Cost effective paper machine rebuild

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ABSTRACT

Rebuilding the existing Paper Machines is the need of the day. It is far more economical than putting up new facilities.

In order to achieve the plans of rebuild in a cost effective manner, the first step is to scrutinise the existing machines and determine areas where maximum and quickest return on investment is possible.

Rebuilds are more tricky than buying or supplying new machines. They call for a high degree of understanding of the machine and process to identify the areas of rebuild on one hand and incorporate contemporary technology using as much as possible the existing components on the other hand. Also from cost angle it is very important to ensure that the rebuilding plans are such that they call for minimum machine down time.

The article has been prepared to project the areas of optimisation and the fundamental factors that govern the successful rebuild.

It is unfortunate that the country is still dependent on imports for contemporary technology and a few critical components for a paper machine. Technology is not a one time commodity. It requires a continuous flow and the Indian manufacturers have to find their way into the heartland of technology at some cost to meet the growing needs in the country.

INTRODUCTION :

The shifting market trends, stringent requirements of the Paper and Board users together with the shift from one furnish to another due to shortage of conventional raw materials and poor efficiency of the machines due to various reasons have thrown the Indian Mills in a situation where the very survival is under pressure.

In addition to this spiraling cost of inputs and utility services have further made the working of the Mills more difficult. It has therefore become essential for the Mills to modernise their Paper Machines for better product, higher volumes and operating efficiency. Modernising and upgrading the existing facilities is far more economical and faster than establishing new facilities and therefore the need of the day. They are not fashion oriented but need based and have to be cost-effective with no compromise on technology and engineering.

IMPROVEMENT APPROACH :

Successful rebuilds do not happen by accident. They require an excellent understanding of current equipment and process capabilities, a working knowledge of practical technology and good follow-up to make sure that the projected goals are achieved. Mill improvement programmes are often poorly focused because the rebuild plans are not sound, and proper understanding of the existing facilities are not done. An effective approach before rebuild plans are taken up should be as under :

1. Measure current machine performance.
2. Compare results to performance standards for machines producing similar grades.

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3. Develop recommendations to improve performance with emphasis on items with the highest return on investment and the greatest ease of implementation

4. Implement changes to optimise performance.

Evaluation of current machine performance is a key stop. By comparing results of machine evaluation to performance standards for similar grade machines, areas of the machine that require improvement can be identified. Performance standards for bond newsprint, corrugating medium, linerboard and coating base stock have been developed. Table I outlines the performance range observed on several fine paper machines and the good performance targets representing practical standards that are being achieved on the best performing machines.

I. Fine Paper Machine performance indices

Parameter	Observed performance range	Good performance
Overall machine efficiency, %	67—93	88
Headbox consistency, %	0.2—0.8	0.4—0.6
Flatbox vacuum, ft³/min/in²	2—12	5
Couch Vacuum	1.9—8.2	5
Consistency off couch, %	8—22	20
Consistency after last press%	25—46	40—42
Moisture entering size press %	1.0—4.2	3

The effect of each parameter on overall machine performance must be determined. Some parameters can be well below the good performance level without causing a bottle neck to higher production rates. Areas of greatest significance must be identified so that capital expenditures and improvement efforts can be concentrated in areas of highest return.

Alternatives for upgrading equipment should be carefully evaluated. Experimentation with new concepts often requires extra time to achieve the projected goals.

Machine rebuilds sometime do not achieve the results projected in capital expenditure plans. Inadequate results can be caused by weak engineering, improper installation, or operating personnel not understanding how new equipment and processes are supposed to work.

In general the existing machines may be suffering from the problems of formation, basis weight variations low dryness out of press, excessive steam consumption in the dryers, or poor smoothness of the sheet. Basically all these things would result into poor runability and productivity of the machines causing a severe strain on the Mills.

It is equally important while upgrading the machines to ensure that the system ahead of Headbox is stable. With stringent quality requirements it is essential to check the refining capacity, stock blending system, additive system, wet and dry end broke handling and white water recovery and make sure that the same are compatible with the increased production requirements. The increasing machine speeds necessiates an approach flow system free of pulsations, consistency variations and entrained air to produce a stable product. Consider a 30 TPD machine operating at 180 MPM speed producing. Writing and Printing papers from Straw/Bagasse furnish. Originally when the machine was designed and manufactured it was based on long fibred conventional raw material. The basis weight was say around 52 GSM. Today the requirement is that of GSM and a volume of 40 TPD.

