Optical system for weft density variation measurement

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An optical measurement system has been developed for automatic measuring of weft density variations from centimeter to another. Two optical systems were built, the first one is to detect picks when the fabric pass between a laser source and a photodetector and the second to monitor passing of the fabric unit length. Signals from the two systems are recorded simultaneously using a digital storage oscilloscope. Signal analyzing is carried out using computer-designed programs. Defects as double pick and yarn spacing variation due to cloth fell displacement are detected and assessed. Weft diameter variation is assessed and weft count is estimated. The experimental results led to a very good correlation to manual fabric analysis.

تم تطوير منظومة ضوئية لقياس اختلاف كثافة خيوط اللحمة آليا من وحدة طول إلى أخرى حيث تم بناء وحدتين ضوئيتين للإحساس بالحدفات عند مرورها بين مصدر شعاع الليزر وأداة إحساس ضوئية والثانية لمتابعة مرور الوحدات الطولية للمنسوج . تم تسجيل الإشارتين آنيا باستخدام مبين الإشارات الرقمي مع تحليل الإشارات باستخدام برامج مصممة بواسطة الحاسب الآلي. تم اكتشاف و تقدير عيوب اختلاف حيز الخيوط نتيجة حركة حافة القماش وعيوب الحدفة المزدوجة باستخدام هذه المنظومة كما تم تقييم اختلاف أقطار خيوط اللحمة وتقدير نمرها . أظهرت النتائج توافقا عاليا مع الطرق التقليدية المستخدمة في تحليل المنسوجات.

Keywords: Weft density variation, Pick spacing, Wide pickspace, Cloth fell displacement, Double pick

1. Introduction

Fabric inspection is considered as a major process in the textile industry. Inspection of 100% of fabric is necessary first to determine the quality and second to detect any disturbance in the weaving process to prevent defects from reoccurring. Currently much of fabric inspection depends on human visual inspection. The work of inspector is very tedious and time consuming and even with the most trained inspectors only about 70% [10] of the defects are detected. Performance and assessment is never constant and effectiveness decreases quickly with fatigue. Owing to the very slow speed of human visual inspection compared to production rate, automatic inspection is more important than ever. Many researchers have worked on the automation of inspection. The researches based on two main approaches. The first one is processing and analyzing digital images of fabric using different techniques as Fourier transformation [2,5,7,8,18], wavelet transform [10,11,12,16], approaches based on Grey-level statistics [4,3,15] or generating a digital moiré image [1]. The second is to obtain optical Fourier transformation using optical device as Fourier lens and a laser beam [6, 9]. An automatic on-line quality control devices introduced recently based on using set of vedio cameras and a suitable software [10, 11] or using dedicated electronics rather than high – resolution video imaging [13].

Fabric weft density is among the important parameters to be inspected because it influences fabric structure and properties and variation of fabric density may leads to off-quality or second quality. Many researches have investigated the causes of pick spacing variation. As mentioned in [14], for woven fabrics with high weft cover, pick spacing variation is mainly caused by the varying intensity of the beat-up force which can result from changing the cloth fell displacement. Other factors include yarn count variations, tension variation, relaxation of the yarn and fabric, improper setting and adjustments of the machine parameters, eccentricity and wear in the motion transmission system. In this work an improved optical system for measuring pick density variation, individual pick spacing, assessment of pick diameter variations and detecting defects in the weft direction as on-line system is presented.

2. Instrumentation

The measuring system consists of a mechanical unit to simulate woven fabric movement on loom and two optical systems, the first to sense the laser beam light after passing across fabric weft threads and the second to measure fabric passing distance. In the first one a laser beam is directed into the gab between two adjacent warp threads which are parallel to fabric feeding direction as shown in fig.1-b.

