is also very different than modern wood pulping methods. The main chemical components of cooking liquor are made from ashes which are burnt from several kinds of agricultural plant. The burnt ash water has totally alkaline property. Besides the property of raw materials, Hanji is prepared from specific traditional handsheet-making procedures and processes. Korean traditional handsheet-making process has classified two kinds of sheet forming processes, which are "Oebal sheet-making" and "Ssangbal sheet-making". The Oebal sheet-forming process is an original method developed in Korea. The fibre stock is firstly dipped onto the paper chest and flow away in the forward direction. Then, paper stock is scooped again and rhythmically rocked from side to side. These procedures are repeated several times. This process makes the fibres intertwine and form to sheet. Ssangbal sheet-making is nowadays developed to Japanese traditional hand-forming process.

Nowadays, with the development of machine-made paper, Hanji is becoming a kind of great national cultural inheritance. Therefore, the name of Hanji is a representative symbol of unique traditional techniques. At the present time, Hanji-making technology is rapidly declined, and stays in existence with difficulty. Recently, with the improvement of living standard and the increase of concerns about traditional culture in Korea, the demand of Hanji is more and more increased. But in spite of rapid restoration of Hanji, there is no standard method for the evaluation and quality level of Hanji.

In this study, for the evaluation of traditional hand-made Hanji and comparison with machine-made Hanji, the mechanical, physical properties on several kinds of Hanji were measured and analyzed, and furthermore, verified in the point of quality properties.

2. Materials and method

2.1 Hanji

Several kinds of Hanji sheet were collected from Korean traditional handsheet makers and used in all experiment. For the comparative evaluations, some kinds of modified hand-made Hanji and machined-made Hanji were also collected and evaluated.

2.2 Physical and mechanical properties of Hanji

The physical and mechanical properties of Hanji were analyzed by the international standard method of ISO including thickness, ISO 534; air permeability,ISO 5636; roughness, ISO 8791; breaking length, ISO 1924; stretch, ISO 1924; tear index, ISO 1974; burst index, ISO 2758 and folding endurance, ISO 5626. For the test of physical properties, Hanji was uniformly conditioned, according to the standard method of ISO 187 at the condition of temperature, 23±2℃ and relative humidity, 50±2% for 48 hours.

2.3 Ink reception test

The ink reception property was measured by ISO 8787, determination of capillary rise - Klemm method, shown in Fig. 1. For the test, samples were cut to the size of strip, 200 mm long and 15 mm±1 mm wide from the Hanji sheet. The ink reception length was measured for 10 min after the immersion of test kit into the suspension device. 10 measurements were

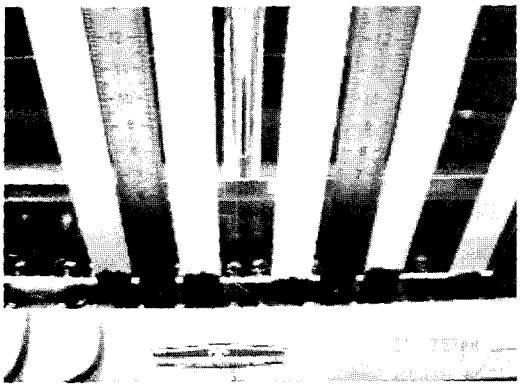

Fig. 1. Klemm ink reception device.

repeatedly carried out from same samples and averaged.

2.4 Spreading property of ink

The ink spreading properties were evaluated by the calculation of round-shape ratio and heteromorphy ratio listed in following formula. The ink spreading property was carried out by dropping a specific ink on the sheet of Hanji with a micro-pipette and scanning the ink spreading configuration shown in Fig. 2 with image analyzer.

$$Round-shape\ ratio = \frac{Maximum\ R}{Minimum\ R}$$

$$Heteromorphy\ ratio = \frac{Ink\ spreaded\ area}{Outer\ perimeter\ area}$$

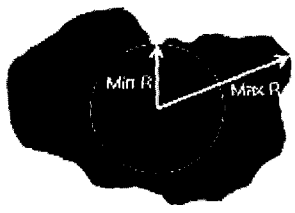

Fig. 2. Configuration of ink spreading.

3. Results and Discussion

3.1 The comparison of physical properties between traditional hand-made and machine-made Hanji

5 different kinds of commercial Hanji were collected and the physical properties of sheet were compared in the points of sheet-making methods, such as traditional forming and machine-made methods. The compositions of raw materials in different Hanji were listed in Table 1.

