CHAPTER IV
RESULT AND DISCUSSION

4.1 Analysis Method

The results of algorithm processing were investigated. Data analysis was classified into 2 ways.

4.1.1 Image output

The image output from imagesetter and printing was examined by human eyes. Overall result of image quality was detected with some criteria such as sharpness, detail in highlight area, tone reproduction, worming line effect and so on.

4.1.2 Grayscale

The performance of halftoning was analyzed in terms of tone gradation. The grayscale target was employed to evaluate it by using a microdensitometer. The obtained density values were modified through low pass filtering technique by which the tone reproduction curve was established. The slope of the curve implies the continuity of tone gradation. It was found that the discontinuity could be occurred by 2 factors, as following:

4.1.2.1 Inadequate number of tone, created by algorithm

The algorithm should create the enough number of gray levels for making the tone curve smooth, which could be evaluated by tone reproduction of grayscale.

4.1.2.2 Poor linkage of hybrid screen

It was found that the discontinuity occurred when there was irregular changing of the curve. To get rid of this appearance, the effective gamut needs to be controlled such as dpi/lpi ratio and screen dot size. The tone reproduction curve of grayscale has evaluated. The slope of tone reproduction curve should not less than zero at the boundary, for corresponding to one to one function.

4.2 Establishment of Skeleton

4.2.1 Algorithm efficiency

Based on using 8 pixel cell size and 300 dpi input resolution, this enabled the out put image of AM algorithm with image resolution 38 lpi to achieve in an excellent function. Although the tone generated by cell had only 64 levels, the image could be printed in good continuous tones as shown in Figure 4-1 (a).

In the module of FM algorithm, it was depicted that the created image is not smooth unlike the original image because the diffusion error did not disperse into adjacent pixels, but spreading to the next pixels in sequent processing, which had the further location as shown in Figure 4-1 (b).

For the hybrid screen algorithm, it was successful on creating the mixture area between AM algorithm and FM algorithms, as a result of the main algorithm. Figure 4-2 showed the different cutoff used in created hybrid screen. The Figure 4-2 (a) used cutoff at 200 of code value, while Figure 4-2 (b) used cutoff at 210.

4.2.2 Further development

The experiment proved the effectiveness and possibility of creation of mixing screen type. However, the algorithm has to be continuously developed as following.

4.2.2.1 The change of cell size should relate to lpi parameter.

4.2.2.2 The FM module had to be modified as realistically error dispersion.

4.2.2.3 The resolution of original digital image should match with that of digital output device. This stage must be done before halftoning process. Accordingly, redundant data was already eliminated by halftoning process. In other words, halftoning technology depended on an output device, whose resolution parameter had to be transmitted to the halftone process.

(a) (b)

Figure 4-1 Halftone image on Establishment of Skeleton using (a) AM algorithm; (b) FM algorithm

(a) (b)

Figure 4-2 Halftone image using hybrid algorithm on Establishment of Skeleton mixing span = 20, (a) cutoff at 200 code value; (b) cutoff at 210 code value

4.2.2.4 As the resolution of the original digital image were set at the maximum level, to maximize the performance of the output device, this abundant of data became huge. Consequently the stability of algorithm was necessary to support the image with high resolution.

4.3 Imagesetter Output

4.3.1 AM Screen .

From Figure 4-3, the images had the same lpi value as 60 lpi using 400 dpi compared with 1270 dpi. It was found that the characteristic of screen dot in 1270 dpi image was round without a wrinkle of dot screen.

Figure 4-4 was the result of halftone images, using the same dpi as 400 dpi but different in lpi values. 40 lpi image, Figure 4-4(a), showed good tone continuity but poor sharp image, while Figure 4-4(b), used 100 lpi, showed sharper image with tone discontinuity.

Figure 4-5 and 4-6 showed the grayscale images and their tone reproduction with different dpi/lpi ratio. It was found that the dpi/lpi ratio more than 8 starts making an image continuous and smooth.

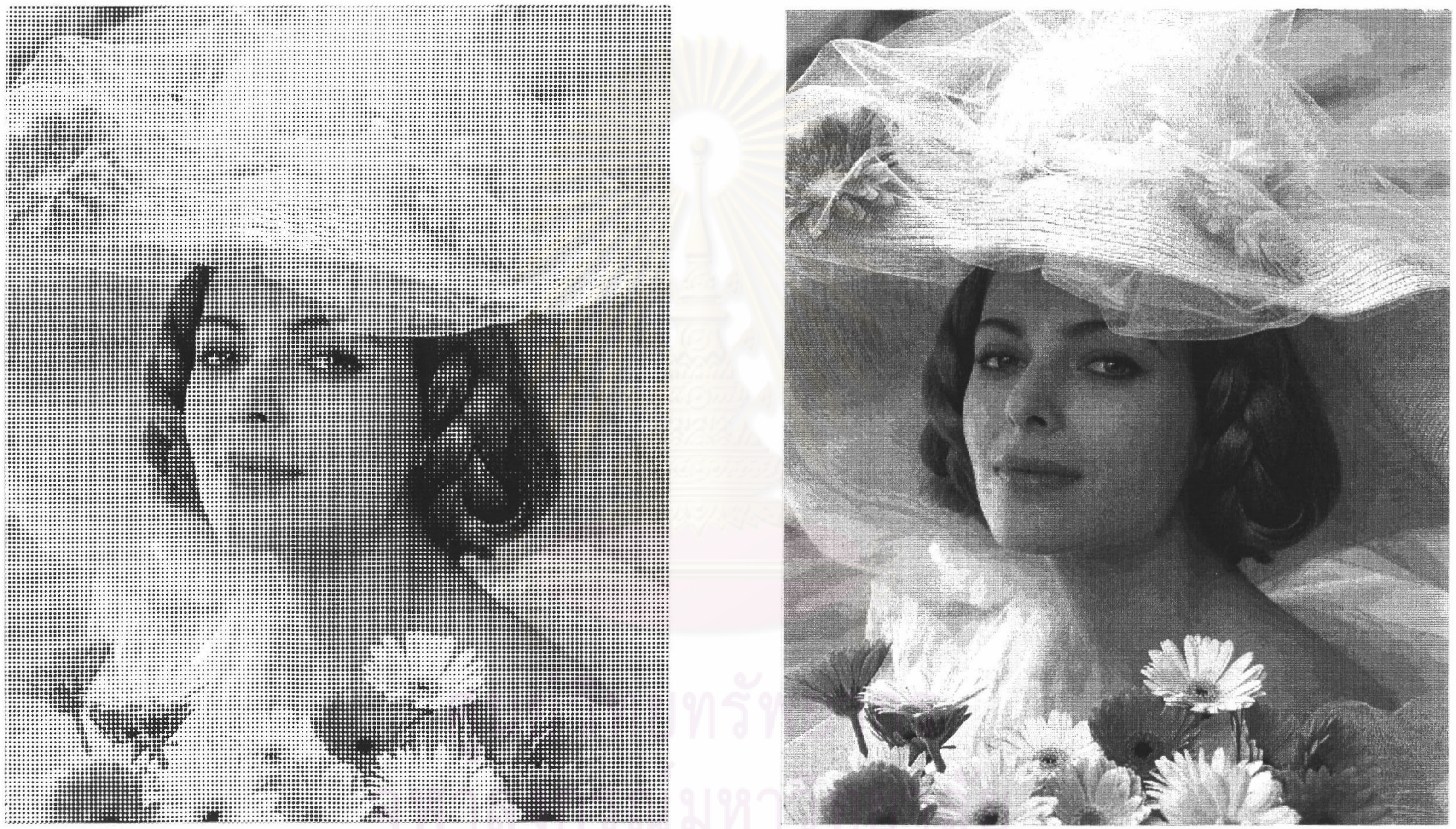
4.3.2 FM Screen

From Figure 4-7, the images used the same resolution as 80 lpi with different dpi: (a), 635 dpi, and (b), 1270 dpi. It showed that the screen size was different. The screen dot size was close to the value of 1/dpi. In contrast, when the same dpi value was tested with varied lpi values, as shown in Figure 4-8(a), and Figure 4-8(b). The result displayed the tone discontinuity.

Figure 4-9, 4-10 showed the grayscale images created from different dpi / lpi ratio and their tone reproduction curve. It was found that the proper parameter for generating image with good continuity should have dpi / lpi ratio more than 12.

(a) (b)

Figure 4-3 Halftone image using AM screen on Compatibility of Digital Output at 60 lpi, (a) 400 dpi; (b) 1270 dpi



(a) (b)

Figure 4-4 Halftone image using AM screen on Compatibility of Digital Output at 400 dpi, (a) 60 lpi; (b) 100 lpi

