Dyeing technology to a small lot and a wide variety kinds order

Makoto Matsumoto and Kazuharu Nakagawa

Technical Support Center for Leather Industries, Hyogo Prefectural Institute of Technology, 3 Nozato, Himeji, Hyogo 670-0811, Japan

Abstract: Recently a small lot and a wide variety kinds of orders were increased in Japanese leather industry. In this case the productivity is not good and the cost becomes to be high. In order to correspond to that situation, we studied on penetration dyeing to the inside of the crust leather by only immersing. The crust leathers of 1.5 mm thickness and three kinds of dyestuffs, the acid dyestuff for the penetration (D-A), the acid dyestuff for the surface dyeing (D-B) and the liquid metal complex dyestuff for the surface dyeing (D-C) were used in this experiment. The penetration level of the dyestuff was judged from the cut section after the leather was dyed. The complete penetrations dyeing were performed with D-A and D-B at 60 ^{o}C. The other hand the perfect penetration was not found by means of dyeing with D-C at 60 ^{o}C, however it was performed at 4 ^{o}C. The penetration level tends to rise as the dyeing temperature is lowered. After the drying of dyed leathers, the color fastness test to rubbing was carried out for dry and wet situation on the grain side. Color fastness to rubbing of dyed leathers with D-C was the most excellent among this experiments.

Key words: dyeing; small lot

1 Introduction

In recent years, bulk lot orders of several hundred to several thousand pieces per lot have been decreasing in the Japanese leather industry. Instead, a wide varieties of products are ordered in small lots. However, when leathers are produced in small lots using conventional small leather-dyeing drums, production efficiency is often very poor and operating costs are high. In addition, it is often necessary to install many small leather-dyeing drums; which results in high investment costs. If it were possible to dye a piece of leather thoroughly from its surface to interior without the use of a conventional leather-dyeing drum, production costs could be reduced.

We attempted to dye crust leather specimens thoroughly from surface to interior simply by allowing them to stand in dye solutions.[1,2] In this study, various static dyeing conditions were investigated.

2 Experimental

*Corresponding author: Email: Makoto_Matsumoto@pref.hyogo.lg.jp, yoshimura.keiji@hikaku.metro.tokyo.jp

2.1 Static dyeing

Four dyes, namely, penetrating dye (powder, brown (dye A)), penetrating/surface dye (powder, brown (dye B)), surface dye (powder, brown (dye C)), and topping dye (liquid, brown (dye D)) were used. Crust leather specimens with a thickness of 1.5 mm were immersed in dye solutions of set concentrations and allowed to stand at set temperatures for specified amounts of time.

2.2 Measurement of the degree of dye penetration

The statically dyed leather specimen was then cut, and the cross-section was visually observed. The evaluation was conducted based on 10 level criteria (1: no penetration — 10: thoroughly penetrated).

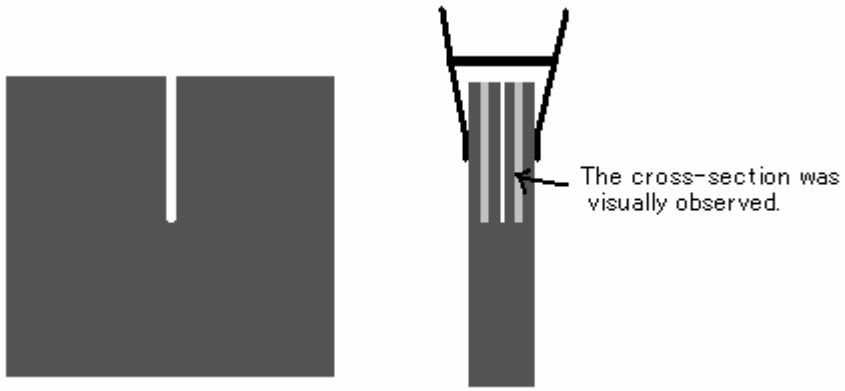

Fig. 1: Dyed leather and its cross section (schematic representation).

3 Results and Discussion

3.1 Effects of the dye type and its concentration on the degree of dye penetration

The relationship between dye concentration and degree of dye penetration for dyeing conducted at 60 ºC for 2 hours is shown in Fig. 2. Complete through-the-core dyeing could be achieved when the concentration of dye A was 2%, when the concentration of dye C was 7%, and when the concentration of dye B was 15%. In the case of dye D, however, dye penetration to the interior portion of the leather could not be achieved even when the dye concentration was increased to 20%.