Table 1. The compositions of raw materials in different kinds of Hanji

Sheet-making method	Compositi on of raw material
Hand-made Hanji I	Korean Mulberry fibre 100%
Hand-made Hanji II	Korean Mulberry fibre 100%
Machine-made Hanji I	Thailand Mulberry fibre 70% + waste fibre 30%
Machine-made Hanji II	Thailand Mulberry fibre(unknown content) + waste fibre (unknown content)
Hand-made Hanji III	unknown the compositions of raw materials

The basis weight of collected different kinds of Hanji were 31 g/m² in hand-made Hanji I, 35 g/m² in hand-made Hanji II, 32 g/m² in Machine-made Hanji I, 30 g/m² in machine-made Hanji II and 29 g/m² in machine-made Hanji III respectively. Compared to around 30 g/m² of basis weight among 5 different kinds of Hanji, hand-made Hanji was generally thicker than machine-made Hanji in sheet thickness. It would be considered that the thickness differences were due to the compositions of fibrous raw material and sheet forming methods, because most of machine-made Hanji

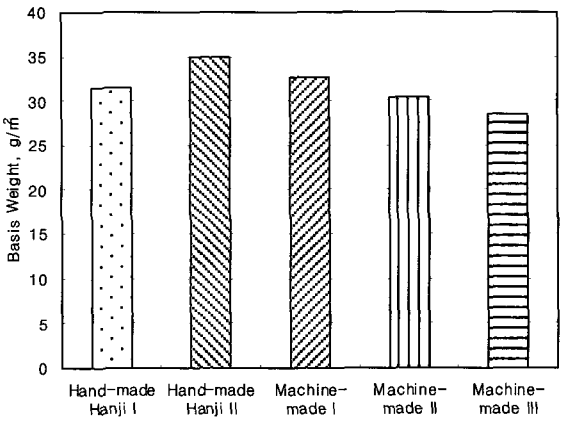

Fig. 3. The distributions of basis weight of Hanji used in experiment.

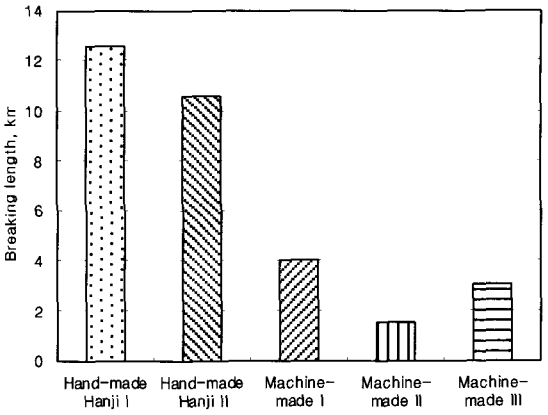

Fig. 5. The relationships between breaking length of Hanji sheets and sheet-forming methods.

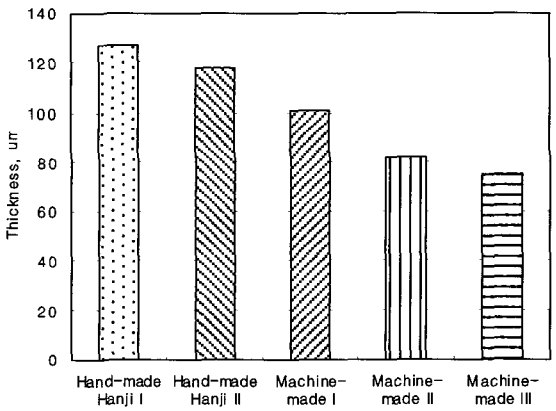

Fig. 4. The thickness profiles of Hanji sheet used in experiment.

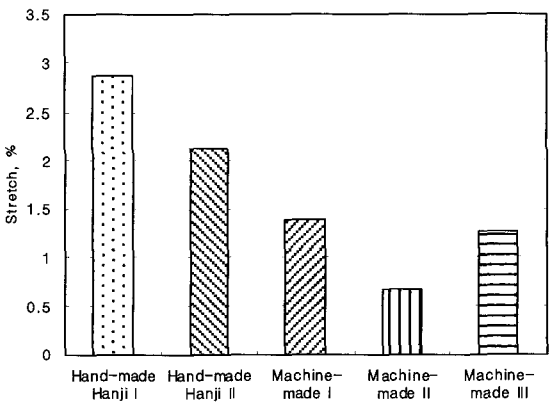

Fig. 6. The relationships between stretch of Hanji sheets and sheet-forming methods.

were produced with the mixtures of mulberry fibres and waste recycled pulp.