The output of the photodetector that is placed under the fabric varies according to the change in light intensity when the crosswise weft threads cut laser beam when the fabric passes between the laser source and the photodetector. The photodetector is placed in a closed space with a very fine hole as shown in Fig.1-c. The output of the photodetector varies with the shape geometrical cross-section of the weft thread. This mean that the amount of transmitted light at the center axis of thread is less than the amount of transmitted light at yarn edges and reaches maximum at the gab between every two successive weft threads. Output of the photodetector is recorded by a digital storage osilliscope as shown in fig. 2.

In The second optical system a photosensor is mounted at 0.46 cm (optimum distance [17] above the driving pulley of the fabric feeding roller . The photosensor consists of an infer-red emitting L.E.D and phototransistor housed in a moulded package. The phototransistor responds to radiation from L.E.D when a reflected object is placed within the field of view .The driving pulley circumference is divided into a numbers of sections using thin reflection paper as shown in fig. 3.

The distance between every two thin reflection paper is corresponding to feeding of a one centimeter of the fabric. When the pulley rotates, the thin paper reflects the light from L.E.D to the phototransistor. The response of phototransistor then magnified using amplifier and the output signal is recorded by the digital storage oscilloscope as shown in fig. 4.

The mechanical fabric feeding part is built to achieve a constant feeding speed of a guided stripe of fabric to simulate both fabric production on-loom at low speed and fabric inspection at high speed. Using a servomotor and a controlled power supply, inspection at different speeds is carried out. Prevention of fabric slippage is achieved by a larg wrap angle of fabric on roller covered with sandpaper. Constant loading on the fabric is applied using dead weights to ensure constant fabric feeding tension. Fig. 5 shows the recorded signals from two optical systems simultaneously using the digital storrage oscilloscope.

3. Signala analysis

Software programs written by Matlap are designed to perform signal analysis. Average pick density and coefficient of variation of pick density are determined in order to determine if the fabric sample is rejected or accepted according to the user input quality limits. Individual pick diameters, gab distances and pick spacing are determined. Assesment of weft diameter variation is carried out according to the user input limits. Defect detection and assessment of pick spacing variations are carried out using the same designed programs.

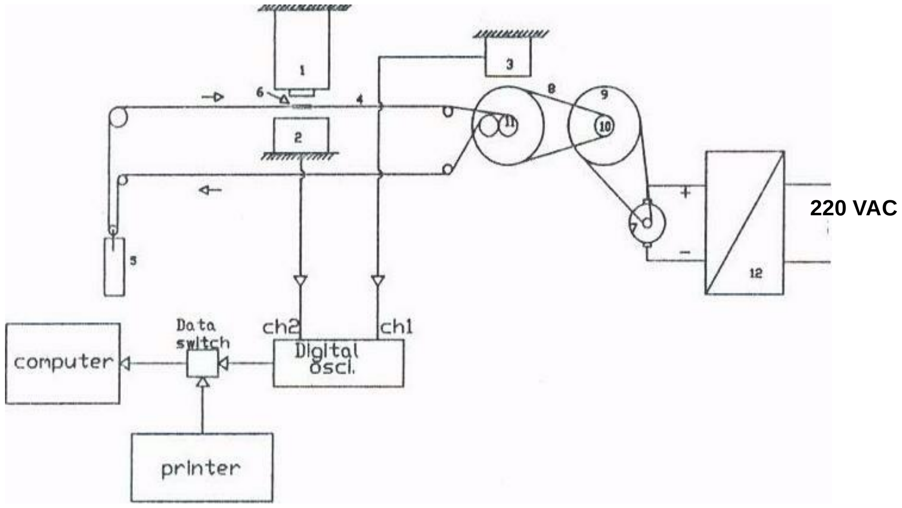
4. Reliabilty of weft thread representation

In order to evaluate the sensitivity of the first optical measuring unit, a grating generated by a computer as a test sample shown in Fig. 6 was analyzed by the designed software as shown in fig. 7. Diameters and gab distances were estimated by converting the time taken either to obstruct or to allow light to pass into distance by multiplying this time by the constant feeding speed which is measured using the second optical unit. The output was compared with the results of a high precision microscope as shown in fig. 8. Both results show excellent agreement and thus such instrumentation was approved.

