Technical University of Liberec

Faculty of Textiles Department of Nonwovens

Id: 3106 -T Textile Technology

In: Nonwoven Textiles

Quasi-Yarns in Nonwovens Production

Kvazi p• íze v netkaných textiliích

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Number of Pages: 70

Number of Figures: 57

Number of Tables: 41

Liberec, 14 May 2010

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Declaration

I hereby declare that this thesis is my work with the only help of below mentioned literature and supervision of Dr. Jaroslav Hanuš.

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Signature

Acknowledgments

I am sincerely thankful to my supervisor Dr. Jaroslav Hanuš for his professional help and to all peoples working in Departments of Nonwovens and Textile Materials for there willing to help me in solving the problems and their friendliness.

Many thanks to my family to keeping faith and patience and kind support during my studies.

Abstract:

The Scope of project is selection of materials for production of nonwovens fixed by quasi-yarns with the aim of maximum quasi-yarns tensile strength. Results of material testing methods and their link to quasi-yarns tensile strength are described; quasi-yarns tensile strength and technology parameters of nonwovens production are discussed.

Abstrakt:

Cílem práce byl výb•r materiálu pro výrobu netkaných textilií zpevn•ných pomocí tzv. kvazi p•ízí s maximální pevností t•chto p•ízí. Výsledky testování pevnosti a tažnosti kvazi p•ízí jsou v práci popsány, dále je zde popsány technologie a parametry výroby. Výsledky diplomové práce jsou popsány a diskutovány.

Contents Pages

Abbreviations and symbols

a	and.
Corel.	Corelation coefficient.
e.g	For example
etc.	et cetera.
Freq	Frequency.
Fig.	Figure.
F	Force.
gsm	Gram per square meter.
L	Length.
m/min	Meter per minutes.
mm	millimeter.
m	meter.
MIU	Coefficient of Friction
MMD	Mean deviation of MIU.
no.	number.
N	Newton.
rpm	revolutions per minutes.
R1	Needle Punched Fabric.
R15	Spunjet Fabric.
R6	Spunlace Fabric.
s	Seconds.
SMD	Mean dev. of geometrical roughness [mm]
Std dev.	Standard deviation.
sam.	Sample.
Tex	Measuring Unit.
Tab.	Table.
v	Volts.
v/cm	Volts/centimeter.
var.	Variance.
%	Percentage.
gf	gram force.
cm	centimeter.
mm^2	millimeter square.

1. Introduction

Almost everywhere on the field, in the streets, in supermarkets, in the car or even in our houses textiles surround us. Nowadays, nonwovens belong to the most developing kind of textiles. Their main advantages are price and a great variety of the end-uses given by new properties to perform specific tasks.

My diploma work concerns around the mechanical fixation technique for nonwoven textiles by the quasi yarn. The aim of my work is as follow:

1. Suggest material testing methods for production of nonwovens fixed by quasi-yarn technique with the aim of maximum quasi-yarns tensile strength.
2. Define the technology parameters important for production of nonwovens fixed by quasi-yarn technique.

2 Theoretical Part

2.1 Non-woven Production Technologies

The non woven are unique engineered fabric offering and cost effecting solution for an increasingly wide variety of applications. The more formal definition of non woven by ISO 9092 is:

A manufactured sheet, web or batt or directionally of randomly oriented fibers, bonded by friction and cohesion and adhesion, excluding paper and products which are woven, knitted, tufted, stitched bonded incorporating binding yarns and filaments, or felted by wet milling, whether or not additionally needled. The fibers are natural or synthetic origin and maybe staple or filament also.