Fig. 5 and Fig. 6 show the results of tensile strength and elongation properties of Hanji. Breaking length is generally affected by the factors of fibre length, individual fibre strength, sheet formation and fibre bonding ability, and is used in the index of tensile strength of sheet. The breaking length of traditional hand-made Hanji was 12.55 km in hand-made Hanji I and 10.54 km hand-made Hanji II, and 4 km in machine-made Hanji I, 1.5 km in machine-madeHanji II and 3.03 km in machine-made Hanji III. The breaking properties of hand-made Hanji were much higher than those of machined-made Hanji. The stretch properties of hand-made Hanji were also much higher than those of machine-made Hanji. The superior properties of breaking length and stretch in hand-made Hanji would be concluded by the long fibre length of paper mulberry fibres.

Fig. 7 indicates the changes of burst index according to the forming methods. The burst index of Hanji sheet is caused by the factors of fibre length and interfibre bonding ability. The

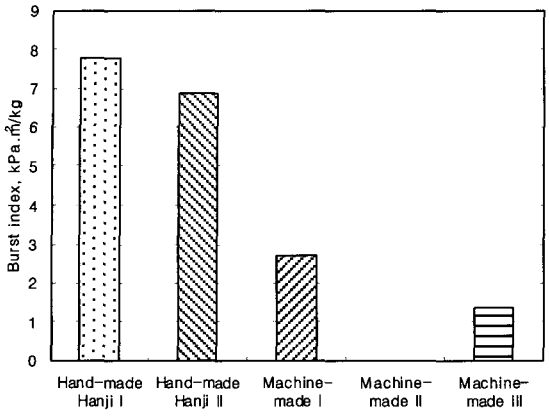

Fig. 7. The relationships between burst index of Hanji sheets and sheet-forming methods.

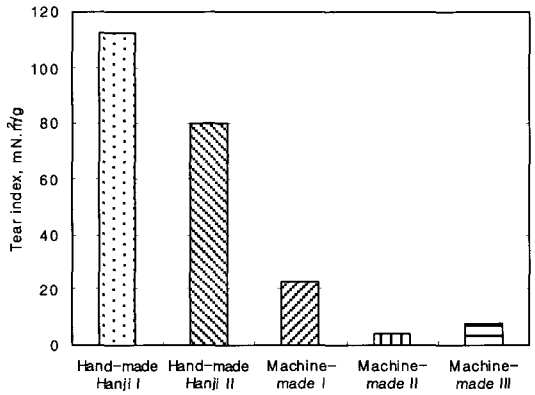

Fig. 8. Changes of tear index in accordance of sheet-forming methods.

burst index of hand-made Hanji was 7.76 kPam²/kg in hand-made Hanji I and 6.87 kPam²/kg in hand-made Hanji II. However, the burst index of machine-made Hanji was 2.7 kPam²/kg, 0 kPa m²/kg and 1.37 kPam²/kg in machine-made Hanji I, II and III respectively. Fig. 8 is the results of tear index due to the sheet-forming methods. In special, tear index of Hanji sheets is closely related to the fibre length. The tear index also indicated the similar physical results with the burst index. The tear index of hand-made Hanji was 5 to 20 times higher than those of machine-made Hanji. It is surely that showing low strength results in the burst index and tear index of machine-made Hanji is originated in the use of waste wood fibres which are relatively shorter fibres than bast fibres.

3.2 The effect of stamping treatment on the physical properties of hand-made Hanji

In this study, the effects of stamping treatment, called to "Dochim", which is a kind of finishing process treated in traditional hand-made Hanji forming are investigated. Generally, the purpose of stamping is the high density and strengthening effect of Hanji sheet. For this experiment, 3 kinds of hand-made Hanji, single-layered sheet, double-layered sheet and triple-layered sheet were formed by traditional sheet-making methods with the assistance of craftsman, and stamped by steel plate hammer.