5. Expermintal results

5.1. Pick density measurements

Fig. 9 shows result of the analysis of two signals taken for two differentt plain weave



1- laser source 2- photodetecor 3-photosensor 4- fabric 5-weights 6- guide 7- servo motor 8- driving pulley of feeding roller 9- and 10 – pulleys 11- feeding roller 12- controlled power supply

Fig. 1-a. The diagrammatic sketch of the measuring system.

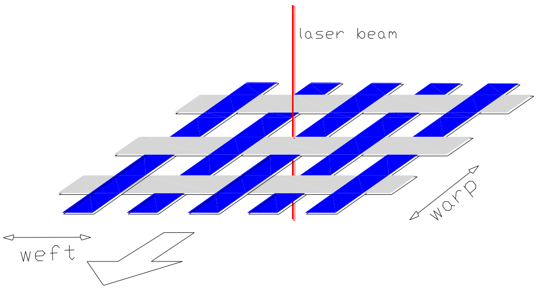


Fig. 1-b. A laser beam is directed in the gab between two warp threads.

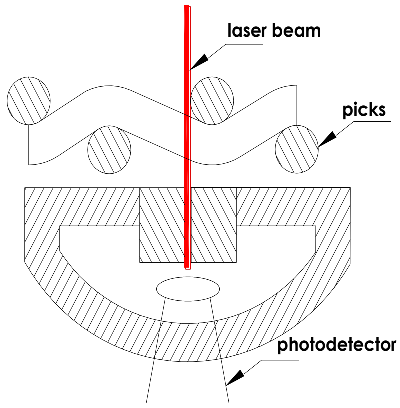


Fig. 1-c. The photodetector placed in a closed pace with a very fine hole.

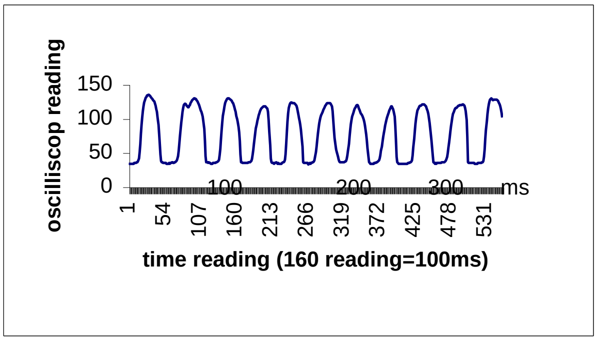


Fig. 2. photodetector output signal.

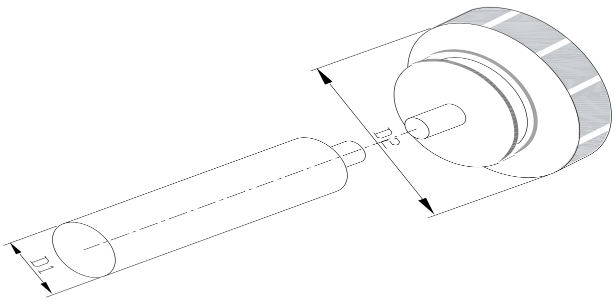


Fig. 3. The driving pulley circumference is divided into a number of sections with thin reflection paper. D1: diameter of fabric feeding roller and D2 : diameter of driving pulley of feeding roller.