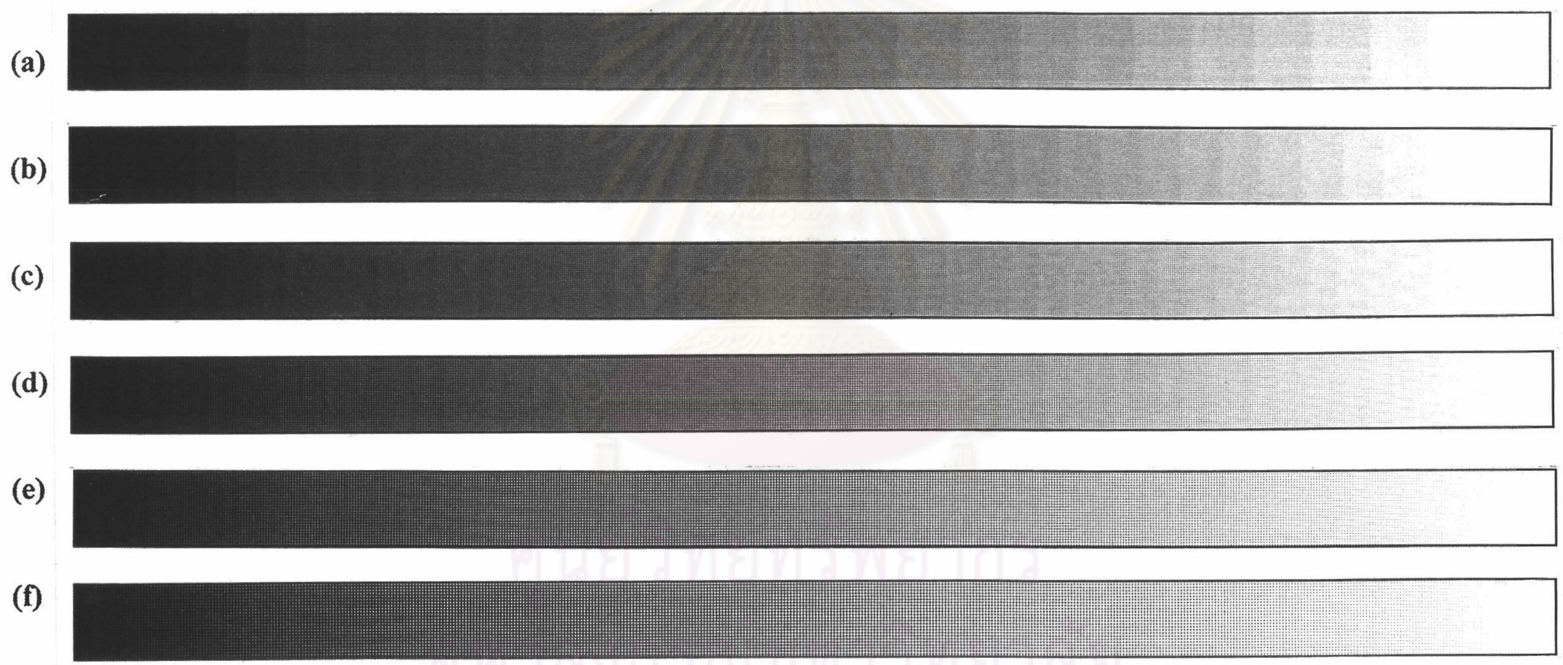


Figure 4-5 Halftone grayscale using AM screen on Compatibility of Digital Output at 635 dpi, (a) dpi /lpi ratio = 5; (b) dpi /lpi ratio = 6; (c) dpi/lpi ratio = 7; (d) dpi/lpi ratio = 8; (e) dpi/lpi ratio = 9; (f) dpi/lpi ratio = 10

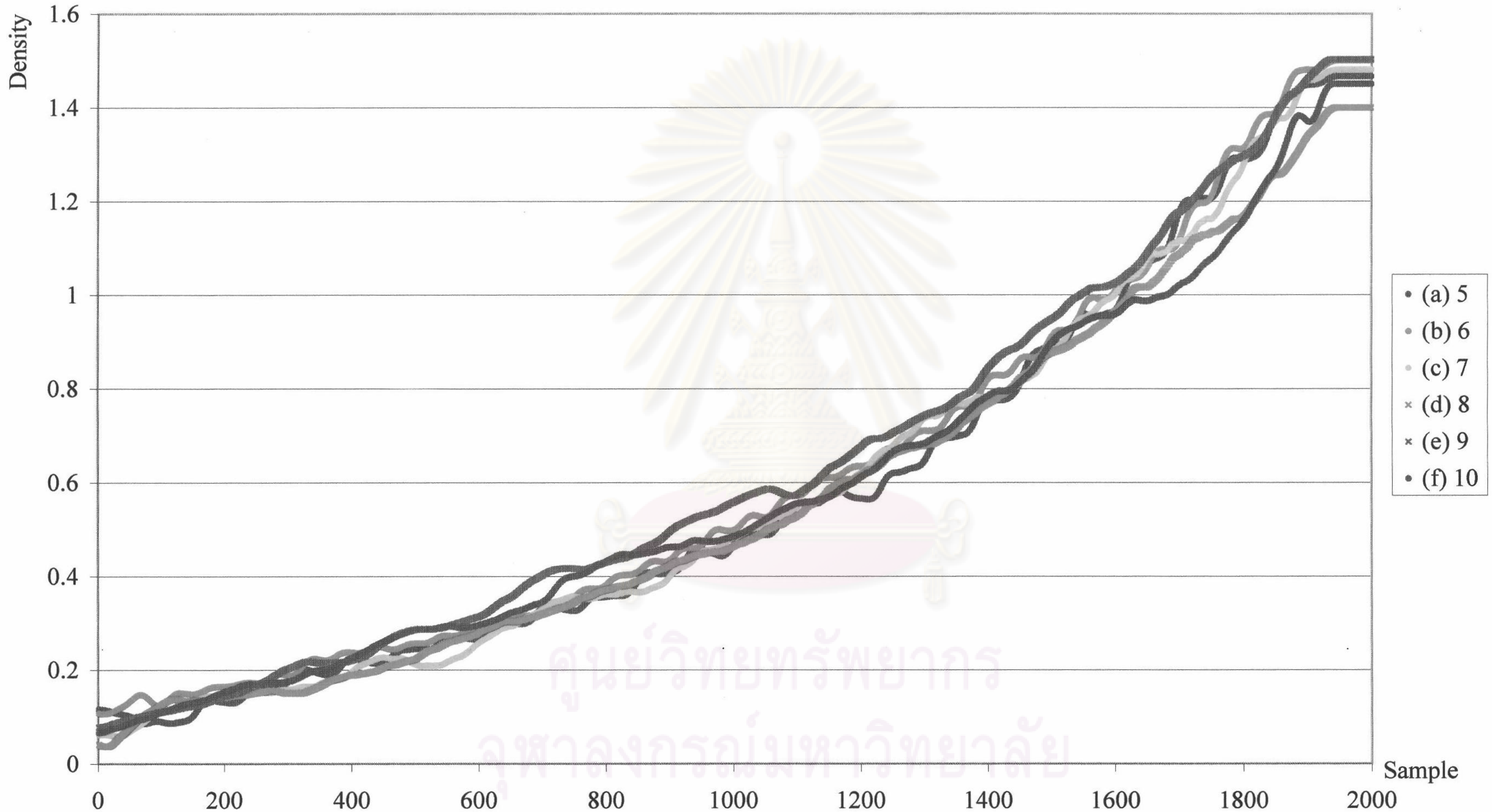


Figure 4-6 Tone reproduction of halftone grayscale using AM screen on Compatibility of Covering Digital Output at 635 Dpi, (a) Dpi/Lpi ratio = 5; (b) Dpi/Lpi ratio = 6; (c) Dpi/Lpi ratio = 7; (d) Dpi/Lpi ratio = 8; (e) Dpi/Lpi ratio = 9; (f) Dpi/Lpi ratio = 10

(a) (b)

Figure 4-7 Halftone image using FM screen on Compatibility of Digital Output at 80 lpi, (a) 635 dpi; (b) 1270 dpi

(a) (b)

Figure 4-8 Halftone image using FM screen on Compatibility of Digital Output at 635 dpi, (a) 40 lpi; (b) 127 lpi

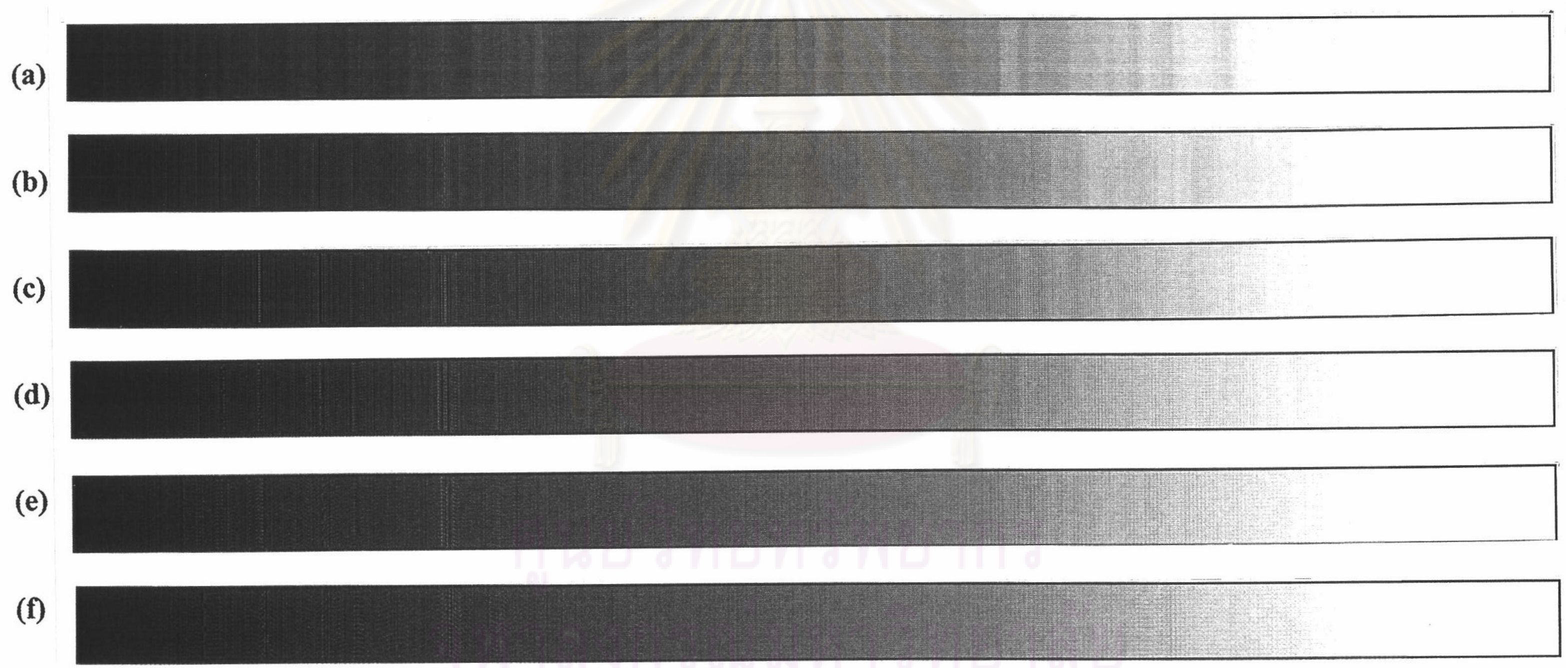


Figure 4-9 Halftone grayscale using FM screen on Compatibility of Digital Output at 635 dpi, (a) dpi/lpi ratio = 5; (b) dpi/lpi ratio = 7;(c) dpi/lpi ratio = 9; (d) dpi/lpi ratio = 11; (e) dpi/lpi ratio = 13; (f) dpi/lpi ratio = 15