The fibers may be of natural or man made origin. They may be staple or continuous filament or formed in situ. The non-woven textile manufacturing systems are shown in fig. 1. [1]

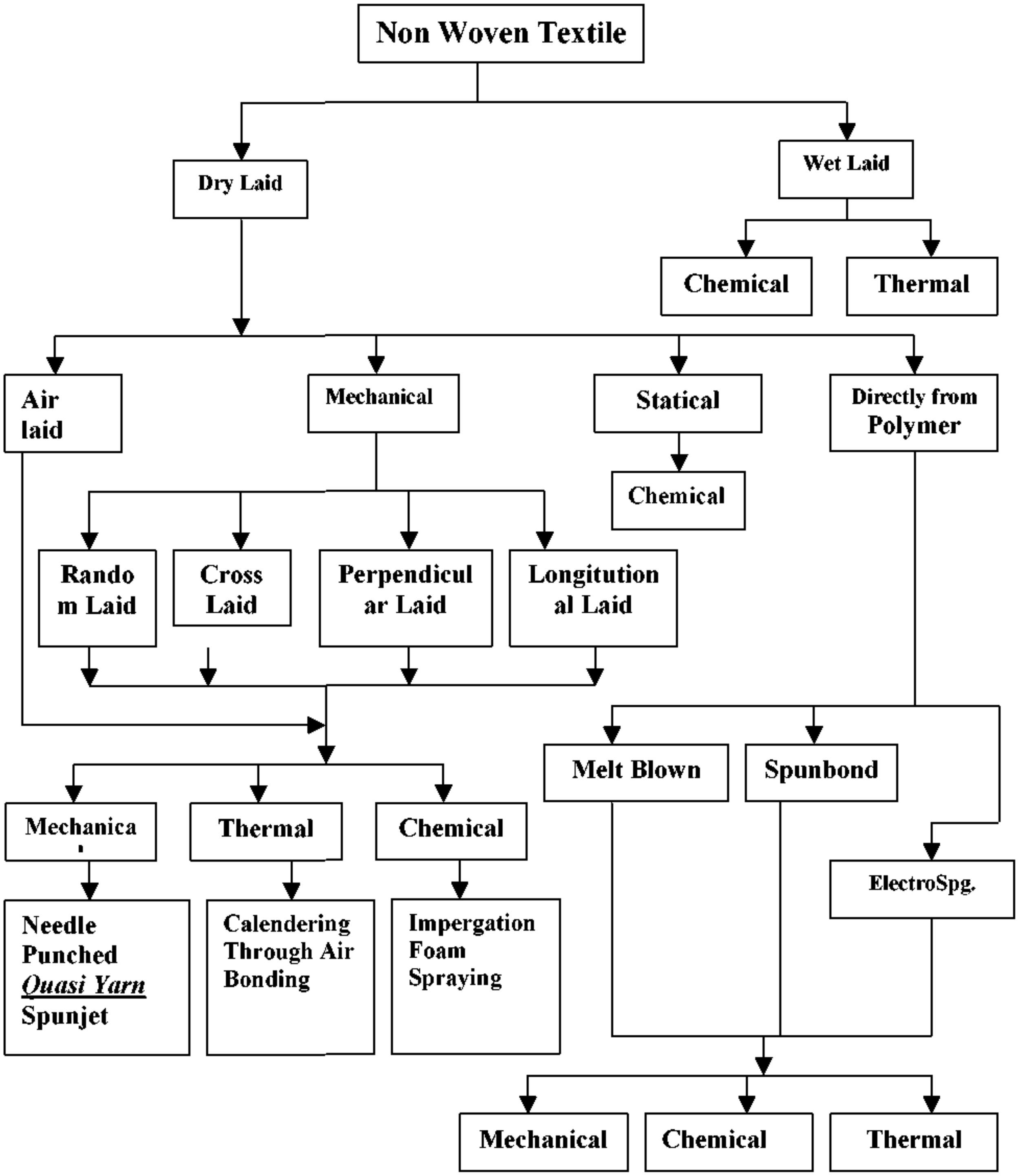


Fig. 1 Non woven Production

2.1.1 Web Formation

The web formation is very important process for further properties of non-wovens. The non woven are processed by mechanical ways of dry laid web formation (air laid, carding) or wet laid.

Dry Laid Web Formation:

At the beginning of dry laid web formation is carding that result in a parallel-laid web. The web can be then laminated crosswise or perpendicular to achieve higher isotropy of the fabric and higher weight per unit area. Another case of web formation is air laying.