Assuming the machine is speeded up to see its performance, it may be found that the formation is unacceptable, flat boxes got flooded, sheet dryness out of press dropped by 3-4 points and moisture out of dryer went up by a few points resulting into complete chaos. Obviously the limitations have to be clearly spelled and objectives well defined before the Mill launches its modernisation plan.

HEADBOX :

In view of the change of furnish and correspondingly the Headbox consistency and the flow requirement, it is essential that the hydraulic capacity of the original Headbox be determined. The velocities in Header and Vat require rechecking for new throughout and if meets the requirements, Headbox need not be changed provided mechanically it is in sound condition and if can handle the required head of stock which goes up by almost 100%. The head requirement would indicate the choice of closed or open Headbox Headbox is a very critical equipment on the machine and is expensive too. Its performance will decide the formation, cross variations profile and ultimately runability. Therefore, in most cases Headbox becomes the major limitation and literally dictates rebuild especially if open Headbox will require replacement with pressure Headbox. In most cases old Headboxes cannot be rebuild effectively because parameters are very critical and manufacturing very stringent.

Open Headboxes, properly designed easily meet the requirements of Paper Machines oprating upto 250 MPM maximum. Beyond this speed due to design and head requirements pressurised Headboxes are preferable Good pressurised Headboxes are not generally manufactured in India as yet. Headboxes designs have gone through revolutionary developments in the last two decades and therefore, call for greater expertise than presently available in our country. Mills surely can blame the indigenous machine builders for this inadequacy, but then this calls for a discussion in a different forum. However, the fact remains that pressurised Headboxs require imports exports and if one claims to make it well it is an expensive apology for self satisfaction.

FOURDRINIER :

In the last decade, there has been total change in the forming concept with twin wire concepts coming in but Fourdrinier continues to be still the favourite of the paper makers because of its versatility.

It therefore, calls for a detail discussion and under standing of the system.

FORMING BOARD :

In recent years, most efforts to improve conventional forming boards have been through constructing heavy duty units to reduce deflection and vibration tendencies. Most forming boards have two to four blades with 5-8 in wide leads blades and other blades 2-6 in wide. Forming board open areas typically range from 20% to 40%, depending on grades run. There is a general trend towards lower open areas on all grades. The effect of Headbox deficiencies has been minimised on some machines by reducing forming board open areas and carrying more water down the table. Forming boards should normally be set so that 5-15% of the stock jet is removed by the first blade. This setting minimise breast roll pumping, provides good retention, and avoids sheet sealing tendencies.

SHAKE :

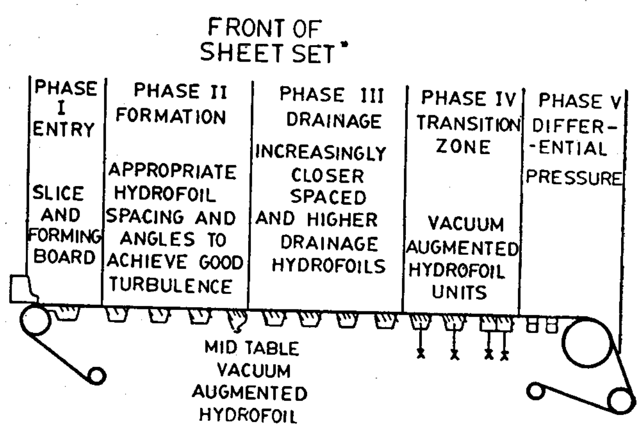
Shake in the Fourdrinier in most cases is not necessary beyond a speed of 150-200 MPM on most common grade. Only a breast roll shake is good enough in view of latest Headbox designs and the furnish available in our country.

FORMATION AND DRAINAGE PHASES :

The area between the forming Board and the first flatbox is critical for achieving good sheet properties and machine performance. Key functions are—

1. To generate and maintain stock turbulence to achieve good formation and critical sheet tests.
2. To smooth variations coming out of the Headbox.
3. To remove water at a controlled rate to avoide sheet sealing and obtain good retention.
4. To achieve satisfactory dryness to the first flatbox.