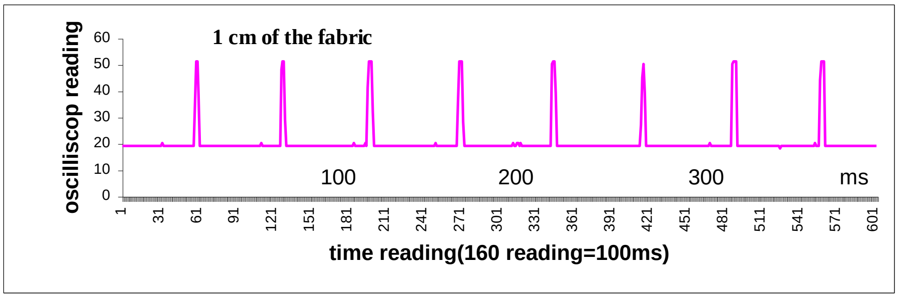


Fig. 4. The photosensor output varies with feeding of each one centimeter of the fabric.

Fig. 5. The recorded signals from the two optical systems.

Fig. 6. A computer generated grating.

Gab mm

Fig . 7 Output of analyzing signal of the test sample by the designed program.

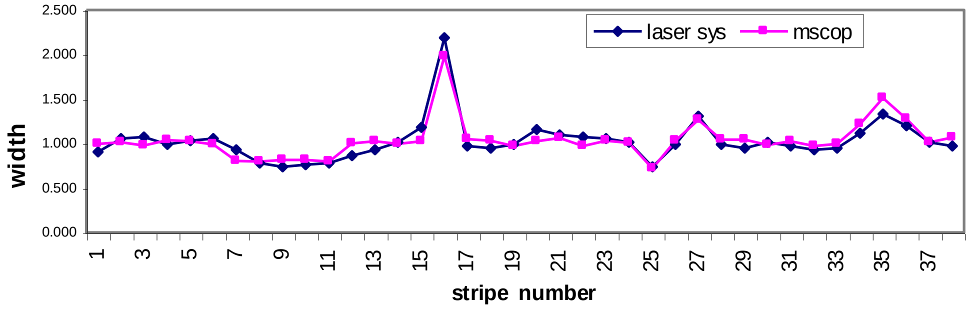


Fig. 8. Comparison between results from both optical system and microscope(mscop).

