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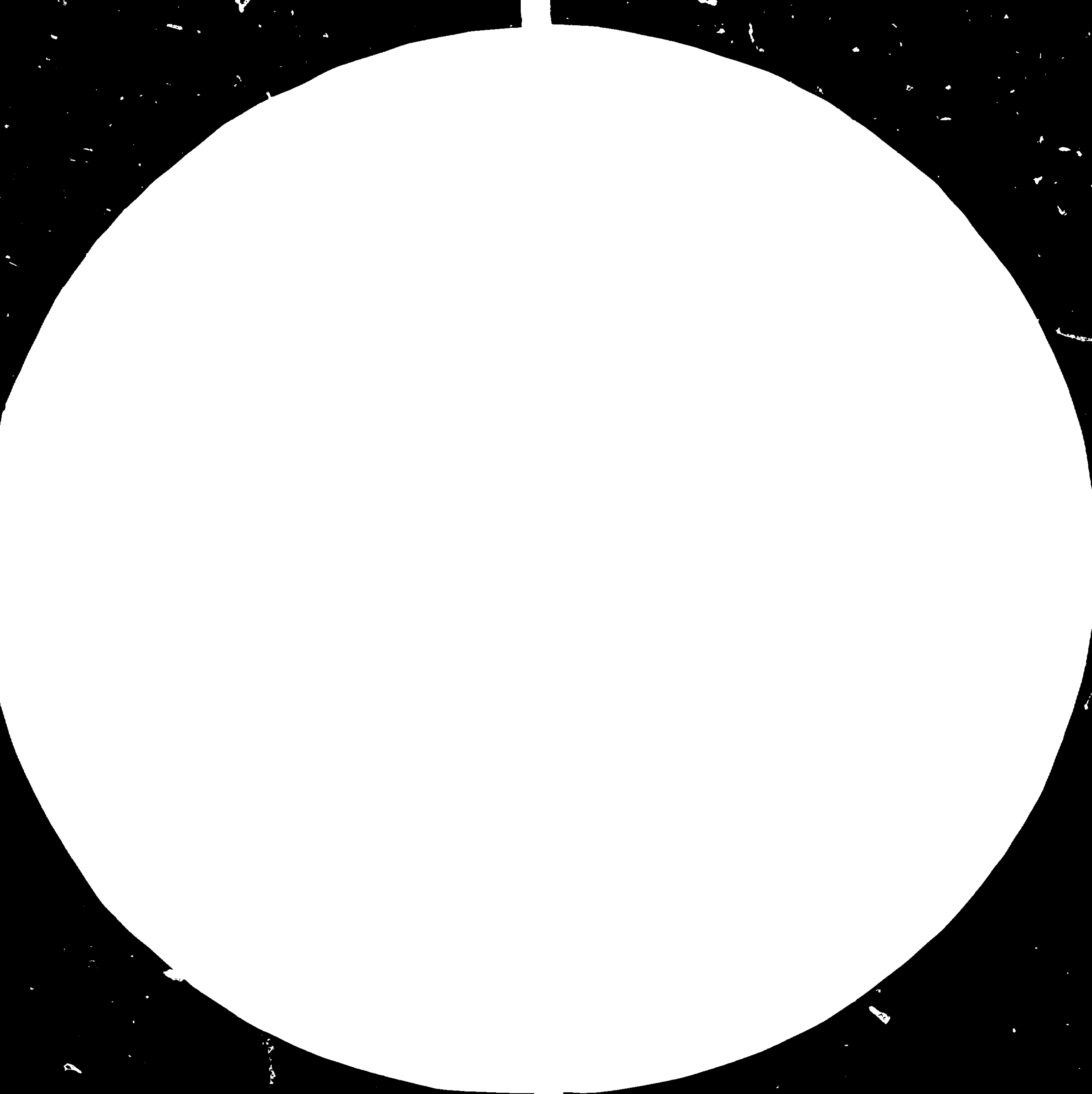

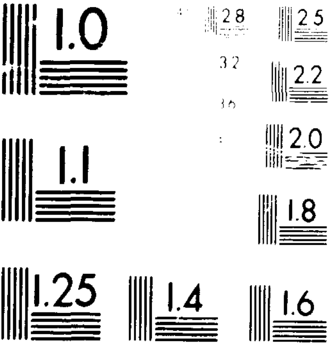

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India. Fibre spinning.
Mission report.

Report on my mission in India
from 14th August until 12th September 1984

Ref.: Project DP/IND/83/015/11-02/32.1.H
Post title: Fibre spinning expert

Index

1. Introduction: As described in the Job Description DP/IND/83/015/11-02/32.1.H, Sasmira obtained with the help of the earlier project IND/71/... a Demonstration Plant Unit for Synthetic Fibres.

In this Demonstration Plant the development and production of several kind of synthetic filaments and staple fibres is possible, principaly Polyester(PES), Polyamid6,6 (PA6,6), and Polyamid 6 (PA 6) in pilot plant scale.