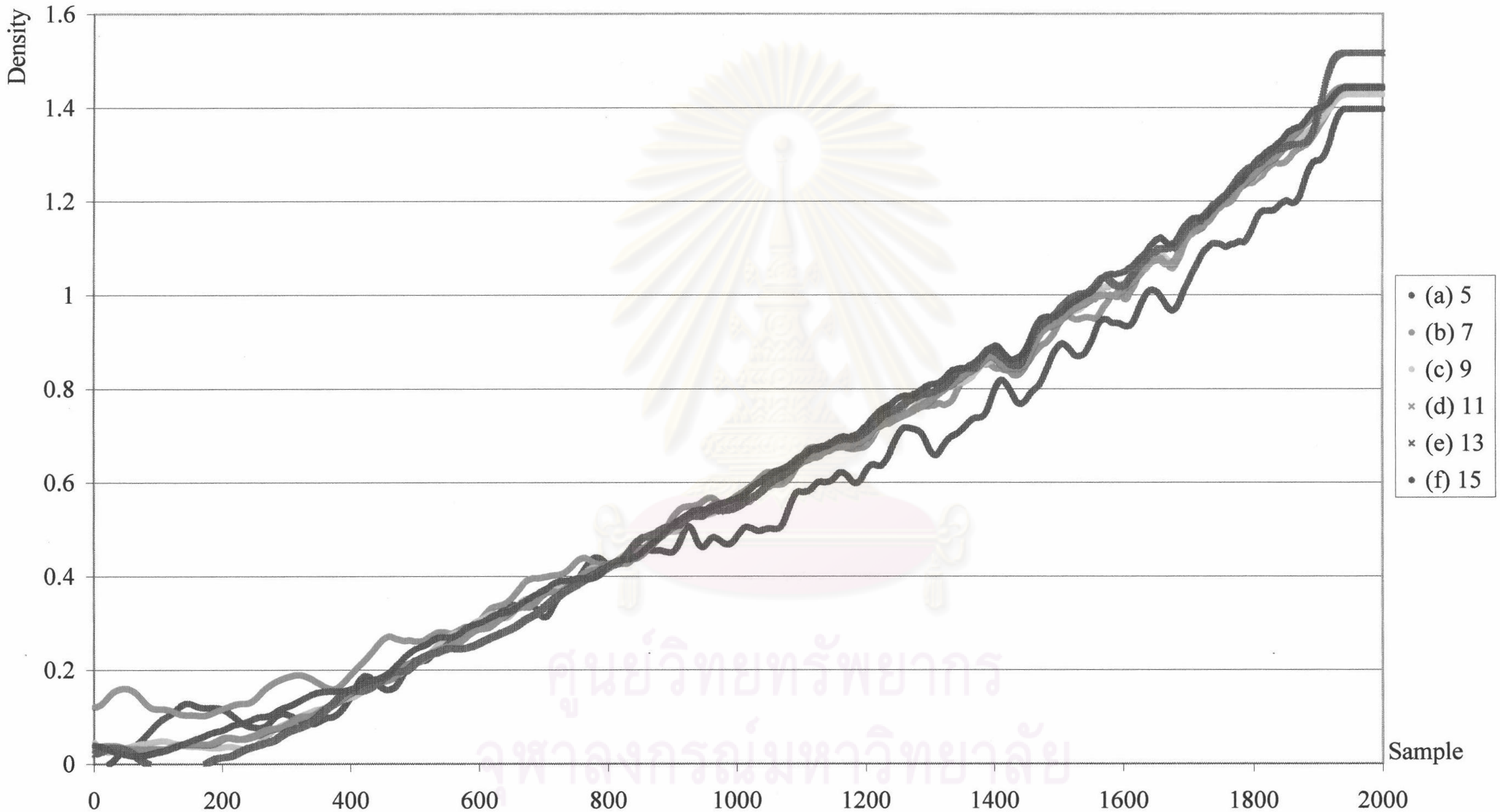


Figure 4-10 Tone reproduction of halftone grayscale using FM screen on Compatibility of Covering Digital Output at 635 Dpi, (a) Dpi/Lpi ratio = 5; (b) Dpi/Lpi ratio = 7; (c) Dpi/Lpi ratio = 9; (d) Dpi/Lpi ratio = 11; (e) Dpi/Lpi ratio = 13; (f) Dpi/Lpi ratio = 15

4.3.3 Hybrid Screen

Due to changing the cutting point, it was founded that when the number of cutting was decrease, the area of FM screen in the image would be increasing as shown in Figure 4-11. However, if the ratio of FM screen was higher, the dot gain would be occurred. This affected on FM screen much more than that of AM screen in the same tone. It was the main cause of tone discontinuity of tone reproduction. Halftone grayscale, shown in Figure 4-12 and its tone reproduction shown in Figure 4-13, supported the statement that the discontinuous tone reproduction would be increased when the cutting was decreased. The ratio cutting point to determine FM screen value depends on the original image. However, the cutting point should choose in the range of 180-220.

From changing the band as shown in Figure 4-14, when the mixing area was applied too wide, the dot variable and cluster dots surrounded by dispersed dot, could be seem by naked eyes. This makes images look inferior. However, the boundary between AM and FM would not be smooth if the mixing area was too short. Halftone grayscale shown in Figure 4-15 and its tone reproduction shown Figure 4-16 supported the statement that the suitable mixing wide band between AM and FM should be 10-30.

4.3.4 Effective gamut

It was found that the proper dpi / lpi ratio of AM should be more than 8; while dpi / lpi ratio of FM should be more than 12. If they linked together, the dpi / lpi ratio should more than 12.

Thus the effective gamut covers the area above the line of dpi / lpi ratio at 12 and is limited by the maximum dpi value of output device. It recommends that the image use parameters in this effective area. This will result in smoothened linkage as shown in Figure 4-17.

(a) **(b)**

Figure 4-11 Halftone image using Hybrid algorithm on Compatibility of Digital Output at 635 dpi, 58 lpi, mixing span = 20, (a) highlight cutoff = 200 code value; (b) highlight cutoff = 180 code value

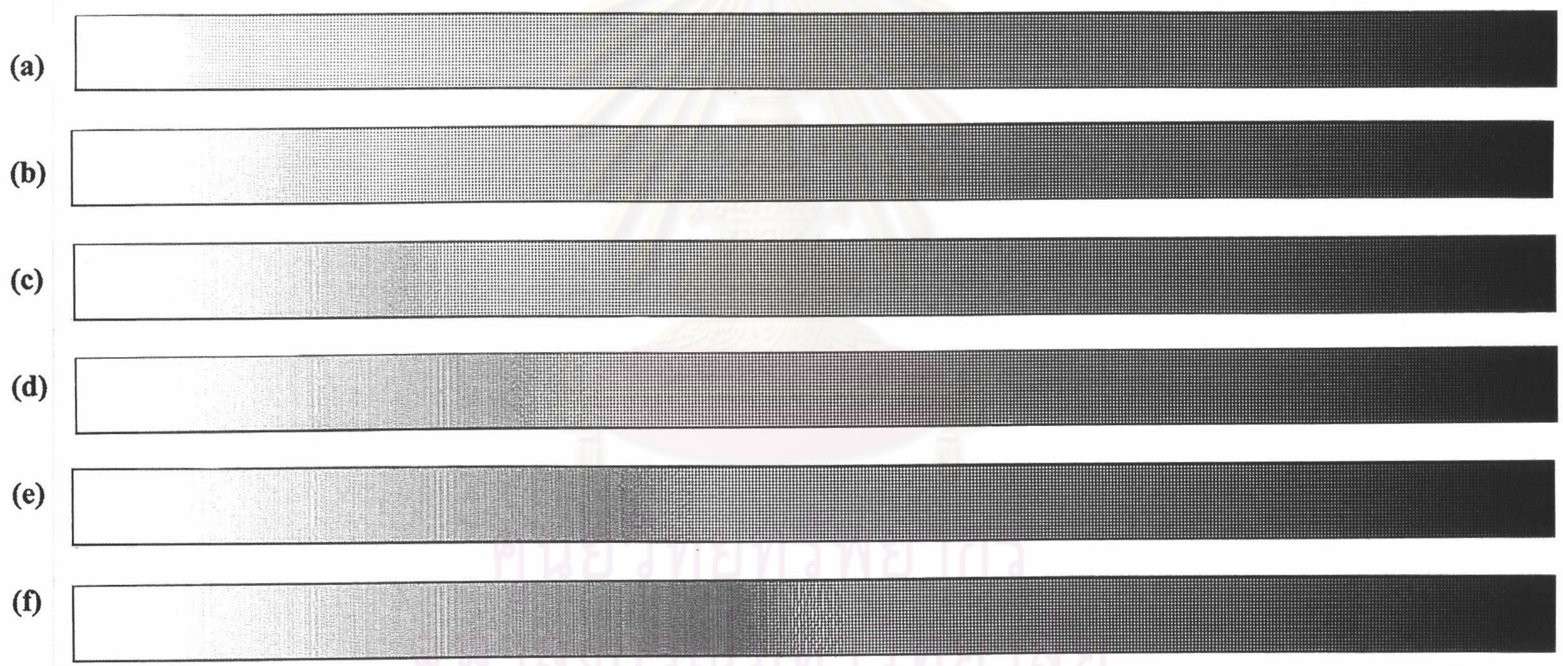


Figure 4-12 Halftone grayscale using Hybrid algorithm on Compatibility of Digital Output at 635 dpi, 58 lpi, Cutoff at (a) 220 code value (b) 200 code value (c) 180 code value (d) 160 code value (e) 140 code value (f) 120 code value

