Daiwa's Automated Spinning System

T. Morikawa and K. Aoki

Daiwa Spinning Co., Ltd.

1. Introduction

Under a long-range research program for continuous automation of the spinning process, Daiwa Spinning Co., Ltd. have developed many different types of spinning machinery of high productivity in the past several years. They include model D opener, model D card, Ever Even (automatic draft control device) and D-L high-speed rover previously reported on in this journal and well-known.

The rapid expansion of Japanese industry has produced a labor shortage. This demands a modernized, economical spinning system for our textile industry.

Our new successful effort in that direction is Daiwa's Automated Spinning System (DASS), perfected with the cooperation of O-M Ltd., Osaka Kiko Co., Ltd., Nihon Spindle Mfg. Co., Ltd., Toyoda Automatic Loom Works, Ltd. and Itami Machine Works, Ltd. Its outline was announced at a symposium held in Osaka by the Textile Machinery Society of Japan on May 22, 1964. This article is to bring DASS to the notice of the textile industries of the world and seek their comments or criticisms.

DASS has these distinct features:

(1) Continuous automation of the spinning pro-

cess obtained from a combination of the conventional spinning machinery, which has been improved upon for higher productivity, with newly developed machinery. Because it permits the retention of the conventional machinery, DASS requires a smaller capital investment in automation than do other well-known systems, such as CASS and NASS, and only about as much labor as they do.

(2) A combination of the roving process with the spinning process by an automatic roving doffer and an automatic roving carrier.

(3) D-L high-speed rover with a large package (20 in. lift $\times$ 6 1/2 in. dia.) and high productivity (flyer speed 1,200 rpm).

(4) Simplifying the blowing process to 3-stage—plucking blender, superior cleaner and model D opener—and the use of the sandwich blending method.

(5) Simplifying the drawing process to a single process by sandwich doubling of card webs and automatic draft control by Ever Even.

(6) Automatic feeding from blowing to carding process by using a pneumatic system, instead of the well-known towered hopper.

(7) Use of the conventional ring spinning frame, instead of sliver spinning frames used in other continuous automated systems.

Table 1

Table 2 Machine Arrangement of Each Process

Process	Machine arrangements
1. Blowing	1. Model D bale plucker 2. Model D blender 3. Superior cleaner 4. Model D opener 5. Injection feeder 6. Main duct
2. Carding	7. Model D card feeder 8. Branch duct 9. Cotton sheet former 10. Model D card 11. Ribbon former
3. Drawing	12. Ribbon conveyer 13. High speed drafter 14. Ever Even (automatic control device) 15. Automatic can changer
4. Roving	16. Model D-L high-speed rover 17. Model D automatic roving doffer 18. Model D automatic bobbin carrier
5. Spinning	19. Conventional ring spinning frame 20. Model D automatic cop doffer 21. Automatic cop conveyer
6. Winding	22. Automatic winder

2. Outline of DASS

2-1. Main Units

DASS is built of 2 main units (see Table 1):

(1) ABCD unit

For continuous automation of the blowing, cleaning, opening, carding and drawing processes.

(2) FRDT unit

For continuous automation of the fly frame and ring frame processes by using automatic doffers and transporter.

2-2. Machine Arrangement of Each Process (see Table 2)

2-3. Spinning Data (see Table 3)

2-4. Process Flow Chart in DASS

As shown in Fig. 1, cotton bales opened previously in a bale house are supplied to bale plucker ① of model D plucking blender, and plucked by its plucking cylinder. Opened cotton is fed, through the pneumatic conveyer duct, into blender ② equipped with control boxes, one for each plucking cylinder.

Cotton laps of a uniform density delivered from control box are piled like sandwiches on the blend-

Table 3 Spinning Data

Process	Grain	Delivery speed	Draft × doubling	Number of machines per 40,000 spindles	Running hour
Blowing	—	—	—	1	24
Carding	300 gr./6 yds.	20 m/min.	—	96	24
Drawing	300 gr./6 yds.	160 m/min.	8 × 8	12	24
Roving	72 gr./12 yds.	1,200 rpm	16.7 × 2	16	24
Spinning	24.7 gr./lea	13,600 rpm	29.03 × 1	96	15.5—16
Winding		24 knots	—	6	15.5—16

Fig. 1 Mill layout for 40's 40,000 spindles.

ing lattice, then opened and cleaned by Superior Cleaner ③ and Model D opener ④. Cotton thus treated is supplied, through main duct ⑥ by injection feeder ⑤, to card feeder ⑦. Card feeder ⑦ holds a constantly uniform amount of cotton and delivers it uniformly to cotton sheet former ⑨ connected to card ⑩ through branch duct ⑧.