Air laying Web Formation:

The orientation created by carding is effectively improved by capturing fibers on a screen from an air-stream. This is done on a Rando-Webber component. Starting with a lap or plied card webs fed by a feed roller, the fibers are separated by a licker-in or spiked roller and introduced into an air-stream.

Compared with carded webs, airlaid webs have a low density, a higher softness and an absence of laminar structure. Air laid webs great versatility in terms of fibers and fiber blends that can be used. The fibers are randomly oriented, which causes the higher isotropic behavior of the fabric. The disadvantage of air laying are low degree of fiber separation by tearing cylinder, irregularities in the stream leading to the differences in the fiber orientations in the layer or possible formation of entanglements in the air stream that could be avoided by low concentration of fibers in the air stream from 0,003 to 0,02 g/m^3 causing higher energy consumption and lower output. [2]

Wet laid:

Wet-laid nonwovens are made by a modified papermaking process. That is, the fibers to be used are suspended in water. A major objective of wet laid nonwoven manufacturing is to produce structures with textile-fabric characteristics, primarily flexibility and strength, at speeds approaching those associate with papermaking. Specialized paper machines are used to separate the water from the fibers to form a uniform sheet of material, which is then bonded and dried. In the roll good industry 5-10 % of nonwovens are made by using the wet laid technology. The advantage of low consistencies is the reduction of defects due to premature entanglement of the fibers in the furnishing. There are related disadvantages, however. One problem lies in finding a way to drain these large volumes of water through the sheet of nonwoven as it is forming without disrupting it. [2]

2.1.2 Web Fixation

Chemical Bonding:

Almost all nonwovens required a chemical binder in order to provide any measure of structural integrity. In addition, the binder was called upon to contribute and convey numerous properties that were necessary for the effective performance of the fabric. During this extended period, binders were essentially the weak element in developing fully acceptable nonwoven fabrics. The fibers that were available to the nonwoven industry were the same fibers that were available to the textile and other fiber-based industries; hence, the fibers were fully acceptable. Generally, the binder limited the performance of the nonwoven fabric. Chemical binders are applied to webs in amounts ranging from about 5 % to as much as 60 % by weight. In some instances, when clays or other weighty additives are included, add-on levels can approach or even exceed the weight of the web.

As polymer technology for manufacturers of synthetic binder systems improved, a greater variety of chemical building blocks became available with much greater flexibility in terms of binder strength, durability, and other properties. The introduction of cross-linkable and self-crosslinking binder polymers turned out an entirely new range of fabric properties. This was particularly noteworthy in durable nonwovens where such durability features as washability and dry cleanability were important.

The common methods of bonding include:

1 Saturation.

2 Foam.

3 Spray.

*Thermal Bonding***:**

The development of the past few years has shown that the share of thermally bonded webs is growing steadily. The first thermally bonded non-wovens were produced in 1940s. Initial products used rayon as the carrier fiber and plasticized cellulose acetate (PCA) or vinyl chloride (PVC) as the binder fiber. The viability of the thermal bonding process is rooted in the price advantage obtained by lower energy costs. However, the thermal bonding process also addresses the demanding quality requirements of the market place. The development of new raw materials, better web formation technologies and higher production speeds have made thermal bonding a viable process for the manufacture of both durable and disposable nonwovens.

Methods of Thermal Bonding:

1. Hot calendering
2. Through-air thermal bonding
3. Ultrasonic bonding
4. Radiant-heat bonding, etc.

Mechanical Bonding

Needle Punching:

Needle punched non-wovens are created by mechanically orienting and interlocking the fibers of a spun bonded or carded web. This mechanical interlocking is achieved with thousands of barbed felting needles repeatedly passing into and out of the web. The needle board is the base unit into which the needles are inserted and held. The needle board then fits into the needle beam that holds the needle board into place. The feed roll and exit roll. These are typically driven rolls and they facilitate the web motion as it passes through the needle loom. The bed plate and stripper plate. The web passes through two plates, a bed plate on the bottom and a stripper plate on the top. Corresponding holes are located in each plate and it is through these holes the needles pass in and out. The bed plate is the surface the fabric passes over which the web passes through the loom. The needles carry bundles of fiber through the bed plate holes. [3]

Today, there is one known methods of mechanical surface fixation of non-woven structures that can be applied onto 3D structures. Splicing by means of fibre bundles which is executed on the MULTIKNIT machine supplied at the market by the German company Mayer. The fig 2 shows the multiknit structure.