The basis weight of Hanji sheets used in the experiment was 31 g/m² in single-layered sheet, 76 g/m² in double-layered sheet and 134 g/m² in triple-layered sheet. Fig. 9 shows the thickness changes of Hanji sheets by the stamping treatment. The thickness of hand-made Hanji by Dochim reduced from 127 ㎛ to 102 ㎛ in single layer sheet, 275 ㎛ to 208 ㎛ in double layer sheet and 438 ㎛ to 360 ㎛

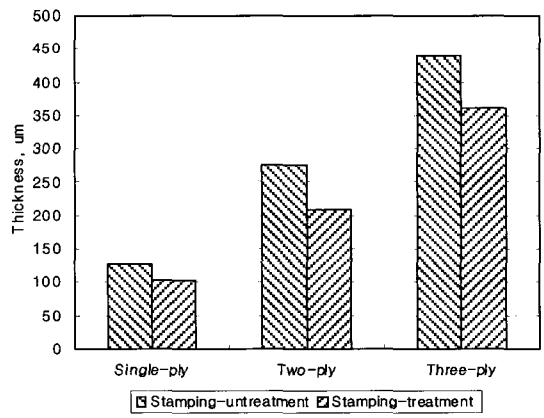

Fig. 9. Thickness changes of Hanji sheets by stamping treatment.

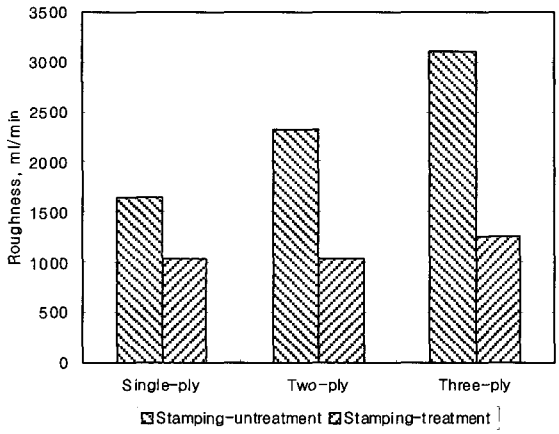

Fig. 10. Roughness changes of Hanji sheets by stamping treatment.

in triple layer sheet. From the thickness results, it can be expected that Dochim treatment makes sheets of Hanji too dense and compact. The compaction of sheet structure also makes the improvement of good surface roughness and smoothness, like the results in Fig. 10. With the stamping treatment, roughness was remarkably decreased from 1,647 ml/min to 1,041 ml/min in single layer sheet, 2,324 ml/min to 1,032 ml/min in double layer sheet and 3,097 ml/min to 1,257 ml/min in triple layer sheet.

Fig. 11 and Fig. 12 show the changes of breaking length and stretch properties of Hanji by stamping treatment. As shown in figures, breaking length increased in MD sheet, but

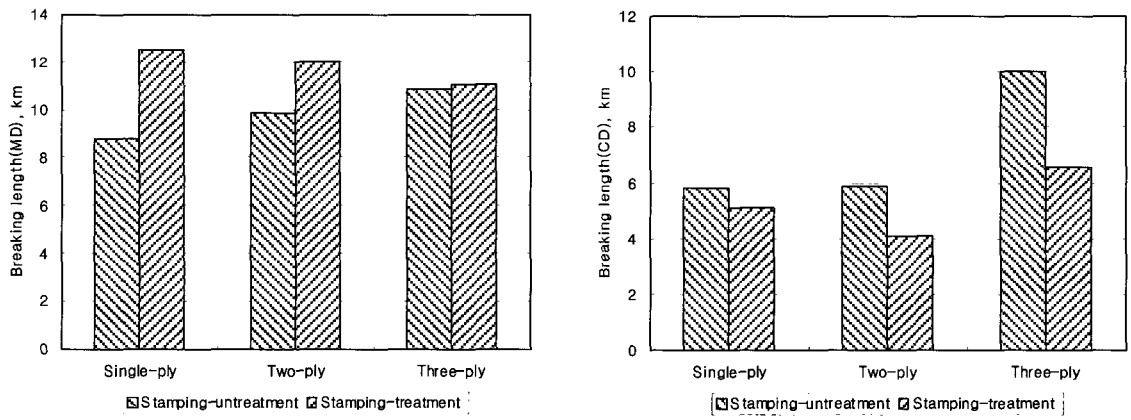

Fig. 11. Changes of breaking length of Hanji sheets by stamping treatment.