Cotton fed into cotton sheet former ⑨ from card feeder ⑦ is delivered to feed rollers of model D card ⑩. Card webs exhausted from doffers of model D cards ⑩ are transformed into cotton ribbons weighing 260–330 gr./6 yds., overlapped like sandwiches on ribbon conveyer ⑫ and then sent to high-speed drafter ⑬ with Ever Even ⑭. Card feeder ⑦, D-cards ⑩, ribbon conveyer ⑫ and drafter ⑬ are driven by a main motor shaft. They are started and stopped perfectly synchronously, as described later.

Slivers delivered into cans of drafter ⑬ are sent to D-L high-speed rover ⑮ for drafting by the operative. Full bobbins of D-L high-speed rover ⑮ are removed from its flyer parts automatically by model D automatic roving doffer ⑰ and hooked on bobbin holders of bobbin carrier ⑱. Bare bobbins on bobbin carrier ⑱ are supplied newly after doffing. Then full bobbins on bobbin carrier ⑱ are sent automatically to the creel side of the conventional ring spinning frame ⑲ and exchanged for bare bobbins on the creel by the operative. Exchanged bare bobbins, hooked on bobbin holders of bobbin carrier ⑱, are fed back to D-L high speed rover ⑮ automatically.

3. Functions of Machines Constituting DASS

3-1. Model D Plucking Blender (P.B.)

This plucker, built of plucking and blending parts, makes better use of the sandwich blending system than the ordinary well-known pluckers do. The announcement of a bale plucker of West German make some years ago has led to the manufacture of many pluckers in Europe and the United States. They are limited in productivity to 20–30 kg/hr per plucking unit. Our plucker has productivity as high as a maximum of 80 kg/hr and is designed to blend any amount of cotton in a desired blending ratio.

The blowing process equipped with this plucking blender is shown in Figs. 2 and 3. Fig. 4 shows its plucking part; Fig. 5, its blending part. Five

bales ① are plucked, one each, by five plucking cylinders ④ and travel on frame ③ supported with guide rollers ②. Grid rollers ⑤ are arranged abreast in the bottom of frame ③ and are driven positively to make right and reverse turns interchangeably. A plucking cylinder ④, built with a pair of saw tooth cylinders, is placed between grid rollers. The grid roller ⑤ gives uniform plucking action unobtainable from other bale pluckers, and reverses the surface of cotton bales for plucking by the interchange of the roller's right and reverse turns.

Plucked cotton drops into hopper ⑥ placed under plucking cylinder ④. It is then air-transported, by duct connected to fan ⑦, into control boxes ⑧ of blender, the boxes being built one for each cylinder.

Fig. 5 Blender.

In the control boxes, plucked cotton forms into laps of a uniform density. The laps are piled like sandwiches on blending lattice ⑩ for the next stage of operation. The amount of cotton in each control box ⑨ is always kept constant by an automatic feed control device. The rate of plucking cotton bales is controlled by adjusting the vertical position of plucking cylinder ④. Waste cotton is supplied from waste feeder, placed near control box, and blended.

Cotton is plucked extremely finely without damage, plucked tufts ranging in weight from 0.1 to 0.3 gram. Doubling necessary in later processes can be reduced markedly, thanks to good feed control (CV = 5.98 %) and uniform blending (deviation under 10 %) in control box. Cotton bales are supplied to plucking blender mechanically by the use of a fork lift or hoist.

3-2. Automatic Blow to Card Feeding Device (B.C.F.)

This automatic card feeding device, because it uses a pneumatic conveyer instead of the well-known tower hopper, produces uniform cotton sheets and distributes them to cards automatically. Figs. 6 and 7 show an outline of this device; Fig. 8, its card feeder; Figs. 9, its cotton sheet former.

Cotton exhausted from opener is fed pneumatically to card feeder ② of cards ⑩ through main duct ③ of injection feeder (see ⑫ in Fig. 2). This card feeder ② has a control box ④, and delivery rollers

⑤. Its opening rollers ③ are attached under the control box ④.

Photoelectric tube ⑨ which keeps the amount of cotton in control box ④ constant, controls the feeding speed of injection feeder and supplies ~~power~~ consumed in cards, to branch duct on the exhaust side of fan ⑧. Moreover, delivery rollers ⑤ are driven by a synchronized driving mechanism for card and drafter, as mentioned later.

Fig. 6 Automatic blow to card feeding device.

Fig. 7 Automatic blow to card feeding device.

Fig. 8 Card feeder.

Fig. 9 Cotton sheet former.