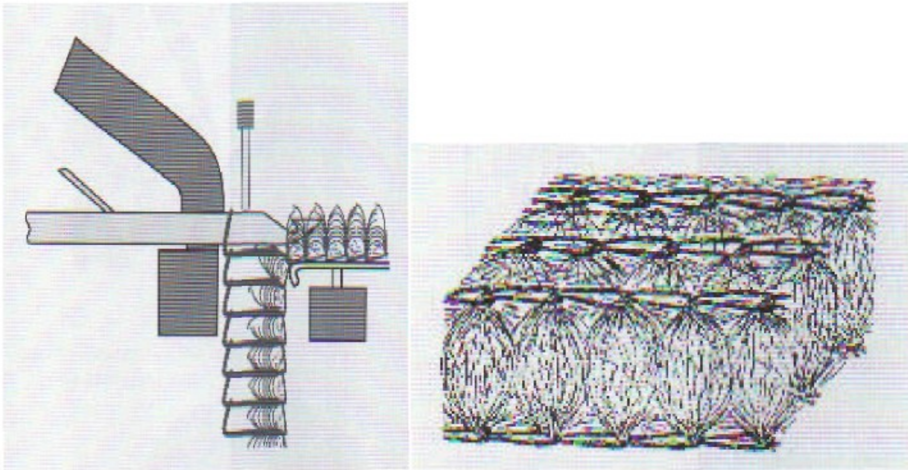


Fig. 2. Multiknit

Other totally different technology of mechanical surface bonding is under development still. Based on mechanical twisting of fiber ends outstanding from the fabric surface to „quasi-yarns“ and based on mechanical bonding of a suitable armor grid by these „quasi yarns“ to the one or both surfaces of the fixed structure, the new technique fixes the 3D structure faster and relatively inexpensive in comparison with conventional stitch-bonding. This technology is studied and developed at the Textile Faculty of Technical University. [4]

2.1.3 Non woven Fixed by Quasi Yarn

The basic structure for quasi yarn applied must be in vertically pleated form. The quasi yarn technique belongs the mechanical method of fixation, in there is no chemical used. The textiles fixed by quasi yarn are thick ranges from 4 mm to 50 mm. It depends on the arrangements of the machines and used of principles. The gsm of the final product ranges from 300 to 1000 g/m^2. The starting material gsm ranges from 20-100. The single fabric or multi fabric can be made, the different properties are obtained.

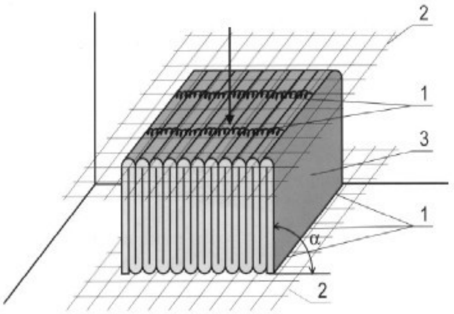
2.1.3.1 Structure of the Product

The basic structure is a wave formation in vertically pleated product. The fibers must pass through the products. Before the fixation of non woven the starting semi-product is passed trough the tooth containing rollers, the material is allowed to form in wave forms, then by the twisting units the quasi yarn is formed. Fig 3 shows the model of non-woven structure.

The structure of quasi yarn is very complex and present on the surface of the final product. Their join only the tops of pleats made on basic semi-products. The entanglement of surface fibers with each other to form a yarn and give strength to the material. The strength of the quasi yarn is depends on the number of free ends and free segments present in the material and either made from staple or filament. The strength of the product depends on the number of quasi yarns on the both surfaces.

The parameters of final product depend on the type of products, and the most important are thickness and gsm (number of the pleats of semi products per meter).