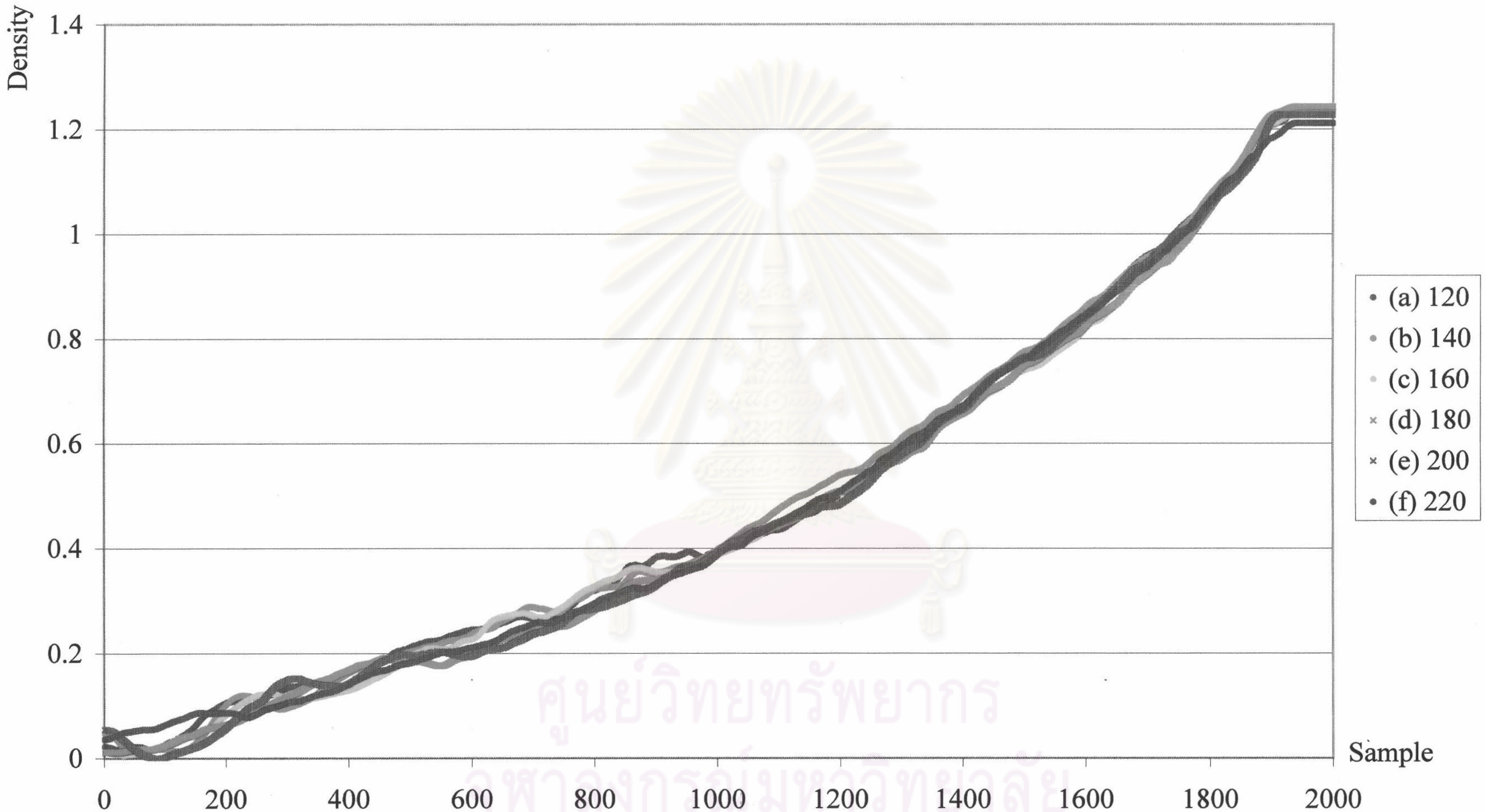


Figure 4-13 Tone reproduction of halftone grayscale using Hybrid algorithm on Compatibility of Digital Output at 635 Dpi, 58 Lpi, Cutoff at (a) 220 code value (b) 200 code value (c) 180 code value (d) 160 code value (e) 140 code value (f) 120 code value

(a) (b)

Figure 4-14 Halftone image using Hybrid algorithm on Compatibility of Digital Output at 635 dpi, 58 lpi, cutoff at 200 code value, (a) mixing span = 10 (b) mixing span = 30

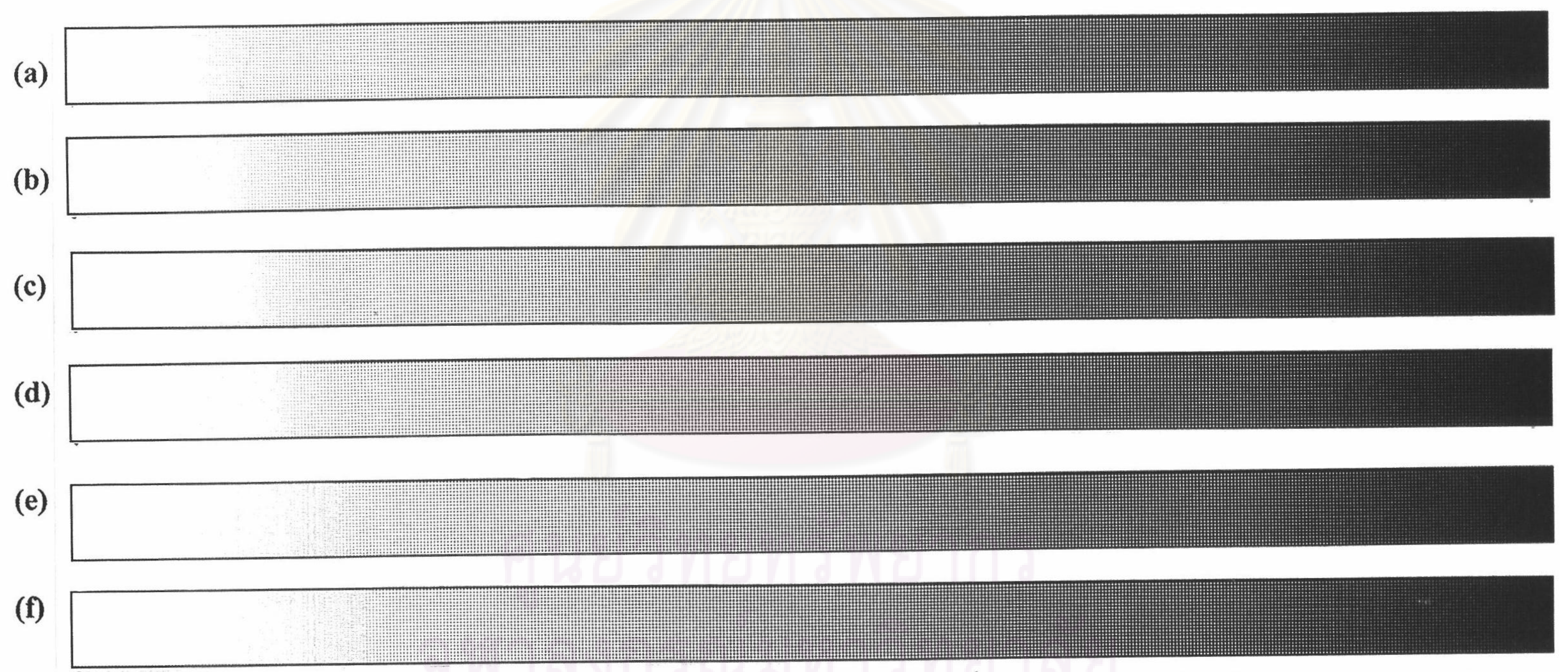


Figure 4-15 Halftone grayscale using Hybrid algorithm on Compatibility of Digital Output at 635 dpi, 58 lpi, (a) mixing span = 5; (b) mixing span = 10 (c) mixing span = 15 (d) mixing span = 20 (e) mixing span = 25 (d) mixing span = 30