The plant had been inaugurated officialy during the International Man-Made-Fibre-Conference for Developing Countries in April 1982. Whereas the spinning plant and the fibre line were commissioned around April 1982, the draw twisting machine for industrial yarn, and the polymerization/ polycondenzation unit could not be commissioned due to some problems.

The necessary modifications in the polymerization plant were completed in July 1984. Since then, this part of the plant is also fully in function and produces polymers for the developing and production of above mentioned fibres.

This mission ought to help to import latest knowledge, for the present day requirements about the synthetic fibre production, structure and properties.

The assistance during the introduction of new physical analysis methods and interpretation of the fibre structure in connection with the obtained physical and textiltechnologycal fibre properties, and the advisory activities for future research and training projects, should be helpful for Cashmira to strenghten its very good textile reputation in India, in the synthetic fibre developing field too.

2.Working plan: As the tasks of this mission are manyfold, during the first discussion with the management Dr. L. K. Jain (plant manager), and with the chemical engineer Mr. Sukhthankar (superintendent) and polymer chemist Mr. Bopasola a priority list was prepared, based on the present developing works of the plant, and my job description. Our panel discussion was enlarged with the chemical engineers Mr. A.C.Shah and Mr M.I. Thakur. The two technicians have good industrial experience and are consultants at Cashmira for synthetic fibre problems. We agreed upon to work on the following projects:

2.1 PES POY spinning

Optimization of the spinning parameters by POY spinning, without godets about 3200m/min, with a jet finishing equipment, installed in the quench air chamber (distance ca 1400 mm for the spinneret

2.2 Experiments on the fibre line

To investigate the possibility for the development and production of high tenacity (HT) and/or high modulus (HM) PES- staple fibres. When possible optimization of the process parameters, and working out of the necessary know how.

2.3 Production of PA 6,6 filaments

To work out and optimize the spinning and stretching conditions, respectively process parameters for the production of PA 6,6 filaments after the classical two-step method (spinning, drawtwisting

2.4 Physical analysis of fibres

Introduction and training of some additional physical analysis methods for polymer, filaments and staple fibres.

Discussion of these results in connection with textiltechnologycal physical fibre properties. Interpretation of the important fibre analysis data with the fibre structure and properties, in connection with the production-process-parameters.

To get an overall impression about the present state of the plant and about the instantaneous developing works, we vicited after our discussion the plant and subsequently the chemical/physical and textile laboratories.

3.Previous working in the plant: An analysis and interpretation of the technical state of the plant appears not necessary, because Professor Herlinger already gave a detailed report after his latest visit concerning this state.

After the discussion with the management about the instantaneous developing works and after a short visit around the plant as mentioned above it must be emphasized, that the management very effectively utilized the last two and half years. The plant personnel - supervisors - learned from the operation manuals, the main process stages on the plant, and in addition a lot of know how, which is necessary for a continous development and production of the different kinds of synthetic fibres. In this two-year period, the polymers, necessary for the spinning, developing and production of filaments and staple fibres in pilot scale were bought on the market from foreign producers.Since the restarting of the polymerization in July 1984 it is also possible to carry out the development works, using polymers produced in the polymer plant at Sasmira.

Furthermore for the analysis and testing of the raw materials, polymers and fibres produced in the plant, the necessary analytical methods, for the characterization of the fibre properties, were introduced, and training for the same personnel in laboratories was imparted.

But unfortunately, because of unproper operations from the shift members and/or from the not enough trained maintenance workers, same sensitive parts - mainly on the spinning equipment has been damaged (e.g. leakages in the spinneret packs a.s.o.) and causes for time to time troubles in the very sensitive spin-prozess. Several measuring recorders didn't write the corresponding values or are disappeared. The single tachomete the stroboscope and the Simovert speedometer are out of order.

To secure proper conditions on the plant, every of this short-comings ought to be urgently corrected.

The plant take on the hole a good impression, but a little higher clean ness, in and around the equipment would increase effectful the developing works, and would be helpful for the education of the plant personnel, too.

4. Experiments on the plant:

4.1 PES- POY- spinning

As in the working plan written, (see point 2.1 page 2), the first experiment was the optimization of the spinning parameters for POY The spinn process carried out without godets about 3200 m/min, wit a jet finishing equipment installed in the quench air chamber. Earlier it has been spun POY on the plant. But during this experiments the jet finishing equipment was installed in the near of the take up machine.

By spinning of fine titers which has most interest on the market e g. 75/35 den draw- texturized yarn, it is to recommend to reduce the POY- tension before the take up process. For this purpose it i an advantageous solution to built up the jet finish equipment at the bottom of the quench air chamber. (Distance from spinnerets depending from titer, air quenching conditions,take up velocity a. s. o.). With this arrangement the PES- synthetic fibre industry ha been able to reduce the waste ratio by the draw texturizing prozess and to increase the yield in the first quality with some per cent (from about 90 to 93 %).

The maintenance group began with the set up of the finishing devic in the quench air chamber. Distance from the spinnerets is 140 cm variable ± 20 cm.

During this time the plant spun polyester filament after the classical method. With some experiments it was possible to demonstrate which spin-parameters have the most influence on the spun filament properties (Uster, CV-value, cakes building, its surface uni formity a. s. o.). Optimum conditions with these experiments were reached.