The different parameters are set according to materials selected also. The input and output speed are important parameters. For the quasi yarns are other important parameters. The most important are: Revolution, Twisting elements and Contact pressure between the twisting elements and surface of product



1 Quasi yarn
2 Reiforcing nets
3 Waves of nonwoven

Fig. 3 Model of non-woven structure fixed by Quasi Yarn and reinforcing by nets

2.1.3.2 Materials for their production

The semi product used for production of non-woven fixed by quasi yarn must be like that quasi yarn can be allowed to obtain. The material must have free ends fibers on its surface or free parts among bonds. Vertical pleating one or more layers can be used. The basic semi product are like: Needle punched, jet-lace, and spunjet or specical types of spun bonds. The manufacturing line for spunjet methods as shown in Fig.4 [6]

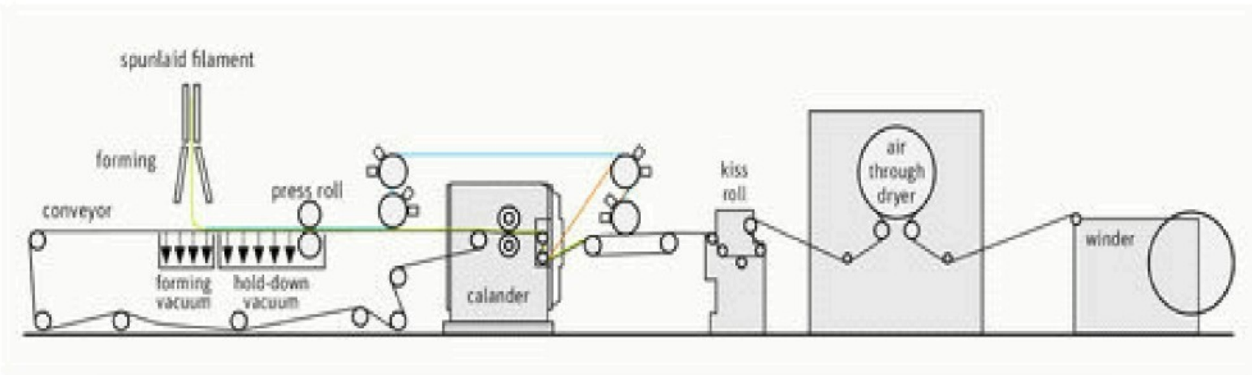


Fig. 4 Manufacturing Process for Spunbond and spunjet fabrics

2.2 Resemblance of quasi-yarn and classical yarn.

The view of the quasi structure was not available on anywhere neither in journals nor on internet. So, this is new work which is carried out by me and shown in my project thesis. For comparison of different classical yarn with quasi yarns structure, the yarns from Rieter are selected. [5]

In Com4 yarn in comparison with conventional ring-spun yarns, in the structure all the fibers lie parallel and are completely integrated in the yarn bundle. This leads to reduced hairiness and higher tenacity and elongation properties of the yarn. The view of Com4 yarn shown in fig. 5.

In ComfoRo yarn structure having made from rotor spinning. There are more free ends available in the outer surface of the yarn. The view of ComfoRo yarn shown in fig. 6.

In ComforJet yarn, formed by the flow of compressed air, shows very low hairiness with short fiber ends and small loops. This results in high wash and pilling resistance. The yarn softness and voluminosity lead to visibly higher fabric density and fabric evenness. The view of ComfoJet yarn shown in fig. 7.

The structure of quasi yarn is not obtained anyone, this view is obtained by the confocal microscope. In quasi yarn structure the loose surface fibers are twisted together with each other and form a strong cohesion of the pleats on the surface of final product. The fig. 8 shows the structure of quasi yarn by confocal microscope by 10x zoom.