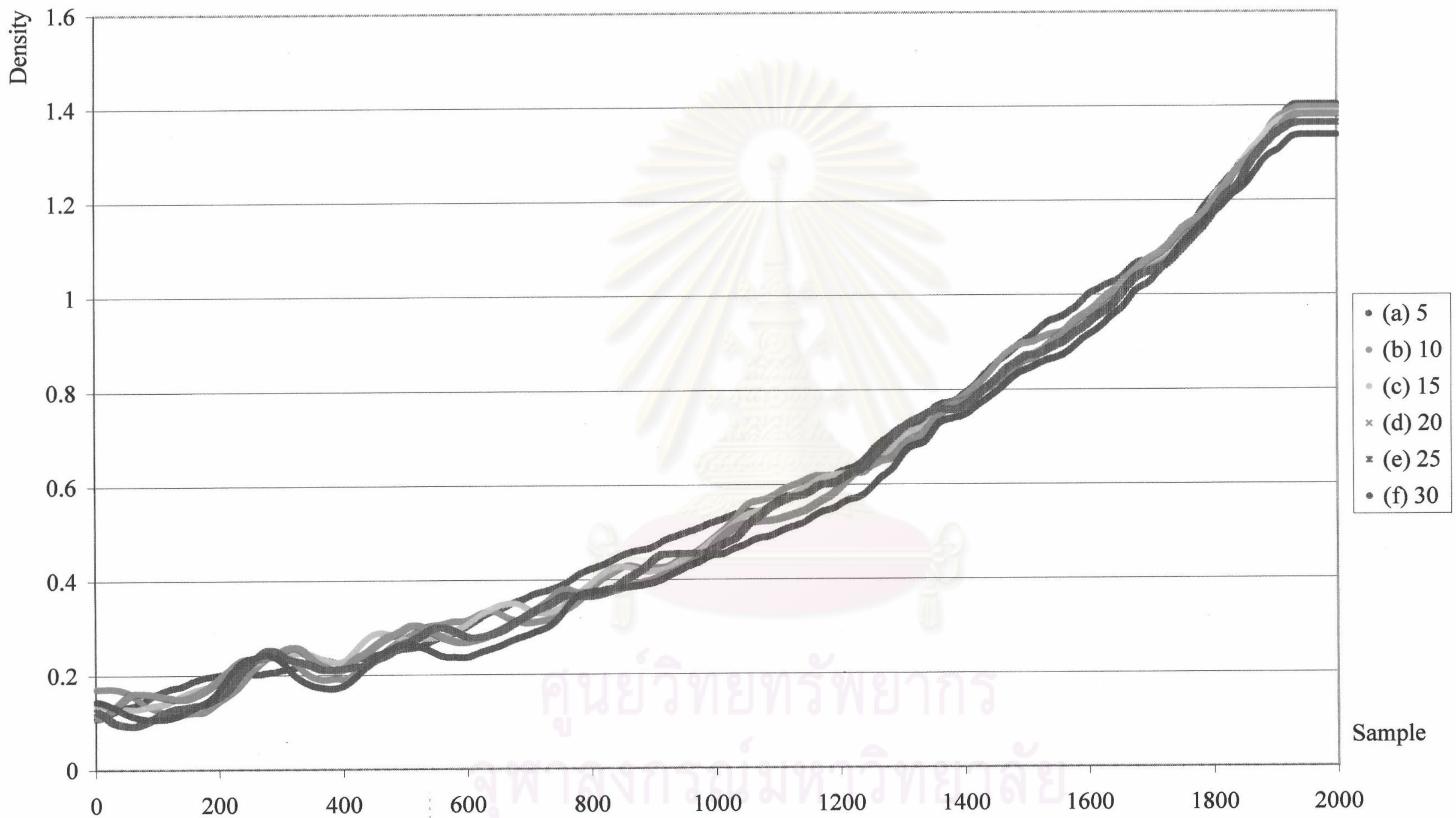


Figure 4-16 Tone reproduction of halftone grayscale using Hybrid algorithm on Compatibility of Digital Output at 635 Dpi, (a) mixing span = 5; (b) mixing span = 10 (c) mixing span = 15 (d) mixing span = 20 (e) mixing span = 25 (d) mixing span = 30

The resolution of halftone image from an imagesetter could not entirely pass through the count-mesh screen printing. The minimum dot size, was limited. If the dot size is smaller than that it should be, the tone reproduction represented by that size disappears. Figure 4-18 (a), (b) showed the result of the misappropriate dot size from FM and hybrid algorithms. Fig 4-19 (a), (b) showed the results of the appropriate dot size from FM and hybrid algorithm. As a result, the effective gamut was controlled by the limitation of printing process as diagrammatically shown in Figure 4-17.

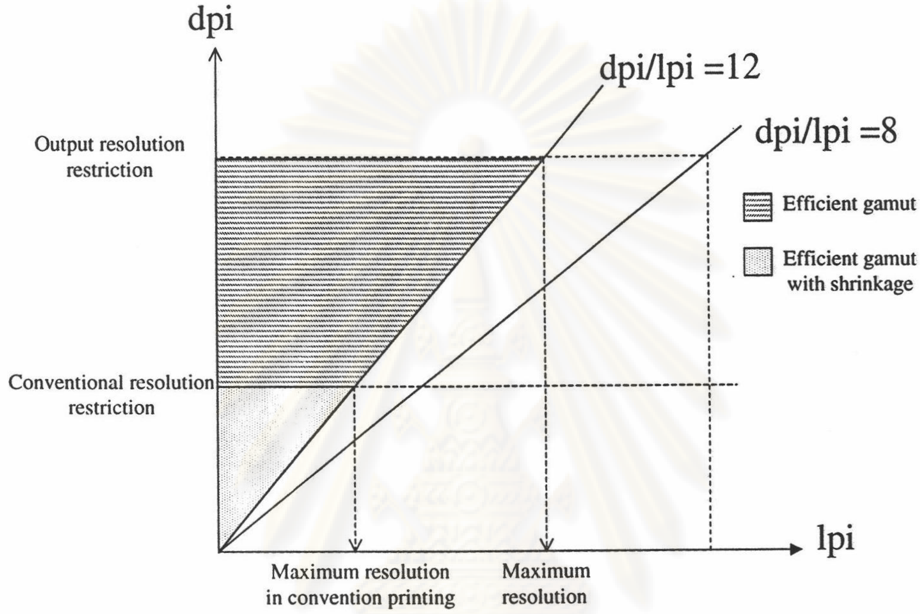


Figure 4-17 Efficient Gamut and its shrinkage when using conventional printing

4.3.5 Further development

For further development, the algorithm had to be improved as follows:

- Effective gamut must be extended, by generating the size of FM dot, being independent on dpi parameter. This can be done by grouping the neighboring pixels, by which the size is variable.

- The size of screen dot on film is essential characteristic: the smaller dot size is, the finer detail of the image becomes. Note that the minimum size of screen dot is limited by printing process. Thus the operator should make clear the workflow component of each printing system, relevant to the screen dot size.

(a) (b)

Figure 4-18 Halftone printout on Compatibility of Digital Output using 400 dpi (a)FM algorithm (b)Hybrid algorithm cutoff at 200 code value

(a) (b)

Figure 4-19 Halftone printout on Compatibility of Digital Output using 635 dpi (a)FM algorithm (b)Hybrid algorithm cutoff at 200 code value

4.4 Conventional Printout (Screen printing)

4.4.1 FM Screen with controllable dot size

Figure 4-20, 4-21 shows the 40 lpi gray scale images based on 1270 dpi, and tone reproduction curves of screen printing results. It was found that the continuity of tone reproduction was occurred when the dot size was smaller than 14 pixel. Note that, when the printing resolution was changed to 80 lpi, a different tone reproduction result were appeared as shown in Figure 4-22 and 4-23. In this case, to achieve the continuity of tone reproduction, the dot size should be smaller than 4 pixels. For 120 lpi printing, the continuity of tone reproduction was preferred at the dot size smaller than 2 pixels as shown in Figure 4-24, 4-25. Thus, it can be concluded the value of $(dpi/lpi)^2$ / cell size should be higher than 72.

4.4.2 Pilot Testform Determination

The printed pilot testform was determined. It was found that the optimum printing quality could be obtained when the minimum screen dot size was at least 15 pixels as shown in Figure 4-26.

4.4.3 Algorithm efficiency

The proposed parameters, mentioned above, were defined whereby the print results were obtained as shown in Figure 4-27. AM algorithm gave overall tone reproduction better than that of FM algorithm as shown in Figure 4-29 and Figure 4-30, this results from dot gain problem.

While hybrid screen algorithm gave results uncertain, depending on the bandwidth and cutoff point. However, its advantage was the boundary tone continuity. Figure 4-28 (a),(b) show the acceptable print result, using the value of bandwidth at 20 and cutoff point at 200 and 210 respectively. Note that the effect of dot gain possibly in fluency at the boundary tone continuity, by which the texture pattern can be appeared as shown in Figure 4-29 and Figure 4-30. The improvement can be done through dot gain compensation of halftone screening process.

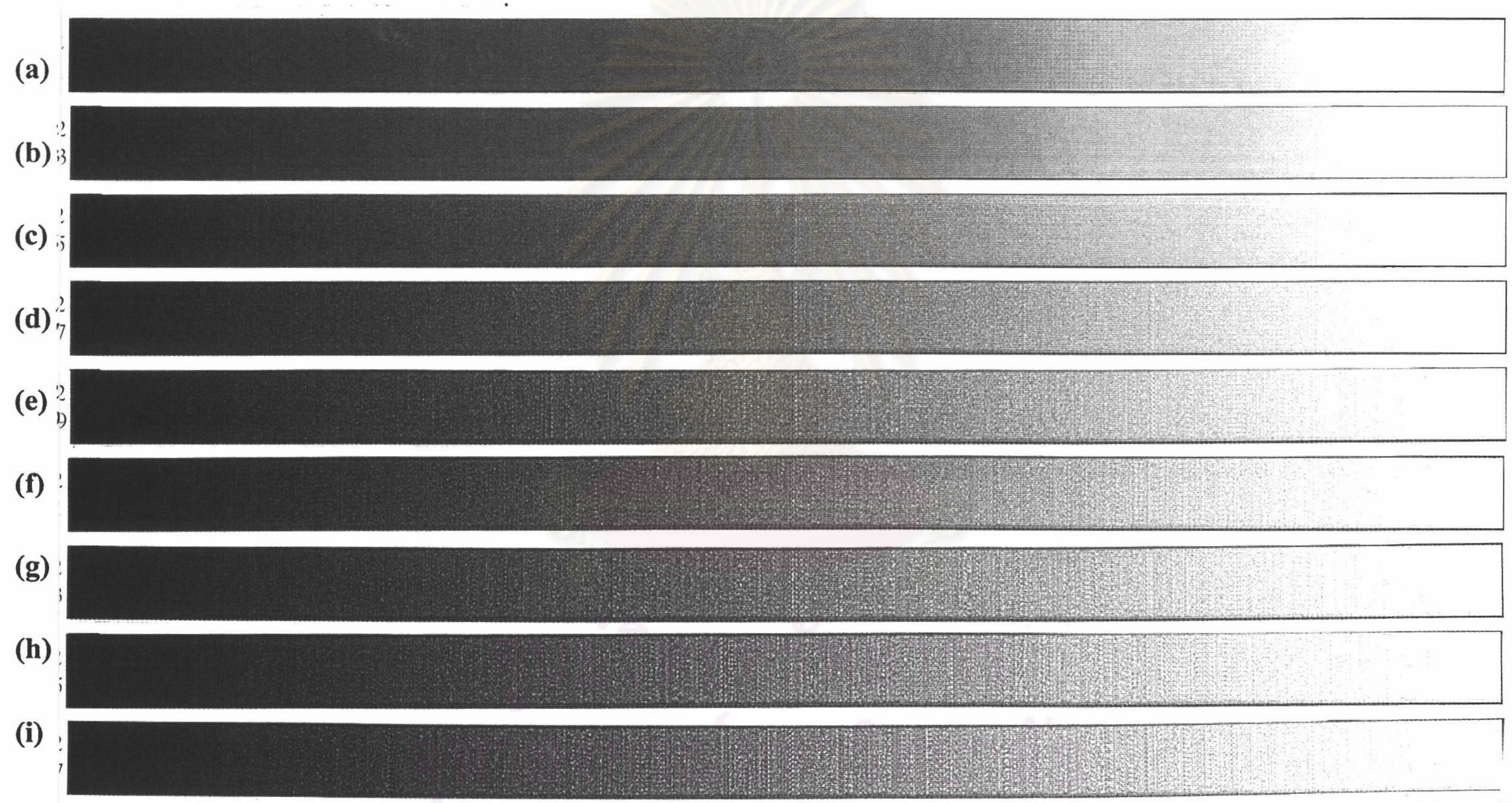


Figure 4-20 Halftone grayscale using FM algorithm at 40 lpi, group size: (a) 1 pixel; (b) 3 pixels; (c) 5 pixels; (d) 7 pixels; (e) 9 pixels; (f) 11 pixels; (g) 13 pixels; (h) 15 pixels; (i) 17 pixels