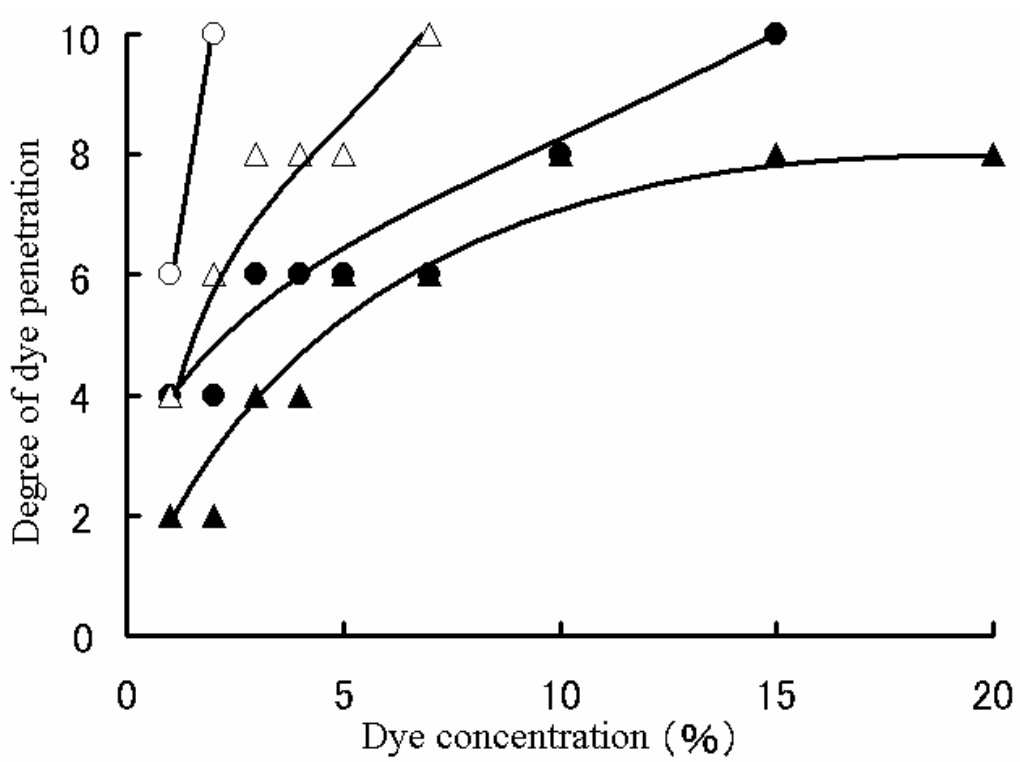

Fig. 2: The effects of dye type and concentration on the degree of penetration for dyeing carried out at 60 ºC for 2 hours.

○: dye A ●: dye B

△ : dye C ▲: dye D

3.2 Dye penetration (dye D) at a dye concentration of 3%

When dye D was used, thorough dyeing to the interior portion of leather could not be achieved at 60 ºC. Therefore, dyeing times and temperatures were varied. The effects of dyeing time and temperature to the degree of dye penetration when a dye concentration of 3% was used are shown in Fig. 3.

The degree of dye penetration increased with an increase in dyeing time at all temperatures, while the degree of dye penetration increased as the dyeing temperature decreased.

Theoretically, the diffusion rate of dye increases with an increase in temperature; thus, it was assumed that the rate of dye penetration into material such as leather would increase with an increase in temperature. However, for thick material such as leather, the opposite is true. This may be attributable that the degree of penetration to the interior portion of leather decreases due to repeated adsorption and desorption of dye on the leather surface as the dye's affinity to the leather increases and dye adsorption only takes place on the surface of leather. Furthermore, it may be attributable to slowing dye penetration as the grain side of the leather likely hardens with increasing dyeing temperature and fiber density.[3)] Based on the above considerations, the

initial temperature is kept low and the temperature is increased later in normal drum dyeing.

In the present static dyeing experiment, the trend was the same as that observed during drum dyeing.

At a dye concentration of 3%, complete through-the-core dyeing could not be achieved even when dyeing at 4 ºC for 24 hours.