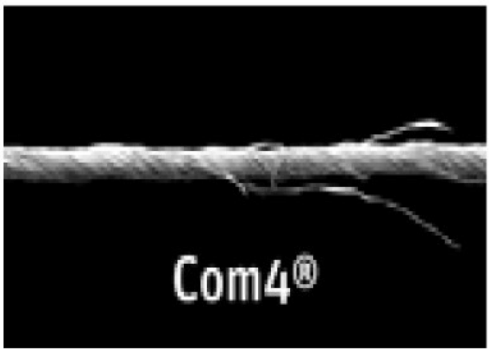


Fig. 5 Com4 Yarn by Reiter

Fig. 6 Comforjet Yarn

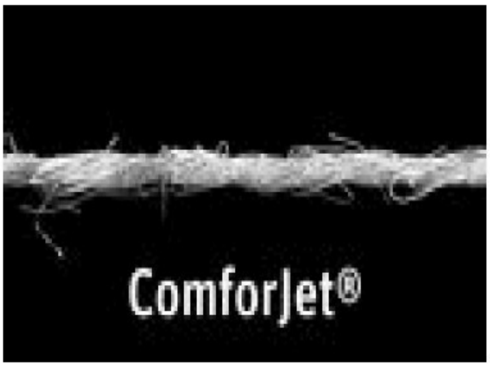


Fig. 7

Fig. 8 Quasi Yarn

2.2.1 Classical Yarn

The yarn is long continuous length of interlocked fibers suitable for use in production of textiles, sewing, crocheting, knitting, weaving and embroidery and rope making. Yarn can be made from any number of synthetic or natural fibers. Yarn are made up of any number of plies, each ply being a single thread these threads being twisted (plied) together to make the final yarn. The yarn is usually measured by weight. In the United States, balls of yarns are usually sold in three-ounce, four-ounce, six-ounce and eight-ounce skeins. In Europe the units used by the textiles engineers is often 'Tex'. This is gram per kilometer. The classical yarn the basic important parameter is the twist, either S or Z twist and the fig. 9 shows the yarn view. The equation 1 shows the relation ship between twists in yarns. [6]

$$TPI = TM\sqrt{Count} \tag{1}$$

TPI= Twist per inch.

TM= Twist Multiplier.

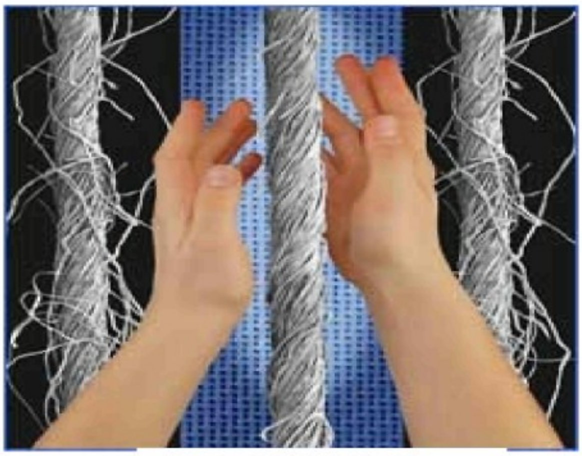


Fig. 9 View of Yarn

2.2.2 Quasi Yarn.

Method developed at the Department of Nonwovens of the Technical University in Liberec which is based on twisting of fiber ends protruding from the web or non-woven peaks into so-called quasi-yarn. The fig. 10 shows the quasi yarns on the surface of product and fig. 11 the model of quasi yarn.

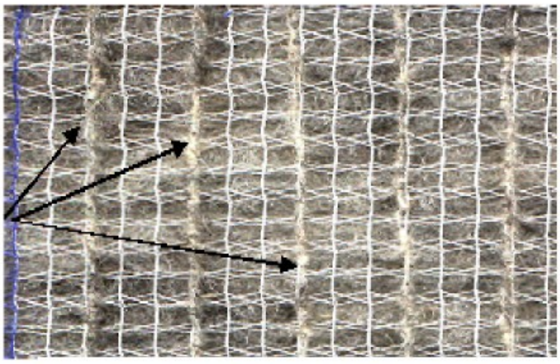


Fig. 10 Quasi Yarn on Surface

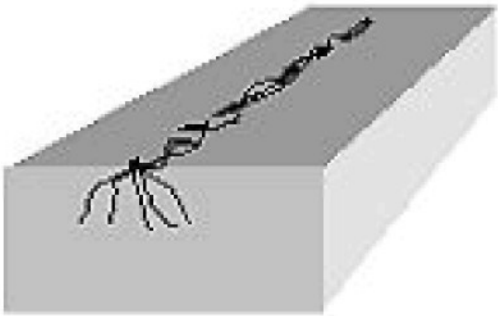


Fig. 11 Model of Quasi Yarn

2.2.2.1 Principle of Quasi yarn

Both classic and quasi-yarns belong to fiber formations that are made by fiber twisting. In contradiction to classic yarns, quasi-yarns are formed by twisting of ends or, as the case may be, of loose segments of fibers situated on surface of a structure - fleece or of other sort of a textile product. The fig. 12 shows the rotating principle for production of quasi yarn.