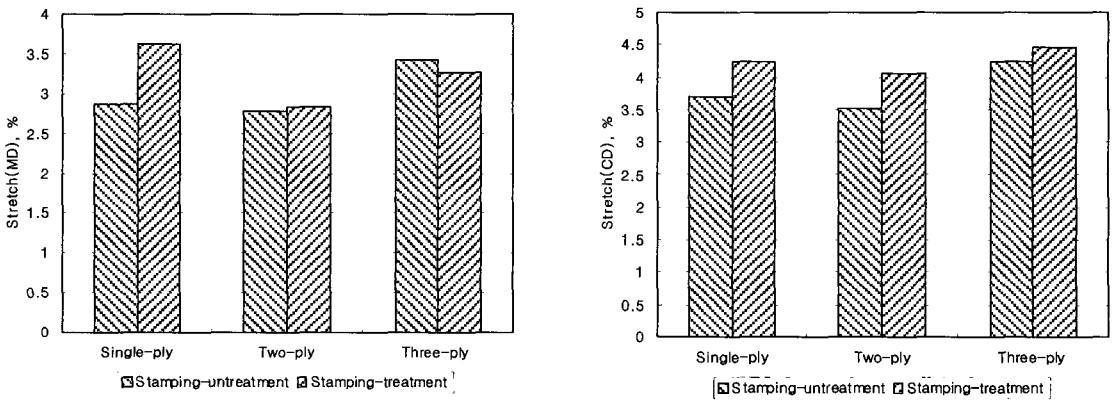

Fig. 12. Changes of Stretch of Hanji sheets by stamping treatment.

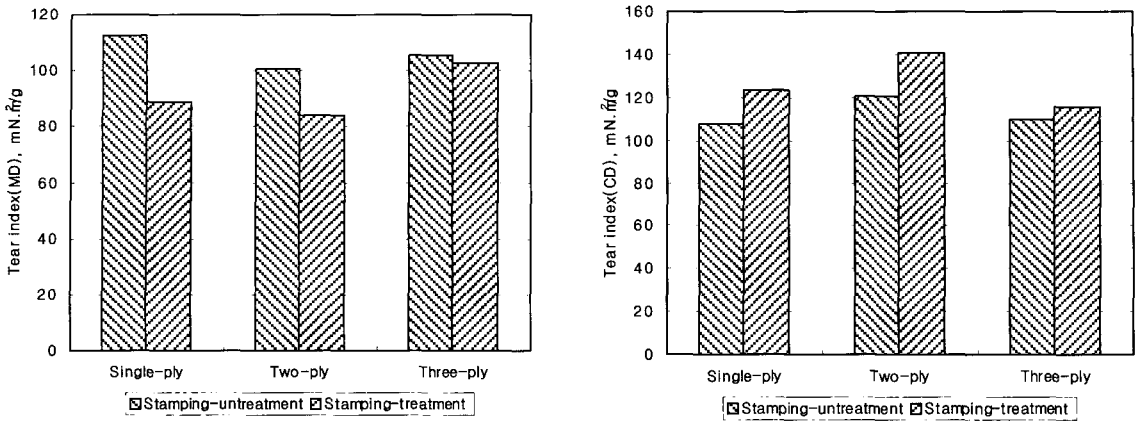

Fig. 13. Changes of tear index of Hanji by Dochim treatment.

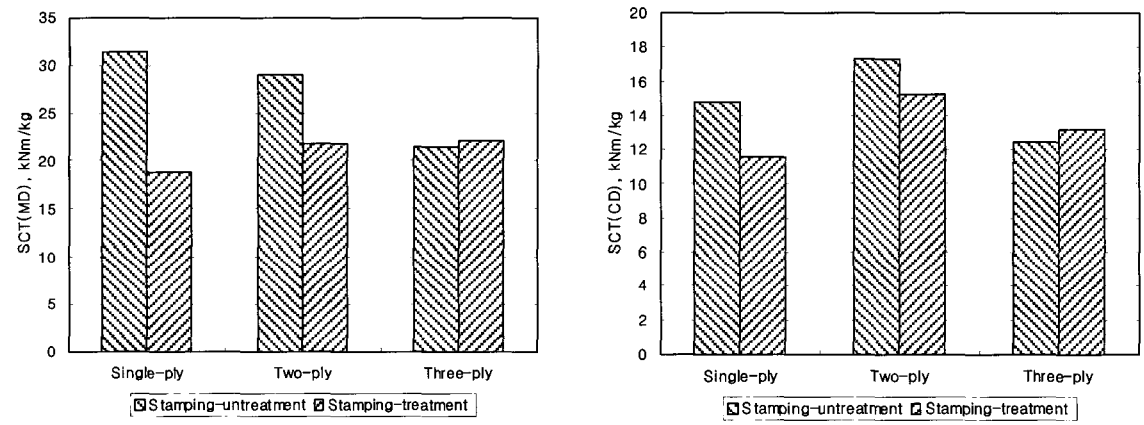

Fig. 14. Changes of short-span compression test of Hanji by Dochim treatment.