The general approach followed by most suppliers of drainage element is outlined in Fig I. General guidelines include proper foil spacings and angles to achieve good turbulence in the formation phase, closer spaced foils in the drainage phase, and vacuum augmented foils units to provide a transition between foils and suction boxes. Foil application guidelines are as follows :-



1. In the forming zone, wider blade spacings increase drainage per blade and decrease turbulence.
2. Uniform blade spacings in the wet and improve turbulence and optimize formation.
3. Increased blade spacings reduce stock pump.

4. Blade angles and spacing influence the intensity of turbulence.

5. Blade width and spacing influence the scale of turbulence.

6. Mixing high and low angle foils can optimize turbulence.

7. At the dry end of the table, closer blade spacing increase drainage per blade.

8. Use vacuum augmented foils at the dry end of the table to provide a transition from open foils to flatboxes.

9. Grind polyethylene blades when half of their width is flat.

10. Use ceramic blades for constant turbulence and dewatering.

Mid-table vacuum foil units have had good success on many heavy weight machines. Most table configuration currently recommend the combinations of foils and vacuum foils. Table rolls are recommended most often on machines producing heavy gsm paper. Worth while improvements in sheet quality and machine performance have been achieved on many machines with little or no capital expenditures by reorienting the table elements.

VACUUM AUGMENTED FOILS :

Many older machines can benefit from vacuum augmented foils. Vacuum foilsexert high drainage forces in the transition zone between open foils, permitting the optimization of Headbox consistencies entering the dandy and flatboxes. Foils achieve a maximum consistency of 1.5 – 3%. Vacuum augmented foils can develop outgoing consistencies of upto 8% on heavy weight grades. Flatboxes do not remove water efficiently ahead of the dry line. Since the dry line generally breaks in the 7—9% consistency range, vacuum foils can be used for efficient water removal and lower drag load upto the dry line.

Where the sheet consistency is in the range of 0.8% to 1.2%, installation of a vacuum foil on the wet end of the table can set the sheet and result in good formation and the optimizing of headbox consistency and the locking in of good sheet formation establishing by good headbox delivery and table turbulence. On heavy weight sheets, mid table units reduces the slurry height to prevent flocculation of fibres that otherwise would be held in suspension further down the table, Care must be taken to adjust the vacuum to the unit so that the sheet is not sealed at the mid-table position.

FLATBOXES :

Effective vacuum foils can provide sheet consistencies of 7-9% ahead of the first suction box. These high consistencies allow the number of flatboxes to be reduced, with an associated reduction in drag load. Following these concepts, the number of flatboxes has been reduced from eight to two in some light weight coated publication grades.

Proper vacuum application in the flatbox area can improve drainage, sheet quality, fabric life and flatbox coverlife as well as reduce drive horsepower. As sheet consistency increases, there is a minimum vacuum below which no drainage occurs. Flatboxes vacuums must be graduated upward from the wet to dryer positions for optimum results. Vacuum adjustment control are necessary to optimize flatbox operation.

LUMPBREAKER ROLL :

Lumpbreaker rolls can increase sheet dryness off the couch 2-5% percentage points . Lumpbreaker rolls should ae positioned so that they are 60-70% down stream from the lead edge of the couch suction box. This permits the couch vacuum to pull air through an uncompacted sheet for optimum water removal.

TABLE LENGTH :

Fourdrinier rebuilds are often part of a total machine rebuild. Additional dewatering capacity may be required to support higher machine speeds. Since most machines were not originally designed with modern drainage tackle, the existing table lengths are often adequate for higher machine speeds. As a general rule of thumb, the table should be long enough so that it takes the stock at least 1 second to get from the primary headbox slice to the first flatbox on most paper grades.

However, for machines running below 1200 ft/min, the 1 second guideline is not adequate. Depending on stock conditions, table configuration, and other variables, the table length should be sufficient so that it takes the stock atleast 1.5—2 second to get from the headbox slice to the first flatbox.