We discussed in all details the spin-prozess, stucture, properties relationships. With some graphes (see enclosures) I made easy to understand the PES-fibre structure (morphology) , textilmechanica properties and its varations with processing parameters. To make easy the control in course of the production, I proposed the introduction of bobbin "cards" which contain the main corresponding production data.

After building up and testing this jet finish device with the classical spinning method, it has been found out, that the high velocity winder is out of order. Unfortunately during my mission it wa not possible to repair this winder.

To demonstrate the effect what is attainable with this jet finish unit, installed in the quench air aerea, a test has been made at 3360 m/min velocity.

A little quantity filament yarn was taken up on a godet, which run with the velocity from 3360 m/min. The textiltechnological values from this filament (tenacity 3,3 g/den, elongation 105 %) are good and correspond with the values optained in the industrial production of 120 den POY, 75/24 den draw- texturized yarn. The spintension from this POY with 18-22 g lay also in the expected regio

To make easy the trouble shooting during the POY production, a char was worked out and distributed for the participant of the discussion group (see enclosures). It can be enlarged with own observations.

4.2 Experiments on the fibre line

As agreed in the working plan (see point 2.2 page 2), the possibility for the development and production of HT- and/or HM- PES-staple fibres ought to be investigated on the fibre line.

Unfortunately the main line switch of staple fibre (heat setting unit) was burned, and had to be replaced. After this repair of this switch the fibre line was only available in the last four days for experiments.

The staple fibre production is carried out in this plant from undrawn filaments on bobbins. The PES- bobbins had been stored for several days and its structure (morphology) would be changed and would not be good for experiments.

In the last three days the plant began to spin PA 6,6 filaments as mentioned later. The - for a small tow collected - undrawn yarn from these experiments were used for these stretching and after-stretching/thermosetting experiment,too.

Conditions for the experiments were the following:

a.) Feed velocity 10m/min
b.) Output velocity 40 m/min and 44 m/min
c.) Temperature 1st hot air chamber 130°C hot air
d.) Temperature 2nd hot air chamber 220°C hot air and 180°C steam
e.)

Stretching ratio	1st step	2nd step	Total
Experiment I.	1:3.6	1:1.1	1:4.0
Experiment II.	1:3.4	1:1.15	1:4.0
Experiment III.	1:3.4	1:1.27	1:4.4

The fibres obtained from the three experiments had the following excellent textiltechnological properties:

Experiment	I.	II.	III.
Denier	4.09	4.08	3.56
Tenacity g/den	7.69	7.55	9.51
Elongation %	48	27.2	26.4
Boiling water shrinkage%	1.44	1.33	1.42

As expected, from the results it can be seen, that in the 2nd hot air chamber both afterstretching and thermosetting can be carried out.

The process can be applied in same way for PES-staple fibres, too. It will also be possible, after the optimization of the stretching, thermosetting conditions, to produce HT and/or HM-PES staple fibre on this fibre line. The necessary conditions for PES were discussed and I recommended to carry out these experiments.

With the working out of a know how for the production of these fibre types it will be possible - when from the synthetic fibre industry required - to transfer this know how in the industry.

As well known these HT- and/ or HM-PES staple fibre types are at the moment on the market the best blending components for the manufacturing of high quality polyester/cotton textiles.

The fibre line is furthermore suitable for the stretching and aftertreatment of polypropylene fibres, too.

Unfortunately the laboratory does not have the necessary fibre density column or density balance equipment.

It is not possible to receive quickly reliable answers regarding the changing in the fibre crystallinity (degree of order), during this afterstretching/ thermosetting process. The hot air shrinkage value only gives an average value about this very important structure changes.

With the DSC-equipment it is possible to measure this value, but only after very precise calibration. For this calibration there was not enough time available. The conditions for this measurments were discussed, and it was recommended. to carry out these experiments with the same three produced staple fibres samples.

By this manner of fibre production, the heat-setter (Type Mohr) is only used as a dryer. It works without tension on the tow and can be set in as thermosetter by the production of wool-type PES-stapl fibres.

During our discussion, I pointed out several times the difference in afterstretching/ thermosetting process carried out with or without tension. The tenacity, elongation, elasticity modulus a. s o. of the fibres are very different, depending from the above mentioned two different conditions.

4.3 Production of PA 6,6 filaments

As written in working plan (point 2.3 page 2) one ought to work out and optimize the spinning and stretching conditions, respectively process parameters for the production of PA 6,6 filaments after the classical two-step method (spinning, drawtwisting).

For this experiment the interfloor tube must be changed, instead of a type which is equiped with steam injection. This allows the necessary moisture take up for PA 6,6 filaments during its spinning. After this change and some little modifications, it was possible to begin with these experiments, too. (BASF polymer viscosity η_{rel} = 2.65). After the fixing of the extruder respectively manifold temperatures (down hill principle), the necessary quench air velocity, steam quantity, oil and moisture containt for the spin process were worked out. Take up velocity 1000 m/min, respectively 745 m/min.

The very good cooperation with the laboratory, allowed to work out the main necessary spin parameters quickly.