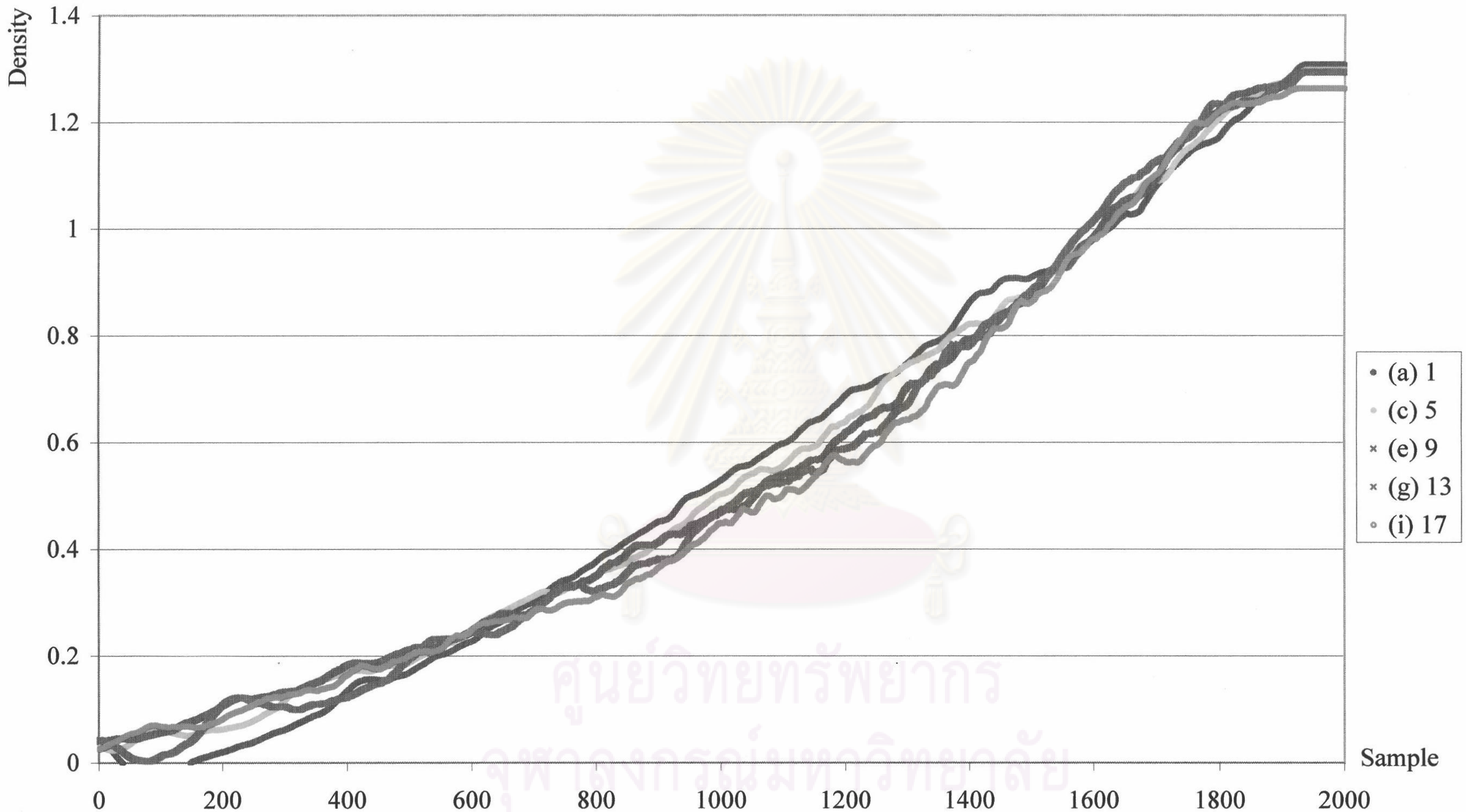


Figure 4-21 Tone reproduction of halftone grayscale using FM algorithm at 40 Lpi, group size: (a) 1 pixels; (c) 5 pixels;(e) 9 pixels; (g) 13 pixels; (i) 17 pixels

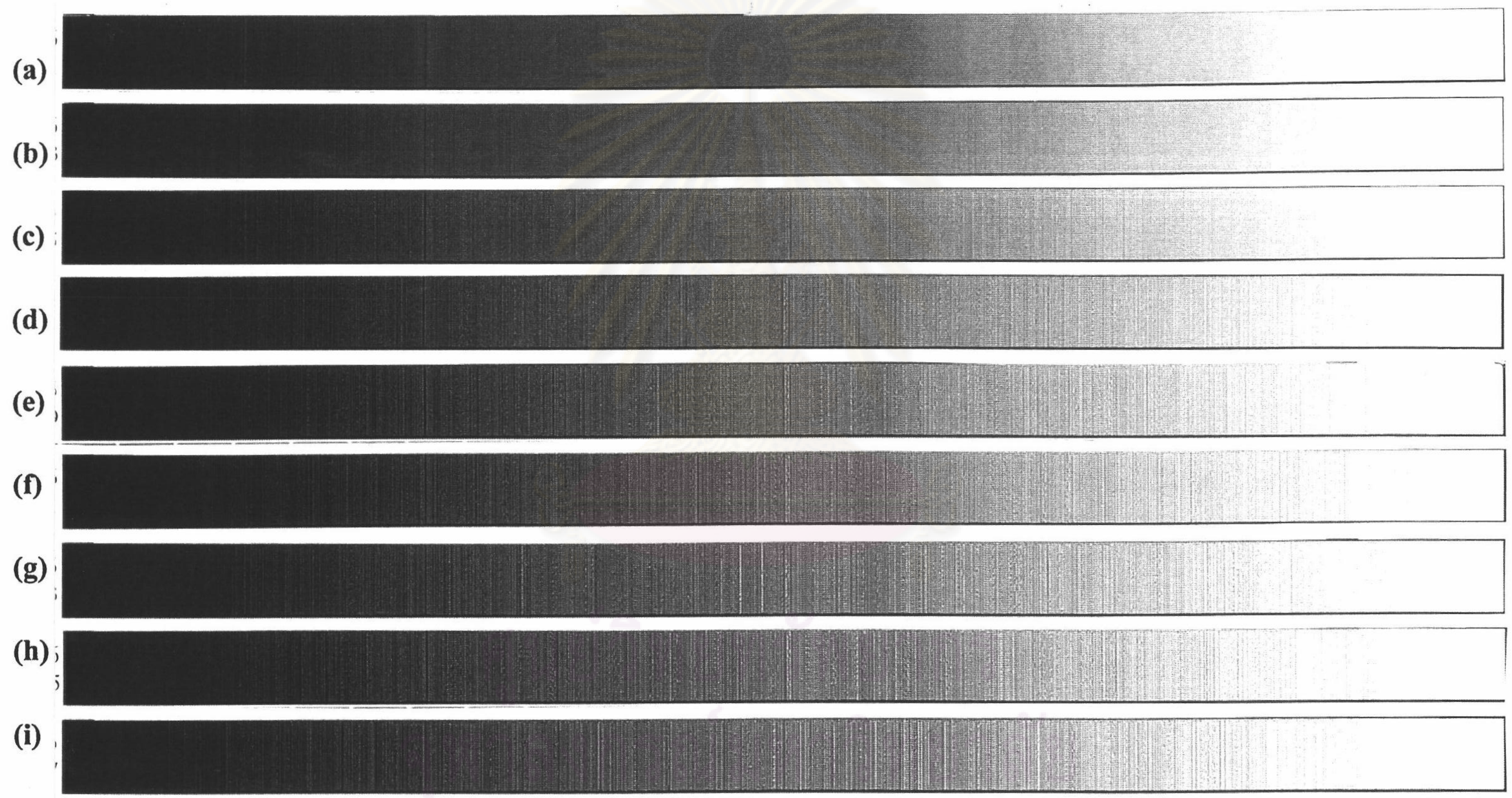


Figure 4-22 Halftone grayscale using FM algorithm at 80 lpi, group size: (a) 1 pixel; (b) 3 pixels; (c) 5 pixels; (d) 7 pixels; (e) 9 pixels; (f) 11 pixels; (g) 13 pixels; (h) 15 pixels; (i) 17 pixels