OTHER FOURDRINIER CONSIDERATIONS ARE

1. Drive horsepower and its transmittability, 40/60 split for couch/wire turning roll, adequate draw control, and reliability.
2. Showers on breast roll, return rolls, knock off etc.
3. Vacuum to the vaccum foils, flatboxes, and couch
4. Forming fabric design
5. Fabric installation
6. Trim and travelling squirts
7. Edge curlers or deckle boards
8. Lumpbreaker roll application
9. Sheet transfer

Fourdrinier drive requirements should be calculated to determine if they are adequate for higher machine speeds with required table configuration changes. Shower requirements can change with speed increase. Knock-off showers are particularly critical and may require upgrading if double layer fabrics are being considered. Vacuum foils should be supplied by separate blowers and should not be connected to the flat-box vacuum header.

PRESS SECTION :

The press section is the last paper machine section where water can be economically removed from the sheet. A machine builder has estimated the relative cost per ton of paper to dewater the sheet at Fourdrinier=10, Press section=12, and Dryer section=78.

Good performance in the press section is essential for efficient machine operation and minimal energy consumption. A common characteristic of all best performing machines producing any grades is a good press section. A 1% percentage point increase in press section dewatering will permit a 3-5% increase in machine speed or a similar reduction in steam consumption. The economic benefits are greatest when improved press dewatering can be converted into added tons of paper sold. Many existing paper machines have the potential for improving press section performance by using proven technology. Efficient press section operation can make the difference between profitable and unprofitable operation in some Mills, especially during poor market conditions.

PERFORMANCE

Consistency of the sheet leaving a press section is the basic indicator of press efficiency. Sheet consistency performance guidelines for newsprint, bond, corrugating medium and linerboards grades are summarized in Table II.

II. Sheet Consistency performance guidelines

Grade	Target press load, pli	Target exist sheet consistency, %
Newsprint		
First Press	350	33+
Second Press	450	28+
Third Press	550	43+
Bond		
First Press	350	37+
Second Press	450	41+
Third Press	550	43+
Corrugating medium		
First Press	400	37+
Second Press	600	41+
Linerboard-single felted		
First Press	400	35+
Second Press	600	37+
Third Press	1000	39+
Linerboard-double felted		
First Press	600	38+
Second Press	1200	40+
	1600	42+
Long nip Press	6000	47+

The press loading capabilities and the measured sheet consistencies for each machine should be campared to the targets listed in Table II. If the target consistencies are being achieved further significant improvements in sheet consistency is difficult to achieve. When the measured performance is below target, all pressing parameters should be reviewed to identify the major opportunities for improvement.

IMPROVING DEWATERING :

Each 100-pli increase in press load in the range of 200 to 600 pli increases sheet consistency from 0.35%

to 0.75% percentage points. Typical values for major grades are linerboard 0.35% percentage points, corrugating medium 0.45% percentage points, newsprint 0.55% percentage points and bond 0.65% percentage points. For high intensity, double felted linerboard presses, each 100 pli increases sheet consistency approx. 0 5% percentage points. For most grades the amount of change generally decreases with increasing sheet weight and press load.

Rewet can decrease sheet consistency up to three percentage points if the shet and felt are not separated immediately after the press nip. Although the amount of rewet may be comparable, the percentage of rewet is greater for lightweight sheets than for heavy weight sheets. It is estimated that one percentage point of sheet rewet occurs for each 500 mm of sheet felt contact after a press nip on heavy weight paper at 600 M per minute.

On heavyweight and low-freeness grades, the best sheet dewatering is usually achieved with wide press nips formed by soft roll covers and large roll diameters. On lightweight and high freeness grades, the best dewatering is achieved with narrow press nips (hard roll covers) at high pressure.

Roll Cover Design: Grooved or blind drilled vented nips increase void volume in highly loaded press nips. The development of press felts with high void volume has reduced the importance of roll cover patterns.

When a press parameters is changed, each press carries through 30-45% of the resulting sheet consistency change. For example, with carry through factors of 0.4, if sheet consistency is increased by 2% percentage points out of the first press, the gain after the second press would be 0.8% percentage points, and the gain after the third press would be 0.3% percentage points. Carry through factors decrease with increasing sheet consistency and decreasing basis weight.

Double felting improves water removal under the following conditions.

1. Basis weight over 120 gsm. The higher the weight, the greater the advantage over single felting.
2. Press loading over 400 pli. High nip loadings generally improve the performance of double felted nips more than single felted nips
3. Low strock freenesses. At low freeness levels, the flow resistance of stock is higher and double felted nips are more efficient than single felted nips.
4. For maximum productivity, generally the last press should be double felted. Press section design or low entering moisture content could indicate the need to double felt earlier presses.