reversely decreased in CD sheet of Hanji. It is generally known that the stamping treatment causes Hanji sheet to closed compact and then results in high bonding ability between fibres. The increases of breaking length in MD sheet and stretch in CD sheet are considered to be the bonding ability by stamping treatment. The strength difference between MD and CD sheet may be caused by the fibre orientation.

Fig. 13 shows the change of tear index of Hanji by stamping treatment. Compared to the results of breaking length, tear index decreased in MD sheet, but reversely increased in CD sheet of Hanji. Fig. 14 shows the change of SCT of Hanji by stamping treatment. SCT properties of Hanji were decreased in MD and CD sheet. It can be considered that the stamping treatment causes mulberry fibres to be flexible or pliable. In special, the decrease in short span compression test by stamping effects would be the structural changes of fibre cell walls.

3.3 Ink reception and spreading properties of Hanji

Ink reception properties of traditional hand-made Hanji were evaluated by Klemn method. 2 different kinds of traditional ink were used

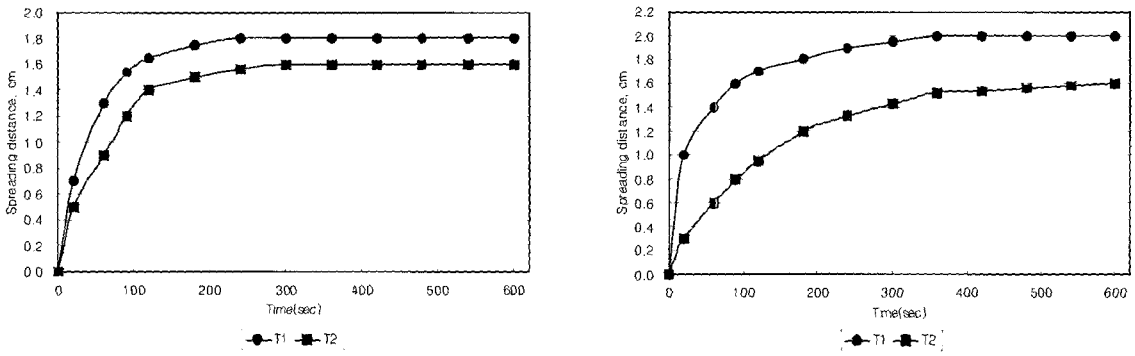

Fig. 15. Ink reception properties of hand-made Hanji according to ink types.

in the experiment. As shown in Fig. 15, according to the ink types, the reception speed and distance were remarkably different. The round shape ratio and heteromorphy ratio were also shown in different trends listed in Table 2. Ink reception and spreading properties of Hanji can not define good or not, because the use of Hanji is diverse for the purpose. However, traditional hand-made Hanji type I showed faster ink reception property and more uniform ink spreading property than Hanji type II.

Table 2. The spreading ink properties of Hanji

	Ink 1		Ink 2	
	T I	T II	T I	T II
Spread area	1.1987	0.5242	0.5359	0.7782
Max R	0.6714	0.4606	0.4503	0.5623
Min R	0.5620	0.3471	0.3727	0.4222
Round-shape ratio	1.1948	1.3272	1.2081	1.3321
Heteromorphy ratio	0.8469	0.7869	0.8417	0.7838

4. Conclusions

The physico-mechanical properties of Korean traditional hand-made Hanji were evaluated and compared, according to the composition of fibrous raw materials, sheet-forming method. The results can be summarized in some points of view. Hanji made from the methods of traditional hand-made procedures was superior to machined-made paper in physical and strength properties. Stamping treatment of traditional Hanji has improved in thickness and density, and increased about 2~3 times in the mechanical properties of Hanji such as breaking length, stretch, burst index and tear index. Stamping treatment has also changed in the structural properties of mulberry fibres, and resulted in decreases of roughness and SCT. Korean traditional hand-made Hanji was superior in most of physical properties of sheet, compared to machine-made Hanji. The smoothness of touch sense of writing was directly correlated with the roughness properties of Hanji. The ink spreading properties was different according to the types of hand-made Hanji and ink.

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