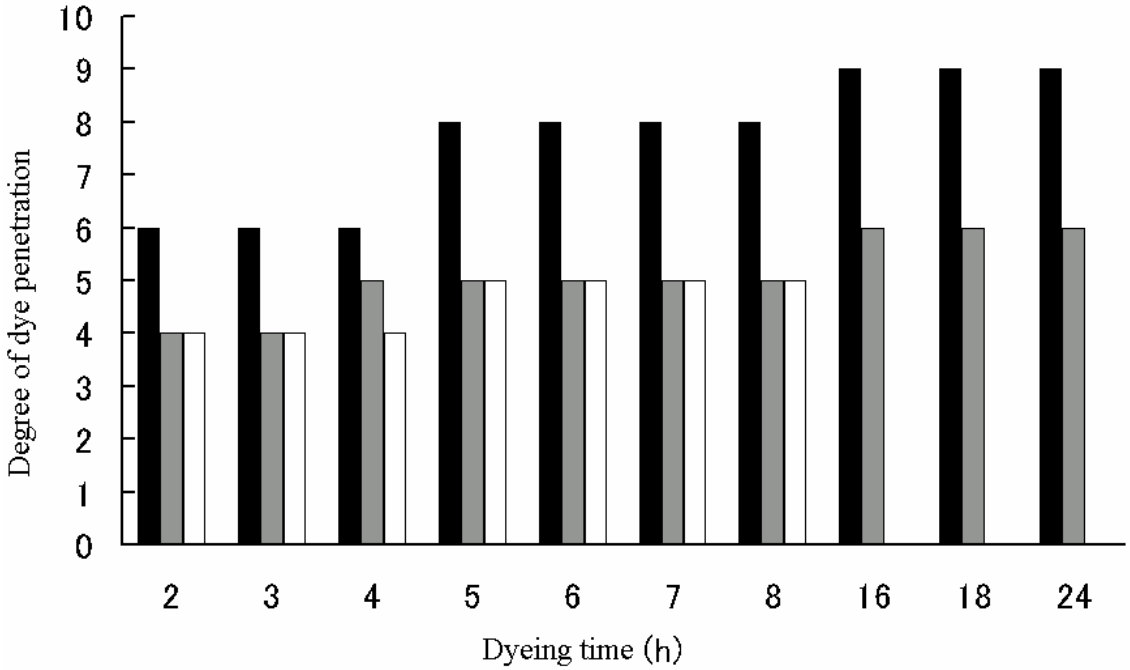

Fig. 3: Dye penetration at a dye concentration of 3%.

■: 4 ºC ▒: 30 ºC □: 60 ºC

3.3 Dye penetration (dye D) at a dye concentration of 4%

The effects of dyeing time and temperatures on the degree of dye penetration, when the concentration was 4%, are shown in Fig. 4.

Compared with the dye concentration of 3%, the degree of dye penetration became higher overall. When the dyeing temperature was lower and the dyeing time was longer, the degree of dye penetration became higher. This trend was the same as that observed for dyeing at a dye concentration of 3%.

Complete through-the-core dyeing could be achieved when dyeing at 4 ºC for 6 hours. At a temperature of 30 ºC or 60 ºC, the degree of dye penetration did not improve over that obtained after 4 hours, even when dyeing for extended times, and through-the-core dyeing could not be achieved. It is considered likely that the dye adsorbed by the leather surface blocked further dye penetration.