PRESS CONFIGURATION

Each press nip should have at least 100 pli greater loading than the previous press. The sheet run should be designed to get the sheet off the felt soonest after press nips. Double felting is required for optimum dewatering of heavyweight sheets. It is also usefully employed while dealing with straw/bagasse furnish which are highly prone to press picking and are also comparatively wet furnish having weak wet strength.

MACHINE SPEED

Each increase in speed of 100 ft/min reduces the consistency out of each press nip by 0.3-0.5% percentage point. Heavyweight sheets generally have a greater loss than lightweight sheets.

SHEET RUNABILITY

Key parameters that affect sheet runability include press configuration, machine speed, felt design, felt conditioning, vacuum application, double felting and sheet moisture content. Press section configuration can have a significant impact on wet end sheet runability. There is a galaxy of press configuration to choose from while rebuilding the machine to achieve the objections in a cost-effective manner. The open draws from wire part to press part has always been causing anxiety to the paper makers There is no doubt that as the basis weight drop, speeds increase and the furnish has a poor wet strength, the closed draw from wire goes a long way in keeping the productivity standards of the machine. This is all the more true when dealing with straw and bagasse furnish like our Mills in India.

Open draws set a speed limit on many light weight machines. Tension in the sheet increases with the square of the speed and is linear to wet sheet weight. Wet strength of the sheet increases with the square of the speed and is linear to wet sheet weight. Wet strength of the sheet doubles if sheet dryness is increased from 20-35%. Accordingly the first open draw should be moved downstream as far as possible. Triple-nip presses with no open draws in the press section are installed on high speed newsprint and fine paper mach ines to minimize wet end breaks.

SHEET QUALITY :

Pressing parameters that contribute to good sheet dewatering and runnability can be detremental to sheet quality requirements. Press section design often becomes a compromise depending on the grade of paper produced. Higher press loads increase sheet consistency but also reduce sheet caliper. This can create problems in meeting bulk and smoothness specifications on fine paper grades. Higher press loads increase mullen, compression strength, and concora on brown paper grades.

Press configuration can increase, decrease or leave unchanged two-sidedness coming from the forming section. The side of the sheet contacting the felt in each press nip tends to be more compacted and dense than the side contacting a plain roll. The last press has the greatest impact on sheet two sidedness. The last to presses should have felts on opposite sides of the sheet to minimize two sidedness.

A large percentage of moisture profile problems originates at the headbox slice or in the press-section Press nip conditions should be monitored routinely to ensure that roll crowns are correct and that variable crown rolls are operated properly.

DRYER SECTION

In the last 30 years, a substantial amount of technology has been developed to improve heat transfer, drying rates, energy efficiency, moisture profiles, and sheet quality in conventional cylinder dryer system. Drying capacity and effiiency should be as high as practical with energy consumption minimized.

Energy consumption is critical because dryer sections are major users of energy in most Mills. The key variables that influence dryer section performance include steam and condensate system design and operation, paper application of dryer fabrics, installation of an effective pocket ventilation system, and a good exhaust system.

STEAM AND CONDENSATE SYSTEM

Few paper mills have a good understanding of steam and condensate systems and how they affect dryer section performance. Many existing steam and condensate systems are complex, complicating operator understanding and effective control. The objectives of the steam and condensate system are to achieve high heat transfer rates, to provide uniform cross machine drying, and to efficiently utilize steam. Basic requirements for a good steam and condensate system are :

1 Properly sized and located close-clearance syphons.
2. Ability to develop adequate differential pressure across steam joints.
3. Properly sized equipment and piping
4. Venting of noncondensibles.
5. Simple system design
6. Convenient for operators to monitor.

Syphon size is critical for efficient condensate removal. Under sized syphons can cause dryer flooding during upset conditions and cause poor moisture profiles. Over seized syphons results in high blow through rates that rapidly erode condensate system piping. Close clearance (1/16) in syphons improve heat transfer rates by minimizing the thickness of condensate in dryers. Drying rate gains of 5-15% have been achieved by proper syphon application.