Unfortunately the lid (closing door) on the interfloor tube (back side) is missing. Because this mistake, the effective lenght of the interfloor as steam chamber is adversely affected (chimney effect). Because this the cake building is not very good

The Uster values from the unstretched bobbins layes between 1.7% and 2.2%, depending from the spin conditions. The elongation with ≈ 400-420 % and CV value 11.3% were sufficient. The draw twisted yarn with 700 m/min velocity and a stretching ratio from 1: 3.62 gives the following values: Titer 101/24 den, Uster 1.05 %, tenacity 5,7 g/den, elongation 45.2%, boiling water shinkage 1.6%.

To reduce the elongation in the desired region of 30-35 %, the stretching conditions must be optimized (stretching ratio, godet, and hot pint temperatures). The experiments has been carried out.

During an unforseen break down, it was possible to demonstrate for the shift members very effectful the necessity of the PA 6,6 filament steam treatment in the interfloor tube. At 5 p.m. by mistake the main steam valve was closed. After 10 minutes it was not possible to spin and wind up the filaments.

As long as the underfloor tube lid is not available, further experiments are not recommended. Without this part it is not possible to spin with the necessary constant humidity conditions.

4.4 Physical analysis of polymer and fibres

The laboratories are well equiped for the different kind of polyme and fibre-analysis methods.

The introduction of some additional analysis methods should help to characterize the physical and textiltechnological properties of the polymer and fibres, too.

A very important polymer property for the spinning from PES chip, is its density (crystallinity befor and after drying). The DSC-method is for this purpose very good also, but more measurments are necessary.

With the pycnometer method it is possible to measure the density (crystallinity) of about _ g chips (average value). The density of the 100 % crystalline PES and this of the amorphous was given. The introduction of this method has been recommended and personnel is trained.

For the characterization of the POY, its density (crystallinity)i also very important.A design and a description for the make of a " density balance" equipment has been given. When this very simple instrument and a cathetometer are available, e.g. the thermosettin properties of the PES, PA 6, 6 and PA 6 filaments and staple fibres can be measured with accuracy.

The laboratory has a very comfortable microscope (Carl Zeiss Universal Photomicroscope Ultraphot). But unfortunately an auxiliary device for this microscope the Berek- compensator was disappeared. Namely with this little aid it is possible to measure exactly the preorientation degree (birefringence) of POY. This value is a very important factor for the characterization for the POY. The repurchase of this compensator is essential and is recommended.

(The birefringence value of the fibres can be estimated in polarized light between crossed nichols, with the aid of "Interferenze-color charts". But this method is not enough exact).

The meassurment of the thermoshrinkage values is also a very reliable method to characterize the preorientation degree of POY, in connection with its density and natural draw ratio (see enclosures) The correlation of this value with the take up velocity for this plant has been discussed.

The measurment of the boiling water (or hot air 160°C) shrinkage has been recommended as routine analysis.

The introduction of a rapid oil content determination method (e.g. the W.I.R.A. method), it would be helpful to receive the necessary oil values, after 10-15 minutes, which are important for the optimization of prozess parameters. The present method requires four houres. For exact determination of the oil content of course this

" long time method" is recommended.

The dyestoff take up velocity is a very sensitive size for the characterization of fibre structure (distribution of the crystalli amorfhous parts).Five different dyeing prescription were given.

All these recommended, partially introduced analysis data have been interpreted with the fibre structure and/or properties, in connection with some production - process - parameters.

5. Recommendations*: For a pilot plant in this size, it is absolut vita to invest from the invested capital about 5% per year in the plant. Without these investments the plant will very quickly depreciate and can not funtion efficiently.

5.1 For the plant

The existing Sasmira synthetic fibre plant is satisfactory for training, for demonstration and for limited research, and to optimize prozess conditions.

When the plant will develop high speed spinning and produce POY it is absolut necessary to produce draw-texturized yarn within Sasmir

Many items like high speed winder, electronic instruments require proper maintenance. Only after this general maintenance will be functioning plant efficiently.

Certain routine testing equipments on the plant are necessary like

- Digital hand- tachometer for up to 6000 m/ min velocity
- Stroboscope for up to 6000 m/min velocity
- Continuous fibre tensionmeter with high sensitivity and digital display
- Instrument to measure the air velocity in quench air chamber or in the inter-floor tube
- Instrument to measure fibre surface temperature
- Instrument for continous measurment of the filament moisture content

*As the task of this assignment does not contain investigations and suggestions for the polymerization unit, the recommendations related only to the filament spinning- draw twisting- unit and the staple fibre line.

For the spinning of POY, a big set of new spinnerets are required, with hole diameter 0.35 and/or 0.4 mm, and L/D ratio 1.50- 1.75. The requirement is 4 spinnerets per position.