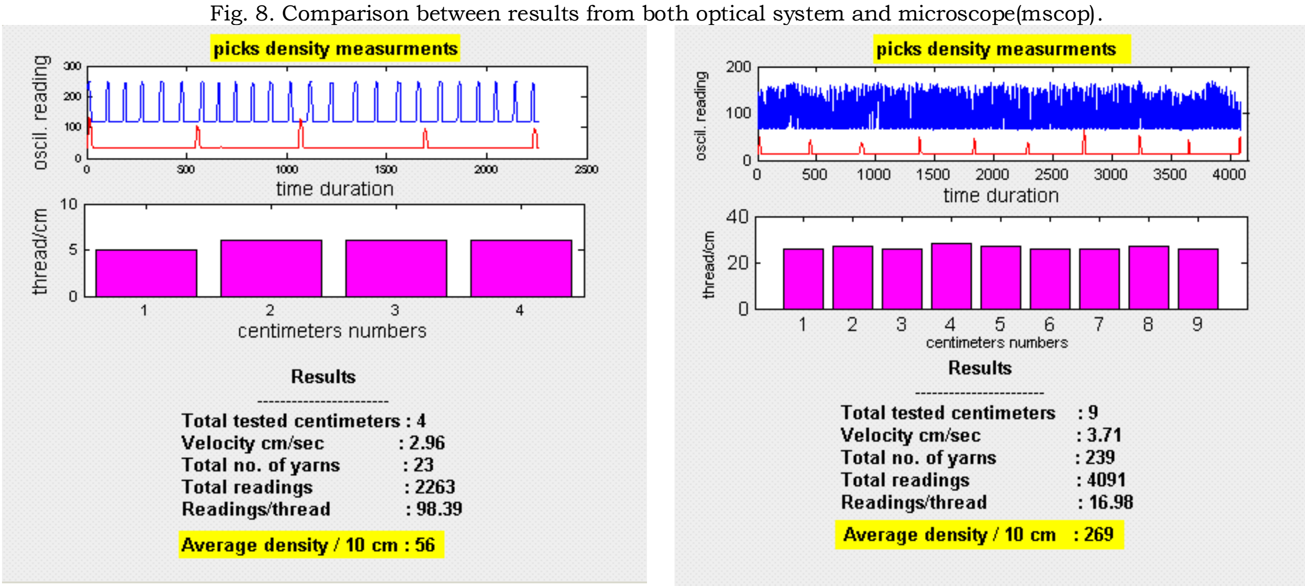
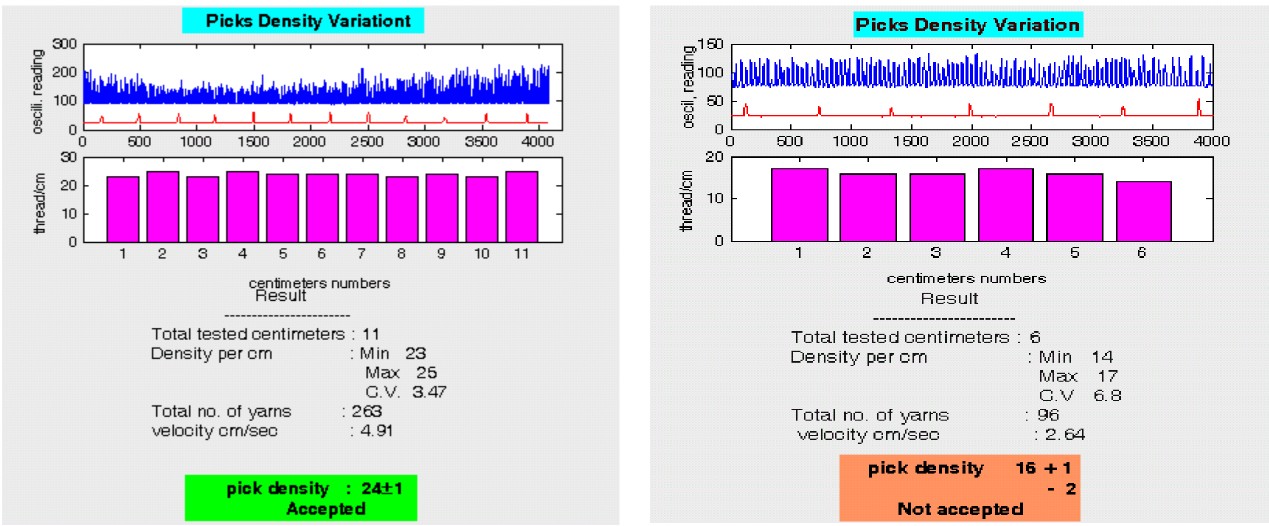


Fig. 9. Pick density measurements result.



(A) **(B)**

Fig.10. Pick density variation measurements results.

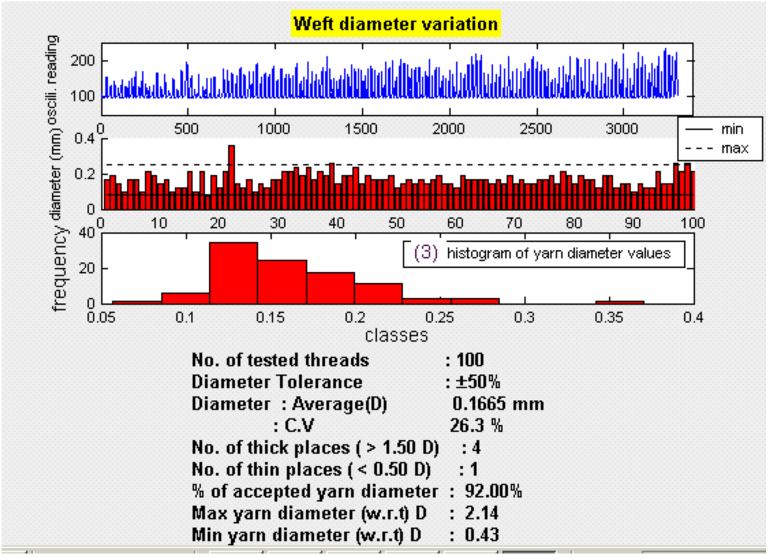


Fig. 11. Assessment of weft diameter variations.