Adequate differential pressure across steam joints is required to efficiently remove condensate from dryers. On cascade systems, the dryer groups should be properly sized to ensure that all flash steam can be effectively used in early sections. Separator tanks should have good baffles while producing no more than a 1-psig pressure drop across the tank. Valve and condensate removal pumps must be sized to handle steam and condensate over the entire machine operating range. Pressure drops through condensate piping should be minimised.

Steam system design should be simple and easy to operate to minimize interactions between control parameters. Control valves should be positioned on the operating floor so that machine crew can monitor valve positions routinely. Some dryers should be fitted with pressure gauges across steam joints to permit checks of differential pressures across joints.

FABRICS :

The use of open mesh synthetic dryer fabrics has resulted in improvements in dryer section performance. As a general rule, fabric permeability should be run as high as possible without adversely affecting sheet runability and dryer fabric stability. Dryer fabric permability numbers reported by fabric suppliers are not necessarily representative of the dynamic air movement capabilities on paper machines. In addition to open area, coarseness and surface characteristics of fabrics have an effect on the amount of air moved. Dryer fabric tension can also have an effect on dryer section performance.

Many dryer sections on linerboard and corrugating medium machines are run with unfelted bottom dryers. Current steam costs and the high cost of adding dryers suggests that paper mills re-examine operation without felted bottom dryers. Depending on sheet tension, heat transfer between the sheet and dryer can be reduced by as much as 75% without dryer fabrics. Increased drying capacity available form felting bottom dryers generally far exceeds the loss in productivity resulting from increased dryer section cleanup time.

HOOD & POCKET VENTILATION SYSTEMS :

Enclosed hoods permit exhausting smaller volumes of air at higher humidity. This results in less heating of make-up air to the dryer section. High energy costs have resulted in good returns from hood enclosure.

Pocket ventilation systems have proven beneficial in increasing dryer capacity. Systems used over the years have included vapour absorption systems, air induction nozzles, pocket ventilation felt rolls, high velocity, low volume stationary ducts. The high volume, low velocity systems have generally given the best results in recent years.

Heat recovery units are usually installed on enclosed hood because high exhaust air dew point is required for efficient heat transfer. Heat recovery from open hoods with lower dew point temperature can be justified in certain climates.

CALENDERING :

Calendering has been under severe pressures for higher smoothness as .require by the printers. The ordinary plans stacks are no more in vogüe. Use of swimming rolls has become a normal feature. Even the plain rolls are being replaced with temperature controlled hollow rolls, keeping the desired roll temperature by means of pressurised hot water, reducing the necessity of cooling dryers at the end of dryer groups.

There are a number of designs for calender stacks and the existing calender stacks can be rebuild to any one of those designs using some of the existing equipments. All stacks rebuild should be incorporated with the nip relieving arrangement. The nip cooling is an option and the system can vary from highly sophisticated one to a bar apology. Basic requirement is that roll temperatures should be higher than sheet temperature for good calendering. This concept if followed will eliminate requirement of cooling cylinder.

REEL :

To-day most machines are provided with level rail type reels instead of pope reels to ensure more uniform density on parent rolls. Good parent rolls go a long way in efficient operation of the machine winder.

All existing pope reels can be converted into level rail type to handle larger dia parent rolls at minimum expense by reusing existing hardware.

Cooling of reel drum, good doctoring keep the reel drum in good condition. Reel spool drive is an optional equipment. The reel is provided with automatic pneumatic operation and on high speed machines, a brake on reels spools for parent roll is recommended.

SIZE PRESS

Size press installation and operations has far reaching effects on improving the surface properties of the sheet and is perhaps an integral part of the fine paper machines. This can be easily incorporrated in any machine at the time of rebuild.

The size press is not a device to coat and as such, it should only be installed where the sheet is required with a good surface and without any linting. The pick up at size press is disputable and depends on a lot of variables. Size press is by itself a very big subject and calls a discussion separately.

CONCLUSION

The key to good results from any rebuild require excellent knowledge of current conditions and how to best apply current technology. Most of the cvrrent technology for rebuilds of fourdrinier machines is presently available in India., and to keep itself abreast with the changings technology some paper machine manufacturers have tied themselves with famous paper machine manufacturers abroad. However, higher import duty and regulations do not allow easy flow of technology into India. Hence the paper machine manufacturers would seek the co-operation of the paper industry to find a solution to the problem.