5.2 For the laboratories

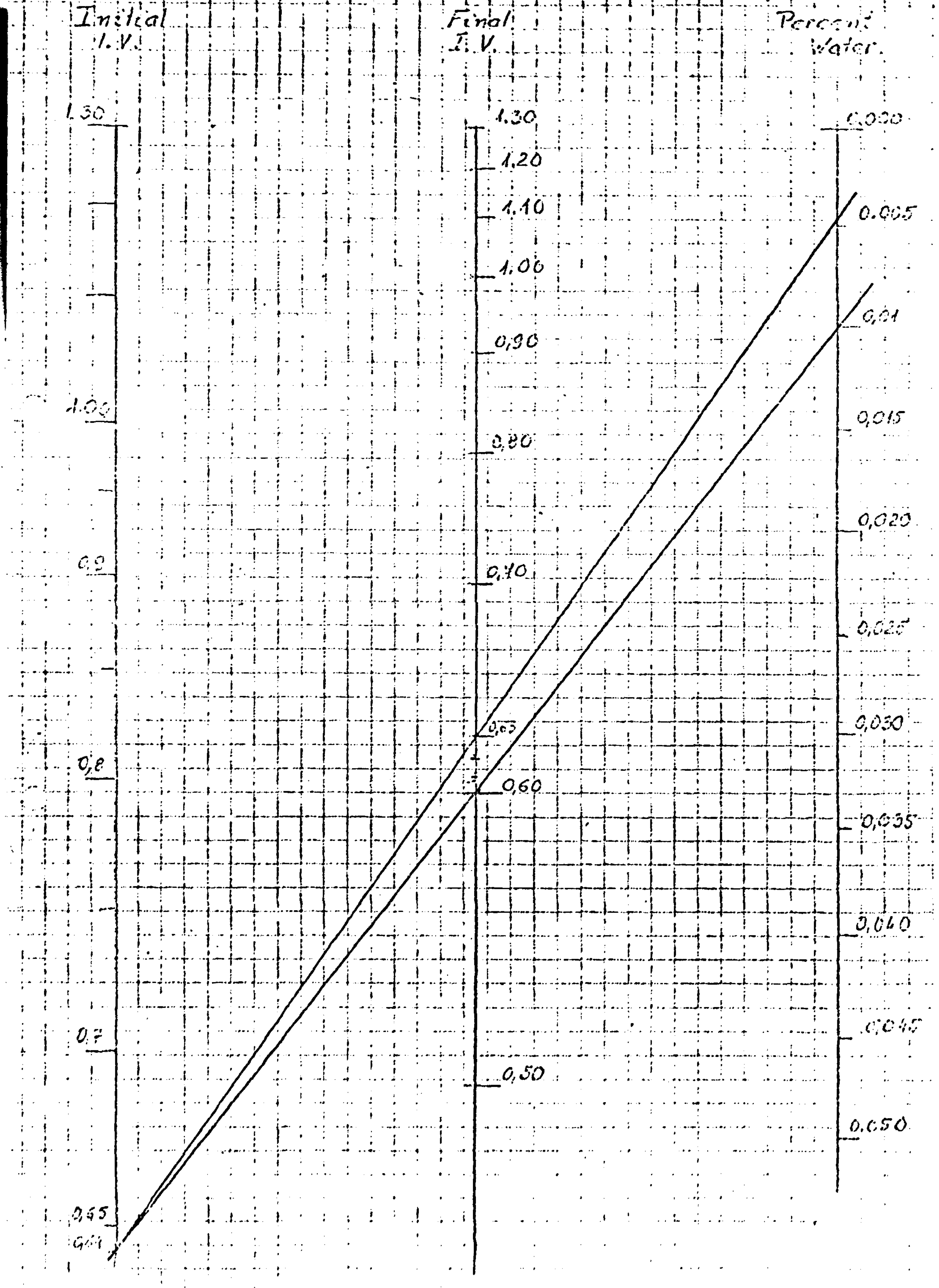
A purchase of a " fibre density balance", or a density column, the repurchase of a Berek compensator and a purchase of additional parts necessary for a rapid oil content determination method are recommended.

6. Summary: Based on the discussion and guidence during the last month, the plant can do limited research and to optimize process conditions.