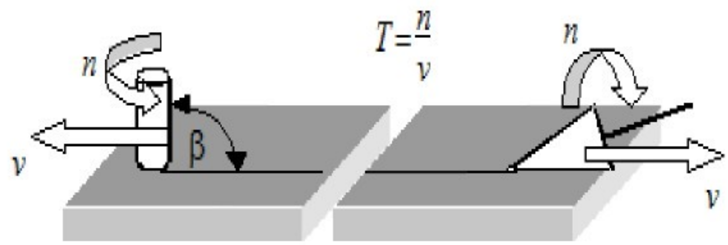


Fig. 12 Principle of Quasi Yarn

A model of a quasi-yarn structure can be illustrated in fig. 11. It can be compared to a „centipede". Its body represented by twisted fibers lies on the structure surface, its legs reach to the depth of the structure. As to principle of rise of quasi-yarn, we have found out that if a rotating cylinder- or cone-shaped body moves on the web surface by its base or by its surface line it leaves behind a „track" in form of twisted fibers. The shape of this „track" is similar to the classical yarn and therefore we called it „quasi-yarn". Quasi-yarns can be laid out on the web surface for example parallel, theoretically though in optional spacing. The basic technological parameter of the quasi-yarn is „T"- the number of the twists per 1m but its measurement on the quasi-yarn is very difficult. [7]

Technology parameters for quasi-yarns

By analysis of the system for quasi-yarn production, it is possible to achieve a list of important technological parameters:

- Diameter of the twisting device d;
- Revolutions of the twisting device n;
- Velocity of the fiber shift motion $v_p = v_2$ under the twisting device;
- Inclination angle α between the twisting device and the surface;
- Contact pressure between the surface of the twisting device and the structure surface.

The contact pressure value is influenced by:

- Structure density values r_1, r_2
- Structure itself (orientation of structure elements against loading) and used fiber material characteristics (flexural rigidity, fiber fineness etc.)

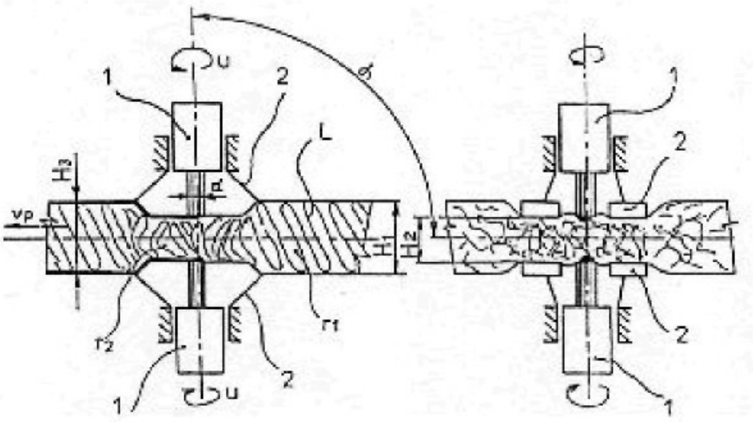


Fig 13 System for Quasi Yarn Production

It is evident that the effect of the twisting device depends on its geometric shape and the "roughness" of its friction area. Characteristic parameter of classic yarns is their twist T_{clas} - number of twists per one meter of yarn. Characteristic parameter of quasi-yarns T_{quasi} is defined similar. It is the ratio of the twisting device revolutions *n [1/s]* and of the rotating body moving velocity v_2 *[m/s]* (or of the textile structure moving velocity under the rotating body). $T_{quasi} = n/v_2$ *[1/m]*[7].