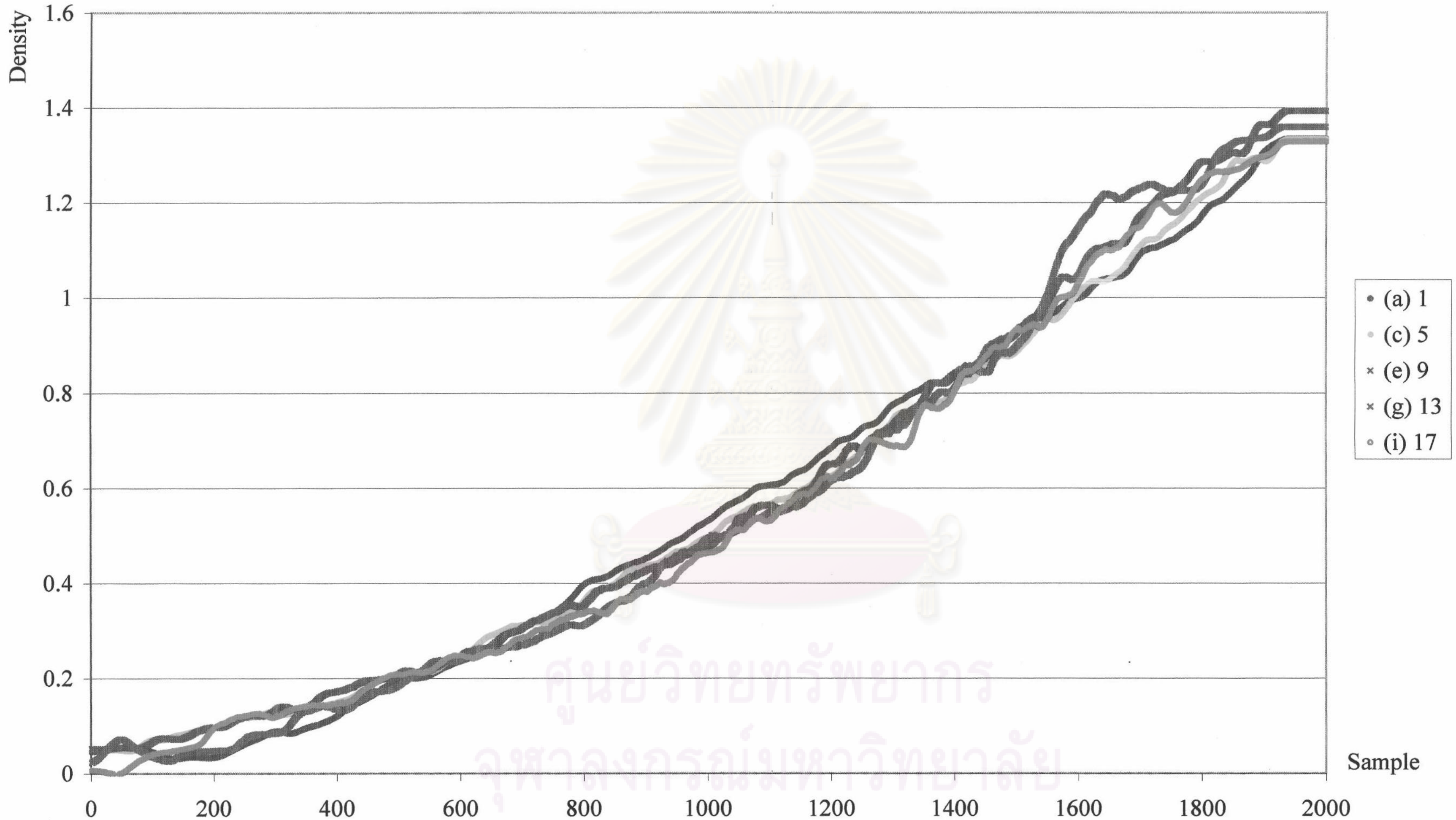


Figure 4-23 Tone reproduction of halftone grayscale using FM algorithm at 80 Lpi, group size: (a) 1 pixel; (c) 5 pixels; (e) 9 pixels; (g) 13 pixels; (i) 17 pixels

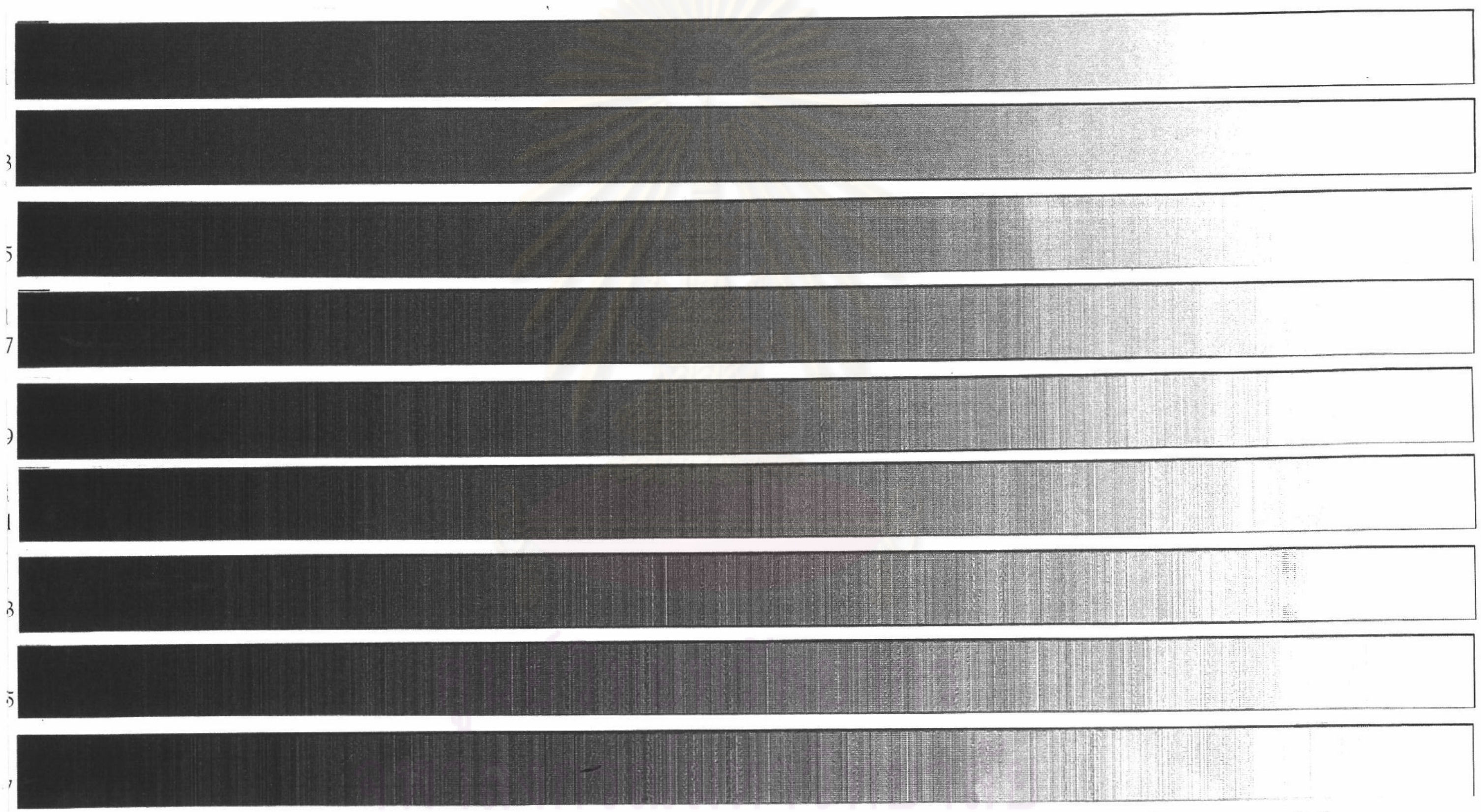


Figure 4-24 Halftone grayscale using FM algorithm at 120 lpi, group size: (a) 1 pixel; (b) 3 pixels; (c) 5 pixels; (d) 7 pixels; (e) 9 pixels; (f) 11 pixels; (g) 13 pixels; (h) 15 pixels; (i) 17 pixels

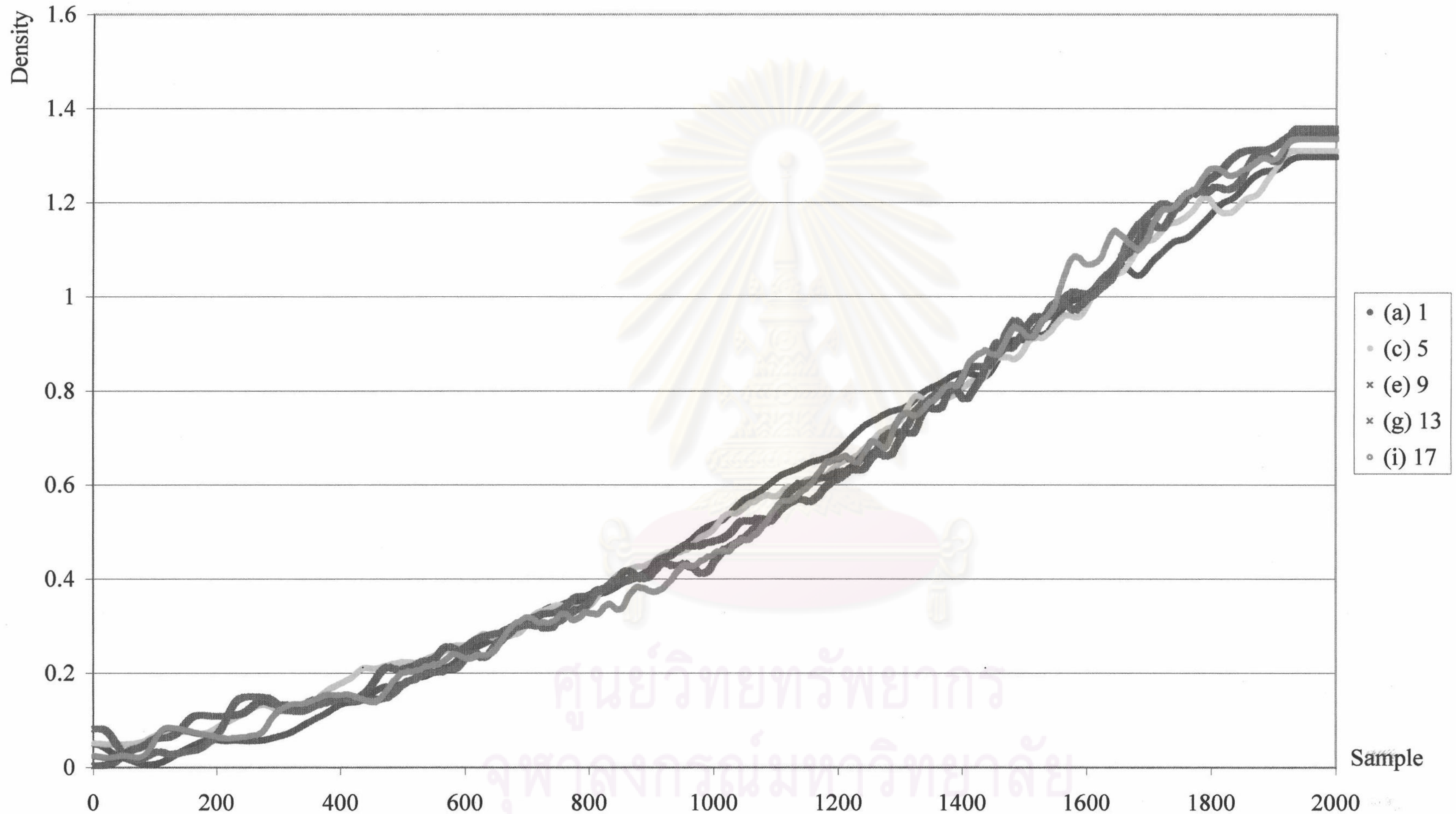


Figure 4-25 Tone reproduction of halftone grayscale using FM algorithm at 120 Lpi, group size: (a) 1 pixel; (c) 5 pixels; (e) 9 pixels; (g) 13 pixels; (i) 17 pixels