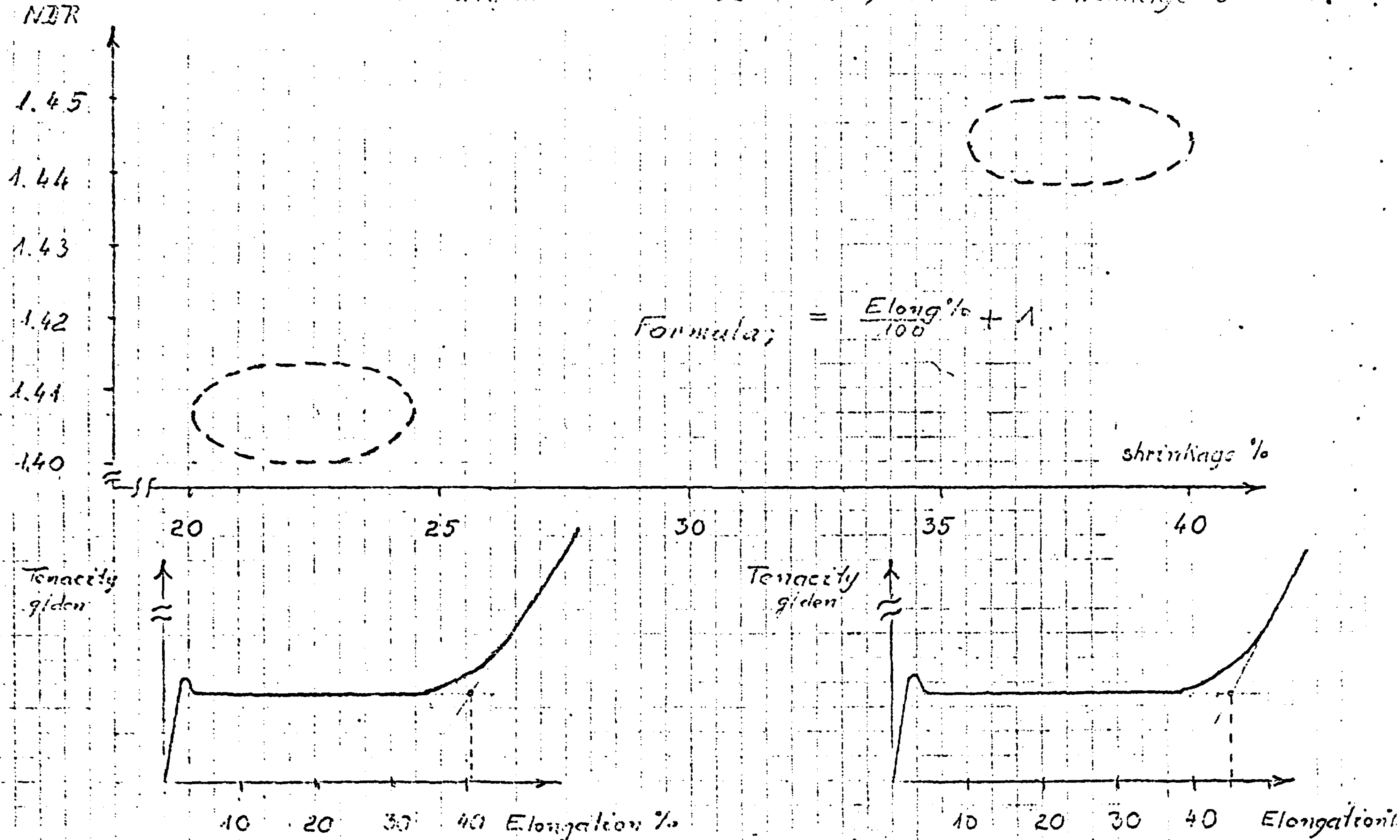
Maintenance requires considerable improvement.

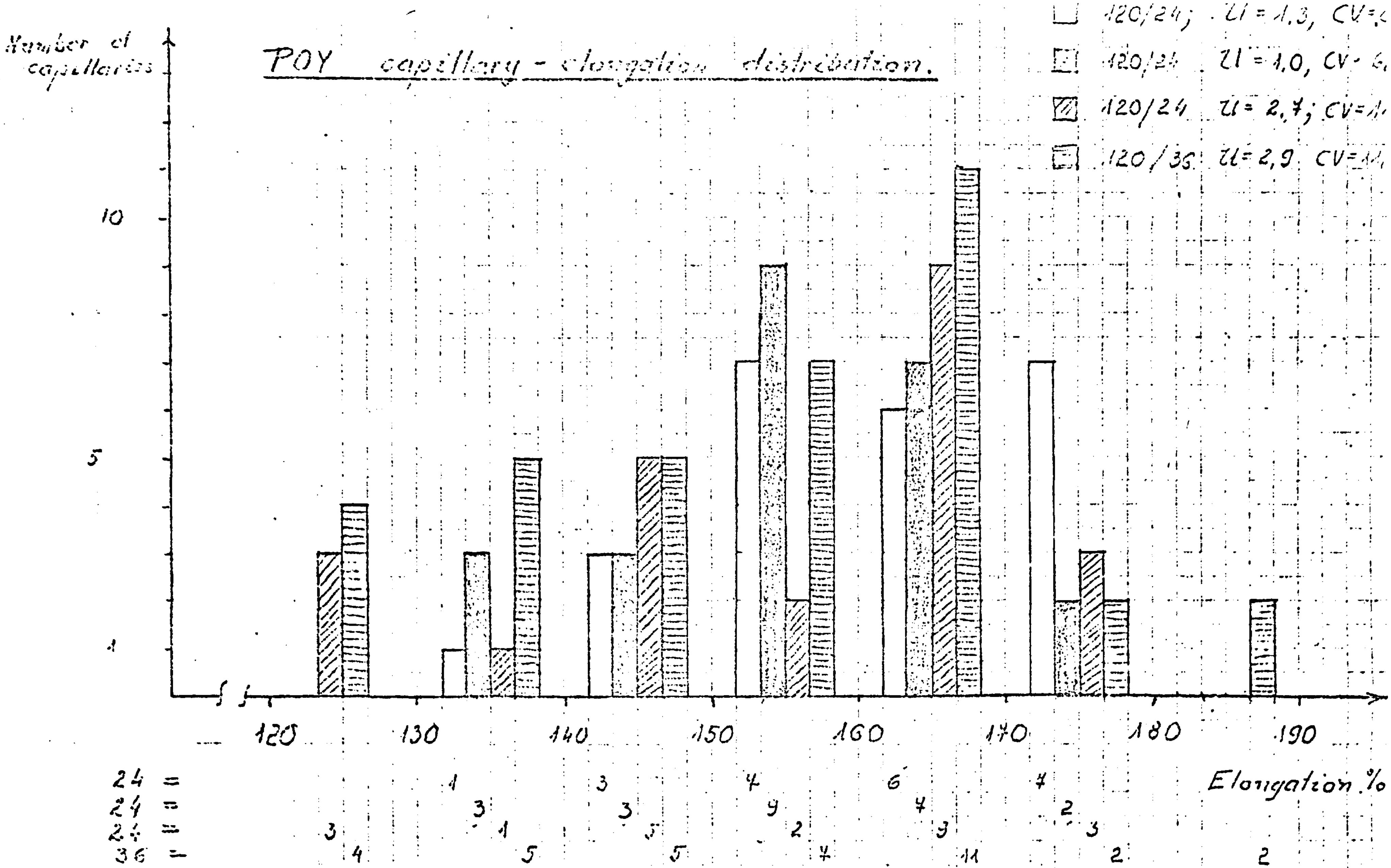
Small expenditure for routining testing equipment as mentioned will be very helpful.