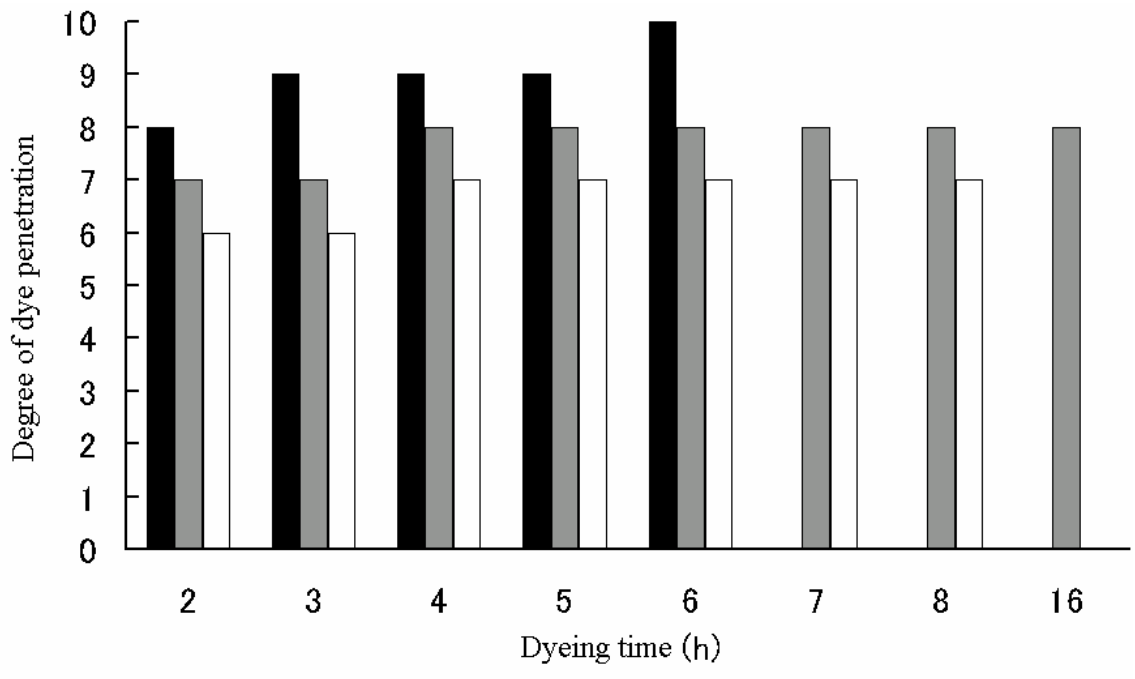

Fig. 4: Dye penetration at a dye concentration of 4%.

■: 4 ºC ▒: 30 ºC □: 60 ºC

3.4 Dye penetration (dye D) at a dye concentration of 5%

The effects of the time and temperature on the degree of dye penetration when a dye concentration of 5% was used are shown in Fig. 5.

When compared with dyeing at a dye concentration of 3% or 4%, the degree of dye penetration became higher overall. The same trend was observed as for dyeing at a dye concentration of 3% or 4%.

Complete through-the-core dyeing could be achieved when dyeing at 4 ºC for 4 hours. However, complete through-the-core dyeing could not be achieved at a dyeing temperature of 30 ºC or 60 ºC, as was the case when a dye concentration of 4% was used.