Cotton in branch duct ⑦ is transported by air flow into filter part ⑪ of cotton sheet former (one former is built for each feeding part of card), and precipitated uniformly on the former, the air being exhausted by filter conveyer ⑫ made of stainless steel nets and through the holes in the side wall.

When cotton precipitation on filter conveyer increases over a certain level, flow resistance through the filter conveyer ⑫ increases. Cotton remaining in branch duct then travels to the next card. Thus cotton is fed to all filter conveyers. Finally, the remaining cotton returns to the control box (mentioned before) of card feeder ② through return duct ⑱.

Cotton accumulating on filter conveyer ⑫ is pressed into uniform sheet form continuously between filter conveyer ⑫ and press roller ⑭, and is supplied to feeding part ⑩ of card ①. Moreover, BCF has compensating duct ⑯, connected to fan ⑮ and built parallel to branch duct ⑦. This duct compensates for the pressure drop in the duct by air exhaust from filter part ⑪, and makes possible good sheet-forming on filter conveyer ⑫. Inlet nozzle ⑰ of compensating air is designed to obtain necessary air pressure by a minimum air supply.

The main features of BCF are:

(1) Weight variations in card sliver

Fig. 11 is an example of weight variations for a combination of 8 cards.

Variations between deliveries $\div 8\%$

Variations within a delivery $\div 5\sim 10\%$

(2) Air flow in branch duct

Fig. 12 shows the distribution of static pressure and air velocity in branch duct. Static pressure is kept at a nearly constant level. Air pressure decreases gradually.

(3) Sliver weight control

Sliver weight control necessary for change of yarn count can be done by changing damper open-

ing in return duct, as shown in Fig. 13. Sliver weight control is possible also by other methods, such as:

- (i) Adjusting cotton supply from card feeder.
- (ii) Adjusting fan opening for branch duct.
- (iii) Adjusting fan opening for compensating duct.
- (iv) Adjusting inlet nozzle for compensating duct.
- (v) Adjusting the contents of filter part.

Details of these methods are omitted here.

(4) Comparison with conventional lap-feeding system

Variations in sliver weight for DASS are given in Table 4. A comparison with the conventional lap-feeding system shows that, since DASS-produced

Fig. 10 Cotton sheet former.

Fan opening for branch duct	60 ϕ mm
Fan opening for compensating duct	110 ϕ mm
Opening for return duct	80 mm $\times$ 160 mm
Card draft	105

Fig. 11 Variation of sliver weight.

Fig. 12 Air speed and pressure in branch duct.

slivers are very uniform, process drawing 1 with Ever Even reduces sliver weight variations to nearly the same level as in drawing process 3 in the conventional drawing system does.

3-3. Synchronized Driving System for Card and Drafter (C.D.S.)

This mechanism, very simple in its principle, insures perfect synchronization of multiple cards, card drafter and card feeder by a single-unit driving source. Figs. 14, 15 and 16 show its transmission diagram and outline.

Motor ① accelerates main shaft ② slowly by 3-stage accelerator. Taker-in roller, dandy pulley, doffer and calender rollers are driven successively, through transmission, by main cylinder fixed to main shaft ②. Synchronized shaft ⑦, which is driven by

pulley ⑥ with clutch via carrier wheel ⑤ for doffer from dandy pulley ④, drives ring cone of Ever Even through drafter ⑧.

Since synchronized shaft ⑦ takes driving torque from each card, speed variations between multiple cards are absorbed mechanically by belt slip on pulley of main shaft ②. Therefore, the delivery speed of each card can be controlled perfectly. Drafter, ribbon conveyor and card feeder are synchronized with card at all times.

To stop drafter ⑧ abruptly, brake it with magnetic clutch ⑩ first, then stop multiple cards by switching off the motor ①. When a card web is broken, stop the doffer by its magnetic clutch ⑫, but keep up the control action of Ever Even (mentioned later).

Fan opening for branch duct	70 mm
Fan opening for compensating duct	120 mm
Card draft	105
Drafter draft	8.8

Fig. 13 Relations between sliver thickness and opening for return duct.

Table 4 Variations in Sliver Weight

Conventional system				
CV (%)	Carding	Drawing I	Drawing II	Drawing III
Within delivery	1.25	0.405	0.174	0.223
Between deliveries	3.40	2.01	1.05	0.545
Total	3.81	2.05	1.07	0.585
Mean weight (gr/6 yds)	268.0	287.0	275.0	258.0
DASS				
CV (%)	Carding	Uncontrolled drawing	Controlled drawing	
Within delivery	1.33	0.315	0.340	
Between deliveries	3.27	2.54	0.310	
Total	3.61	2.57	0.462	
Mean weight (gr/6 yds)	276.2	258.9	276.4

Fig. 14 Synchronized driving system for card and drafter.