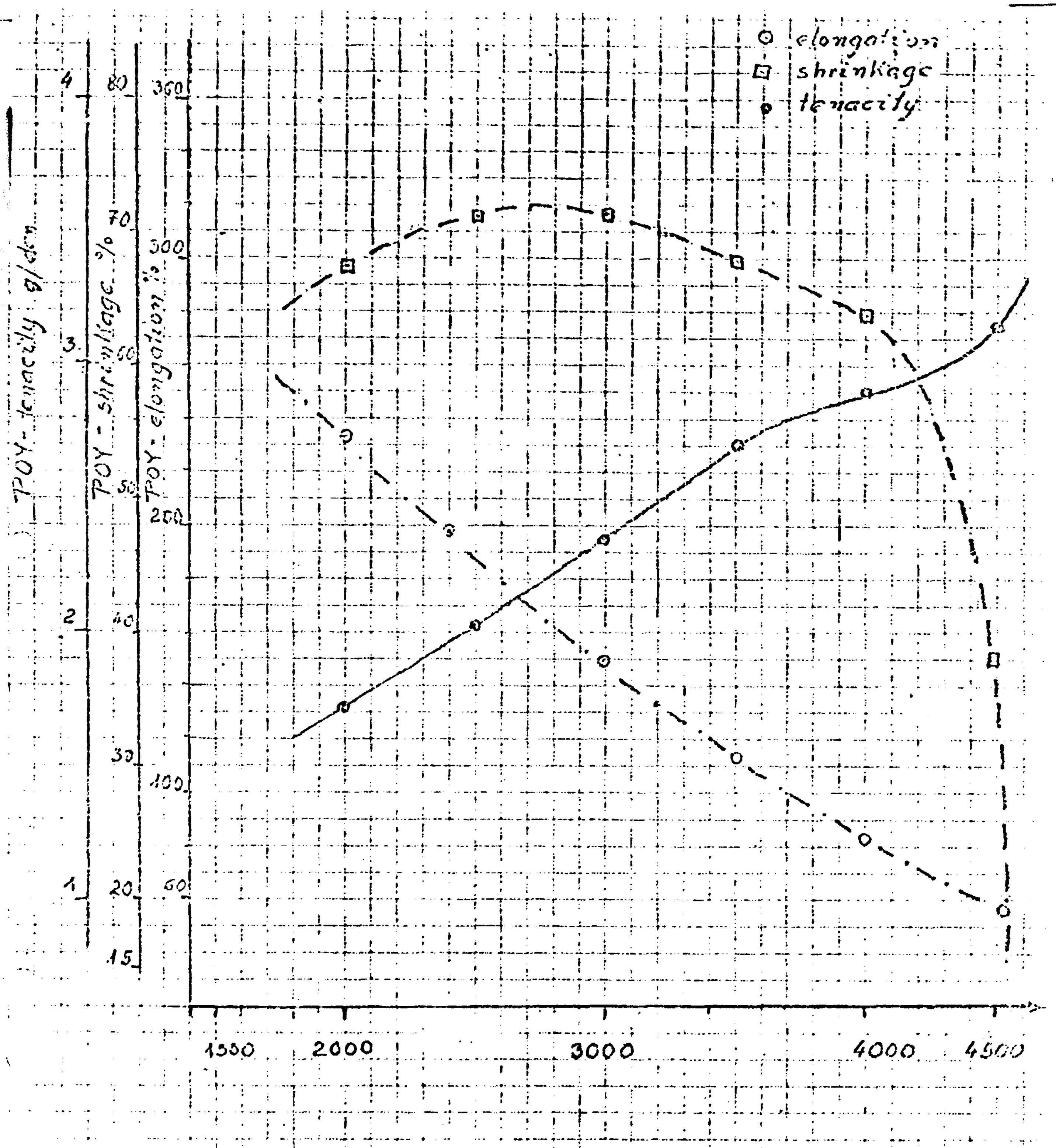
Effect of Water on Intrinsic Viscosity.