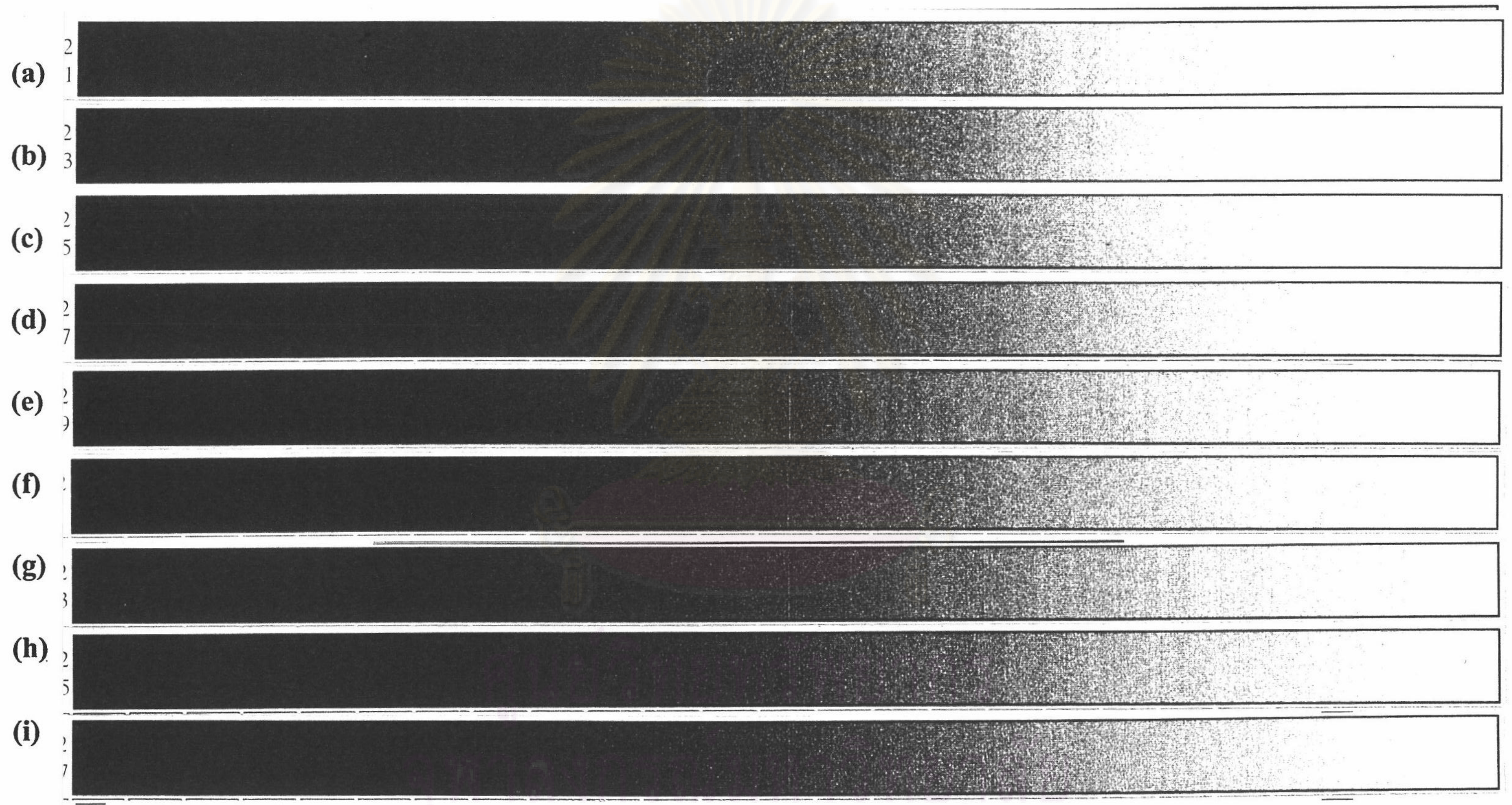


Figure 4-26 Halftone pilot test form using FM algorithm at 80 lpi, group size: (a) 1 pixel; (b) 3 pixels; (c) 5 pixels; (d) 7 pixels; (e) 9 pixels; (f) 11 pixels; (g) 13 pixels; (h) 15 pixels; (i) 17 pixels

(a) (b)

Figure 4-27 Halftone printout on Compatibility of Conventional Printing using (a) AM algorithm; (b) FM algorithm

(a) (b)

Figure 4-28 Halftone printout using hybrid algorithm on Compatibility of Conventional Printing mixing span = 20, (a) cutoff at 200 code value; (b) cutoff at 210 code value

Figure 4-29 Halftone grayscale printout 1270 dpi, 80 lpi, (a) AM algorithm; (b) FM algorithm; (c) Hybrid algorithm, cutoff at 180 code value, mixing span = 20; (d) Hybrid algorithm, cutoff at 200 code value, mixing span = 20

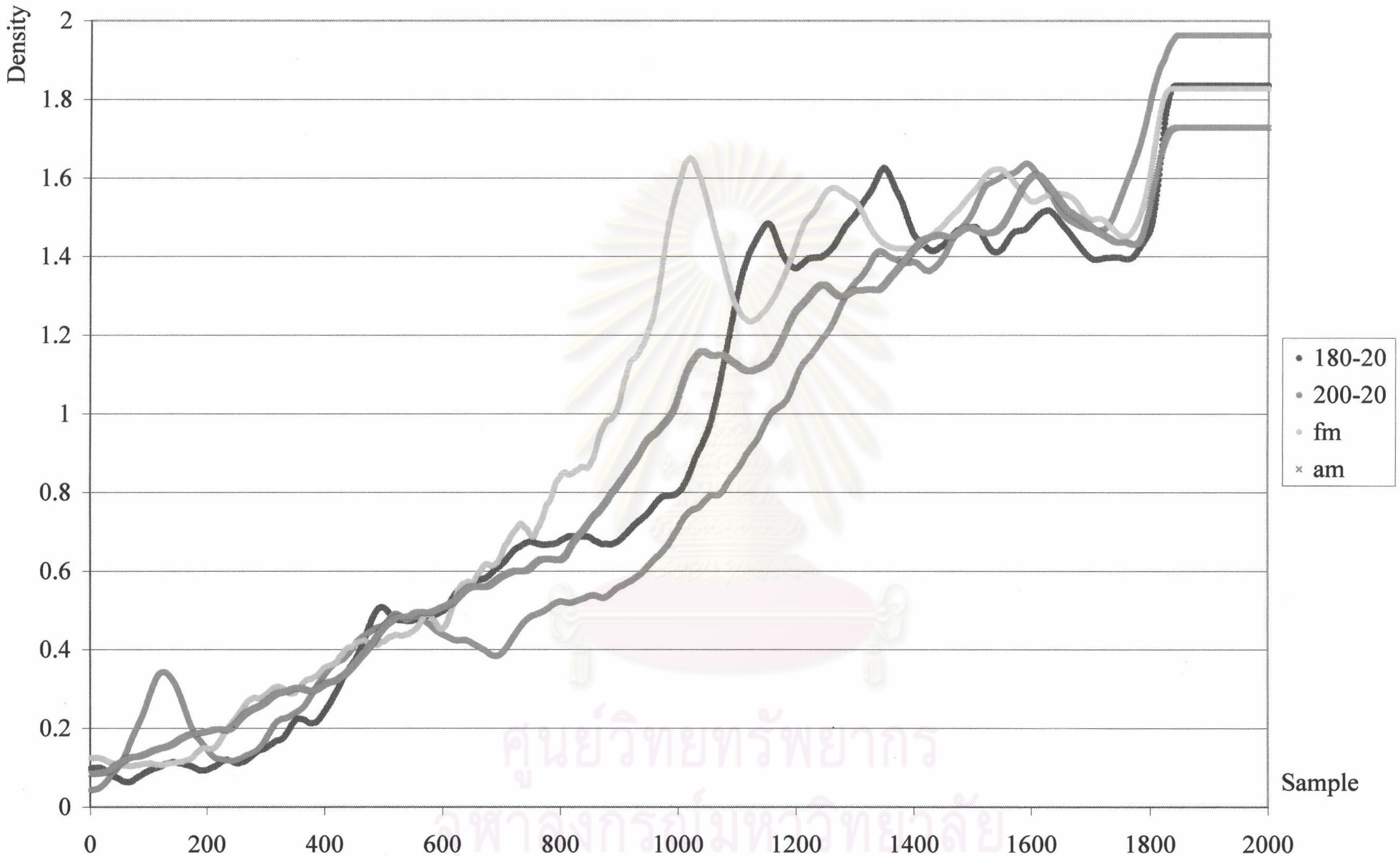


Figure 4-30 Tone reproduction of halftone grayscale printout 1270 Dpi, 80 Lpi, (a) AM algorithm; (b) FM algorithm; (c) Hybrid algorithm, cutoff at 180 code value, mixing span = 20; (d) Hybrid algorithm, cutoff at 200 code value, mixing span = 20