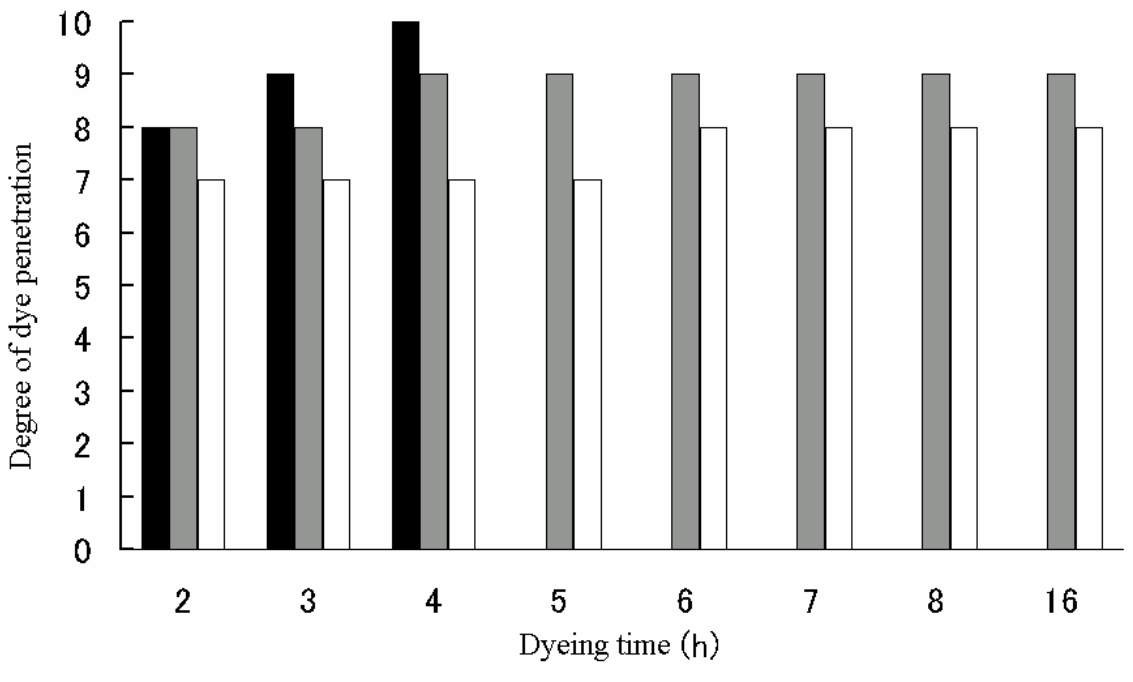

Fig. 5: Dye penetration at a dye concentration of 5%.

■: 4 ºC ▒: 30 ºC □: 60 ºC

3.5 Dye penetration (dye D) at a dyeing temperature of 4 ºC

From the results of 3.2–3.4, it can be seen that dyeing at a low temperature is effective for penetration of dye to the interior portion of leather. Therefore, the effects of dyeing time and dye concentration on the degree of dye penetration were studied at a dyeing temperature of 4 ºC, and the results are shown in Fig. 6.

Complete through-the-core dyeing could be achieved at a dye concentration of 5% and a dyeing time of 4 hours, or at a dye concentration of 6%–8% and a dyeing time of 2 hours. The shortened dyeing time was made possible by increasing the dye concentration.

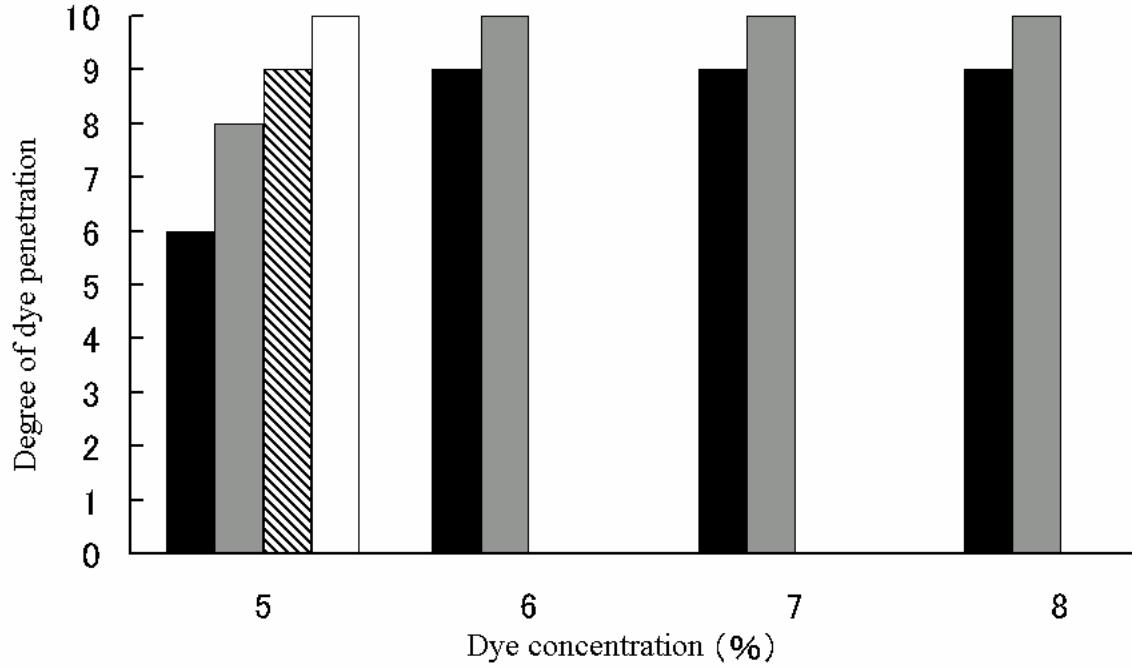

Fig. 6: Dye penetration at a dyeing temperature of 4 ºC.

■:1h ▩ : 2h ▧ : 3h □: 4h

4 Conclusions

The degree of dye penetration tended to increase with an increase in the dye concentration and a decrease in the dyeing temperature. Even when a less penetrating dye was used, thorough dyeing to the interior portion of the leather was possible with adjustments to the dyeing temperature and time.

References

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