Effect of the natural draw ratio (NDR) on the shrinkage of POY.




POY capillary - elongation distribution.
Number of capillaries
10
5
1
120/24; U = 1,3, CV =
120/24 U = 1,0, CV =
120/24 U = 2,7; CV =
120/36 U = 2,9 CV =
120
130
140
150
160
170
180
190
Elongation %
24 = 1 3 4 6 7
24 = 3 3 9 4 2
24 = 3 1 5 2 9 3
36 = 4 5 5 4 11 2 2



POY - properties vs. spinning speed m/min
I.V. 0,64, TES.

Trouble-shooting spinning equipment

1. Problem: Excessive spinning breaks

Possible causes / Corrective actions

Possible causes	Corrective actions
high moisture cont in dried chip	Check the moisture level in dried chip; less then 0.005% good spinning perform.
Low viscosity of polymer	Check I.V. incoming chip and spun yarn 0.02 IV - drop visc. o. k.
gels in polymer	Check the gels in microscope (in polarization field, improber melting condition)
poor TiO_2 distribution in polym.	Check the distribution in microscope (chip and fiber)
poor polymer filtration	Check the filtration unit
improper spinn. temp.	Adjust spinning temp to avoid cold spinning manifold temp = exit extruder temp - 2°C.
improper spinneret surface	Wiping in routine operation (brass stick + silicon spray) every 48 hours.

If the spinning breaks are occured repeatedly from the particular spinning positions

Wipe-out spinnerette surface to clean the deposits around orifice	Check cross-section of spunyarn to see any irregular filament	If the problems repeals more than 3 times in 24 hours, change the pack.

2. Problem: Polymer drips

Possible causes

deposits around spinnerette	high moisture, low I.V. of polymer	too high spinning temperature

Corrective actions

if the problem is over the spinning machine, decrease the spinning temperature gradually while watching out the performance. Analyze the incoming chips for moisture and I.V.	if the problem is from particular spinning position, first clean the spinnerette surface. If it doesn't work, change the spin pack.

3. Problem: Slow holes (low polymer flow through orifice)

Possible causes / Corrective actions

too low pack pressure	partial plugging of orifice
if the problem is over the spinning achine decrease the spinning temperature gradually, while observing the performance change. If not change the pack formula to give higher pressure drop in spin pack)	if the problem is from particular position, try wiping first. If it doesn't work, change the pack.

4. Problem: Cold spinning

Corrective actions

cold spinning results in excessive orientation and skin fracture which can cause drawing breaks and broken filaments along the drawn yarn.	if cold spinning is observed, raised spinning temp. about 2-3°C. If any particular spinning position shows cold spinning, check insulation of pump and pack.

5. Problem: Off limit spin denier

Possible causes / Corrective actions

Possible causes	Corrective actions
metering pump polym. leaks	check the machine average denier to ascertain the normal operation through-put
spin pack polymer leaks along the gasket	check the metering pump and pack of the position, which show off-denier, for any sign of polymer leaks.
off-standard metering pumps speed	change the pack of troubled position
out dated pack yeilding high pack pressure	verify the spun yarn path to winder, and check drive roll speed with stroboscope. If problem persist, then change metering pump.

No.							
6.	Problem	Denier variation, poor eveness					
		Possible causes					
		turbulent quench air flow	non-uniform mixing of polymer chips having uneven I.V. distribution	non-uniform temp. distribution on spinneret surface	too low spinning tension	improper traversing at the winder	too high [illegible] pressure
	Corrective actions	scan the quench air flow against the eveness value by adjusting the plenum pressure to find out optimum flow level	check the I.V of polymer and fibre.	check the insulation on the spinning pack	increase overfeed, amplitude, and decrease period.	decrease overfeed, amplitude, and increase period.	check traverse cam alignment, lubrication and the conditions of traverse guide

No.							
7	Problem	Broken filaments					
		Possible causes					
		high moisture content in chip	high degradation due to high spinning temp.	slow hole from defective orifice of spinnerette	cracked or worn-out guides along the yarn path.	defective traverse guide	poor finish oil application on yarn
	Corrective actions	use stroboscope to inspect the running bobbins on winder. If broken filament is found over the spinning machine					
		check yarn path while running			adjust spinning, temperature for optimum		

Problem	IF particulars position shows the broken filaments						
	check yarn path while running		rotate or change guides on path		check finish applicator	change spin pack, if not solved by the above work	
	Possible causes						
	poor cohesive of filaments	high friction between yarn and contact points	improper winder setting;	misadjustment of timing traverse a d-grooved roll	misalignment of drive roll and grooved roll	silica deposit on roll surface	low wind-up tension
Corrective actions	increase to finish on yarn slightly		make mechanical of timing and alignment			clean roll surface to remove silica deposit	[illegible] amplitude and increase [illegible]