Table 1
Results of weft count estimation

real Ne	real diameter (inch)	optical diameter (Inch)	real diameter / optical diameter	corrected diameter = (Flattening factor * optical diameter)	estimated Ne*
12.8	0.010	0.014	0.710	0.011	11.4
14.7	0.009	0.012	0.754	0.009	14.8
17.8	0.008	0.011	0.746	0.008	17.8
23.6	0.007	0.009	0.798	0.007	26.6
		average	0.752		

* diameter = 1/ (28*Ne$^{0.5}$)

fabric where result showed exact coincidence with manual measurements by counting lens.

5.2. Pick density variation

Fig. 10 shows the analysis of two signals taken from two another different plain weave fabrics. Fig. 10-A is for a non-defective sample and Fig.10- B is for a defective sample with thin place.

5.3. Pick diameter variation

Pick diameter variation can be assessed also using this optical system as variation of diameters resulting from the spinning process can affect fabric appearance and pick spacing regularity. Fig. 11 shows analysis result of diameter variation assessment according to the user input tolerance limit. Results show four thick places and one thin place according to tolerance limit 50%.

5.4. Pick count estimation

After weaving yarns tend to flatten increasing their width, so the measured diameter of picks in the fabric is the flattened diameter. In order to estimate the real count of picks, a convenient fattening factor for cotton picks used in this wok is estimated and used. Flattening factor is estimated as a value of 0.752 from the following table 1. The estimated weft counts shows a very good agreement with the real counts.

5.5. Defect detection

5.5.1. Weft spacing variations

Weft spacing variations; due to cloth fell displacement, can be detected and assessed by the system which can give individual measurements for pick spacing in the defective region.

Variation becomes prominent if it is sudden or large. The program detects wide spaces of picks according to the user input quality limits as shown in fig. 12 with the corresponding photograph

5.5.2. Double pick

The double pick defect is a result of inserting two picks in one shed during weaving when one weft yarn is intended. The fault appears as a thick line across the fabric length. In plain weave fabric, the two wefts are close together and seen by the system as one weft with nearly double diameter and have gab distance less than the average. Fig. 13 shows a good example with the corresponding photograph.

6. Conclusions

An optical system for measuring pick density variations is developed. As the fabric pass between a laser source and a photodetector, the laser beam is directed into the gab between two adjacent warp threads. When picks cut the path of the laser beam, photodetector output varies according to the change in light intensity. The output of the photodetector describes diameters of picks and gab distances between every two picks. Number of picks per unit length is determined