Fig. 15 Synchronized driving system for card and drafter.

If two or more card webs are broken, switch off the motor ① and stop all cards.

To exchange drafter cans, slow down motor ①. After cans are exchanged, cards are automatically restored to their normal running speed.

3-4. Ribbon Former and Its Accessories

Ribbon former placed between doffer and calender rollers of each card, makes uniform ribbons 4 in. wide from doffer web, piles them like sandwiches and supplies them to drafter, thus improving blending and drafting measurably.

Moreover, exhaust conveyor for cotton waste and exhaust device for card fly waste are placed, as accessories, in the bottom of each card.

3-5. One-process Drawing System

DASS uses a one-process drawing system, instead of the conventional 3-process drawing system. Many technical problems accompanying the simplifying of the drawing process, such as draft limitation, equalization of sliver weight by doubling, blending, uniformity and fiber orientation, are solved successfully in DASS by improvements in preparatory processes, such as doubling in blender and ribbon conveyor, automatic draft control by Ever Even and double roving feed in D-L high speed-rover.

In a 4/4 or 4/5 line draft system, a pair of press rollers taking a 60-lb. positive load are used near draft rollers of drafter. Table 5 compares DASS and the conventional spinning system in fiber orientation, U % and lea strength for siliver roving and yarn.

3-6. Ever Even

Ever Even used in DASS gives slivers nearly as uniform as does the conventional 2- or 3-process drawing system. Ever Even uses a pneumatic circuit system to compensate for disturbances, such as the temperature and humidity in the spinning atmosphere. It uses also an ON-OFF feed back draft control system by phototransistor. Details of these systems are omitted here, because patents for them have been applied for.

3-7. Can Exchange in Drafter

Cans in drafter connected directly to card in DASS are automatically exchanged by lowering the sliver-drawing speed and bringing it close to the speed of can-exchanging. Slivers are cut only by the removal of the cans during exchange. The lowering of the delivery speed uses the inertia of the moving parts after the main switch is switched off.

Table 5

	Drafter sliver			Roving		Yarn		
	Fiber orientation (%)		U%	U%	U%	Lea strength (lbs.)	Appearance	Lint neps
	Normal	Reverse						
DASS	95.44	97.19	4.22	6.0	16.13	48.18	105	130
Conventional	97.38	95.82	4.5	7.4	16.62	44.80	90	127.5

3-8. D-L High Speed Rover

Developed from model D flyer frame, also made by Daiwa, this high-speed rover is now widely used. It uses a high drafting apparatus with 5-line, double aprons (total draft 15–20) and a double roving feed system. It compensates for total draft lowered by simplifying of the drawing process, straightens leading hooks and improves fiber orientation and short range irregularity present in slivers delivered from Ever Even.

A special winding system is used as a bobbing winding mechanism. It rotates and traverses the presser fitted loosely inside the flyer leg and bobbin, the flyer being turned in a fixed position, instead of on the conventional bobbin rail and cantilever flyer which cause frame vibrations in high-speed running. Therefore, stable, high-speed running with a large package is obtained from this machine.

Fig. 17 shows D-L high speed rover with automatic roving doffer. Fig. 18 shows details of flyer construction. Flyer ① is supported by ball-bearings at both ends. Plastic bobbin is inserted between top nose ③ of spindle ⑤ which is covered with sleeve ②, and bobbin holder ④.

Presser ⑦ is fitted movably inside flyer leg 8, takes lifting motion from presser rail ⑥ and revolves together with flyer ①. The underpart of flyer leg ⑧ is fixed to center shaft to prevent deflection of flyer leg ⑧ and vibrations of flyer top due to high-speed running. Flyer ①, spindle ⑤ and bobbin are driven by helical gears which are enclosed and lubricated inside gear box ⑨. False twist device ⑩ and flyer cover ⑪ are placed on the flyer top to reduce end downs of delivered rovings and entanglements of broken ends with other rovings.

3-9. Model-D Automatic Roving Doffer

This device, an automatic doffer for D-L high-speed rover, is shown in Fig. 19. Details of its doffing cycle are: Bobbin chuck ①, fixed rack ② and lifting rack ③ are slid forward and backward by travelling rack ④. First, bobbin chuck ① which is slid forward, grips top end of bobbin ⑤. Then top arm ⑥ lifts the bobbin ⑤ from spindle nose. Bobbin chuck ① then slides backward with full bobbin. When bobbin chuck has finished its backward slide, pinion ⑦ is pushed up along fixed rack ② by hydraulic pressure. Lifting rack ③, therefore, rises at a double speed. When a full bobbin is inserted into bobbin holder ⑧ of bobbin carrier,

bobbin chuck ① is detached from it. Then the lifted bobbin chuck is slid back and bobbin carrier is moved longitudinally half the spindle pitch by stopping mechanism.

Bobbin chuck ① slides forward again, grips bare bobbin, comes down with it, then inserts the bare bobbin into spindle nose. Top arm ⑥ and bobbin chuck ①, successively, are detached from bare bobbin, and one doffing cycle is completed. The time taken for doffing is 6–10 min. per frame. Model D automatic roving doffer is operated by the following stages:

- (1) Full bobbin stops (Auto counter)
- (2) Presser rail stops in a set position
- (3) Presser rail comes down to sleeve-winding position
- (4) Winding a few layers to sleeve
- (5) Flyer leg stops in set position
- (6) Doffing starts
- (7) Frame starts, presser rail rises for winding
- (8) Normal running

Fig. 16 Synchronized driving system for card and drafter.

Fig. 17 Model D-L rover and automatic roving doffer.

Fig. 18 Flyer part.

3-10. Creel Part of Ring Spinning Frame

Fig. 20 shows umbrella type creel of ring spinning frame with full bobbin (20 in. length $\times$ 5 1/2 in. dia., or 20 in. length $\times$ 6 1/2 in. dia.)

3-11. Model D Automatic Bobbin Carrier

Model D automatic bobbin carrier, working with model D automatic roving doffer, sends full bobbins on the rail, which is used also for the blow cleaner, to the creel side of ring spinning frame and returns bare bobbins to model D high-speed rover.

Fig. 21 shows its outline and Fig. 22 shows details of stopping device for it.

Bare bobbins fed back from ring spinning frame are supplied to spindle nose by bobbin chuck ① as mentioned in 3-9.

Full bobbins are transported on carrier rail ④ by carrier driver ③ automatically, and exchanged for bare bobbins on creel of ring spinning frame by creeling operator. Then bare bobbins hooked on bobbin holder ① are returned on carrier rail ④ to D-L high-speed rover by carrier driver ③, and stopped just on the center line of each flyer ⑤ by stopping device fixed for each rail, and await next doffing.

When roving doffer starts to operate, full bobbins are exchanged for bare bobbins automatically, as mentioned before.

3-12. Automatic Doffer for Ring Spinning Frame

Automatic cop doffer (A.C.D) is well received as a cost-saving method. An economical automatic doffer which can be used directly in the conventional mill with only very few modifications is sought by every mill. AD used in DASS needs only slight modifications of the spinning frame or the spinning room and yet gives the advantages of group doffing.

Major features of ACD are:

(1) Doffing motions are simulated to the conventional manual operations, and ACD can be used on the conventional ring spinning frame.

Fig. 19 Model D automatic roving doffer.

Fig. 20 Creel for ring spinning frame.

Fig. 21 Model D automatic bobbin carrier.

(2) Irrespective of variations in the relative height of spindle rail to the floor or floor rail, the body frame of ACD can be held in the same set relative position to the spindle rail by adjusting the bottom wheel's set position. In other words, the floor needs no modification. Therefore, the bottom wheel can be pulled in easily on the main floor.

(3) The body frame of ACD is driven along the frame side by friction wheels which are simple and cheap. Therefore, no rail connection from the cop carrier is needed. Moreover, if there is a difference in the relative height of the spindle rail mentioned above to the surface of the main floor where the cop carrier travels, ACD can be moved easily to the cop carrier by separate adjustment of the end surface of friction wheel rail attached to frame side.

(4) Bobbins are arranged or loaded by gravity shooting which uses a simple mechanism and operates accurately.

(5) Bobbin ends are gripped by an elastic holder, and no difference in the outer diameter of the bobbin affects doffing. Fig. 23 shows an outline of ACD.

4. Conclusions

DASS is a new continuous automated spinning system which uses the 3-line high draft ring spinning frame so popular with the textile industry. DASS is built of two main units:

Fig. 22 Carrier setting device.

1. ABCD unit (continuous automation of blowing, carding and 1-stage drawing process).

2. FRDT unit (continuous automation of the fly frame and ring frame processes by using automatic doffers and transporter).

DASS requires a small capital investment than for other continuous automated systems and yet reduces labor costs to about 50 % of the labor costs required by the conventional spinning system.

Efforts are being made to modernize DASS further to the extent of continuous automation of all processes from spinning to winding as well as the combing process.

We express our thanks for the cooperation of the firms mentioned in the introduction to this article.

Fig. 23 Front view of AD