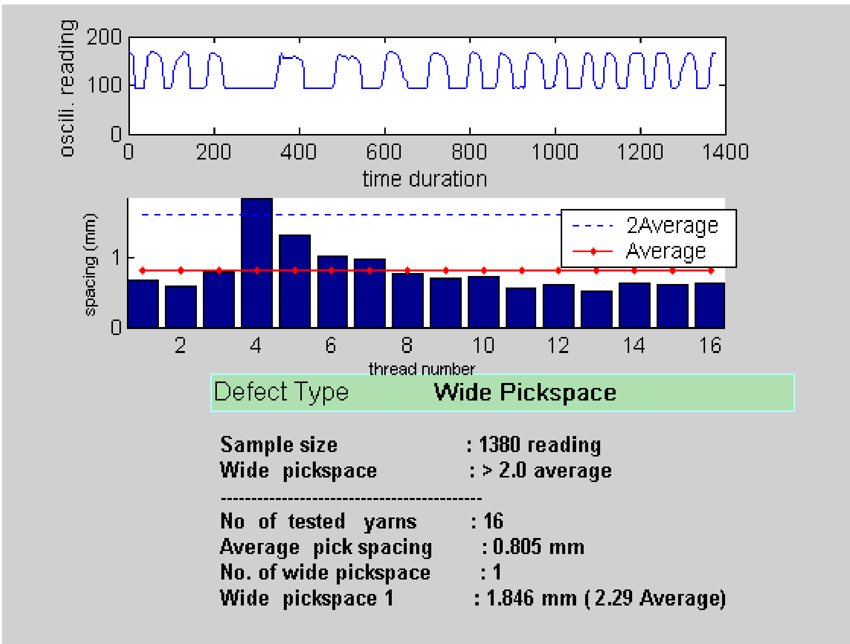


Fig.12. Detection of yarn spacing variations.

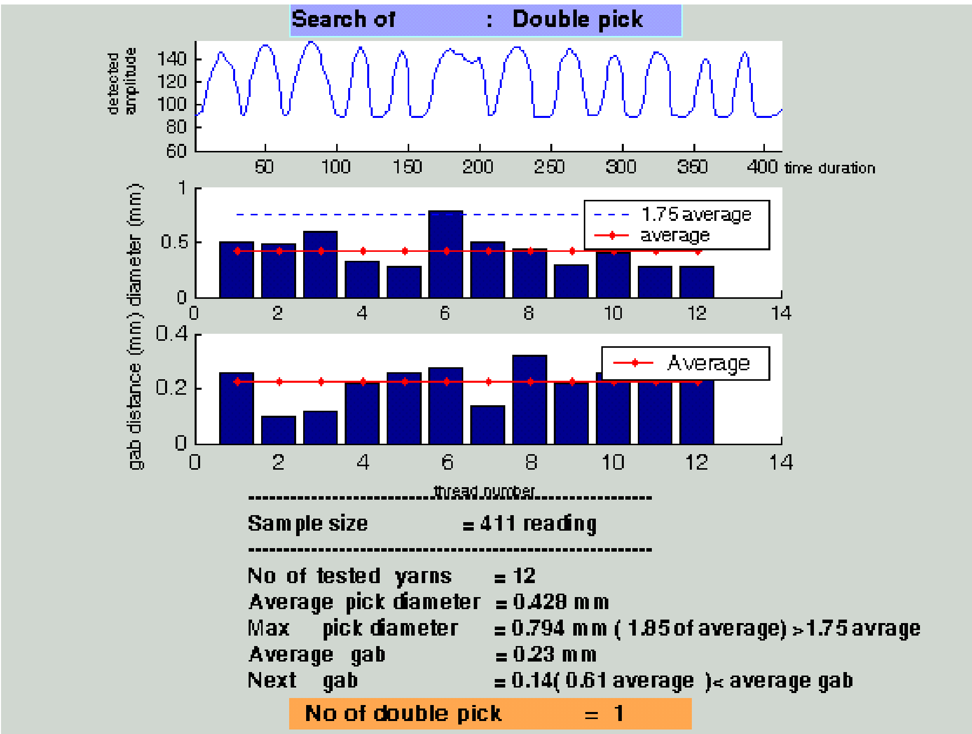


Fig. 13. Detection of double picks.

precisely using amplified signal of a photosensor output that varies with feeding of every unit length of fabric. Using computer designed programs for signal analysis, the system is capable of measuring average density, the density coefficient of variation, and determine if the fabric is accepted or rejected according to the user input quality limits. The system also makes it possible to evaluate pick diameter variations in the fabric and estimate pick count using a suitable flattening factor. Individual yarn spacing measurements can be used in assessment of yarn spacing variations due to cloth fell displacements as in start up marks. Double pick defect is detected also. The system is considered applicable for on loom measurements with a very low cost. Using electronic circuits, an on-loom signal analysis system could be further developed and commercially used.

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