2.2.2.2 Properties of Quasi-yarn

- The quasi yarn fixation technique is used for web or nonwovens. The quasi yarn present only on the surface of materials, and it cannot be removed.
- The classical yarn contains the twist, but quasi yarn doesn't contain any twist, it is the just entanglement of fibers present on the surface of material.
- It is the efficient and fast method for the production of non-wovens which are mechanical fixed.
- The quasi yarns fixed products has lot of possibilities for application (lamination) of reinforcing nets to the surface of the products.
- Quasi yarn fixation technique can be used to form 2D and 3D fabric by lamination process is shown in Fig. 23.
- The strength of quasi yarn is much lower than classical yarn. The results are shown in tables 8 to 16.

For testing of quasi-yarn strength it is not possible to use identical methods as for classic yarn testing. This is because it is difficult to separate quasi-yarns from the product surface as well as because a quasi-yarn separation interferes its cohesion.

The fig. 14 shows example of cohesion test of quasi yarn. And fig. 15, 16 and 17 shows the results of quasi yarn by different parameters.

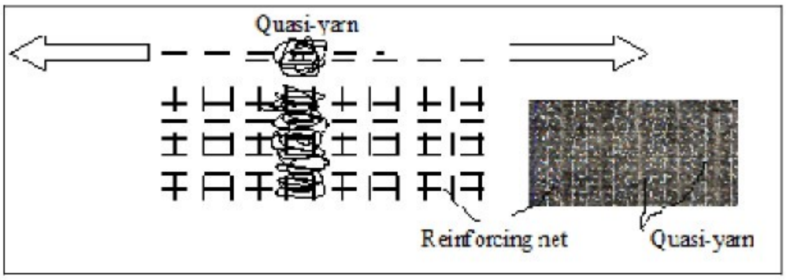


Fig. 14 Example of cohesion Test

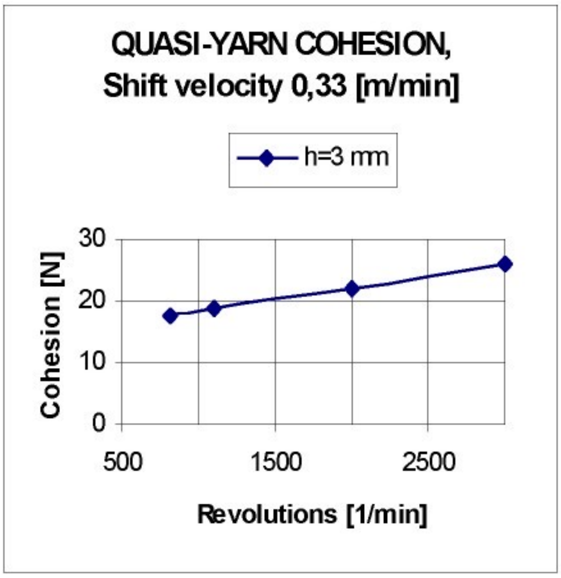


Fig. 17 Constant out-put speed

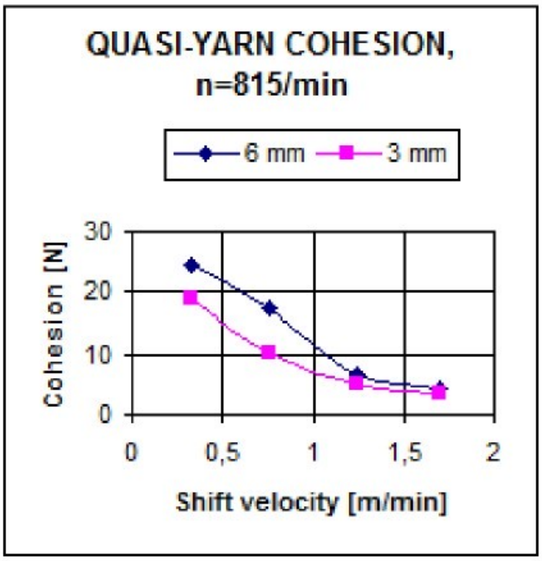


Fig. 16 Constant Revolutions

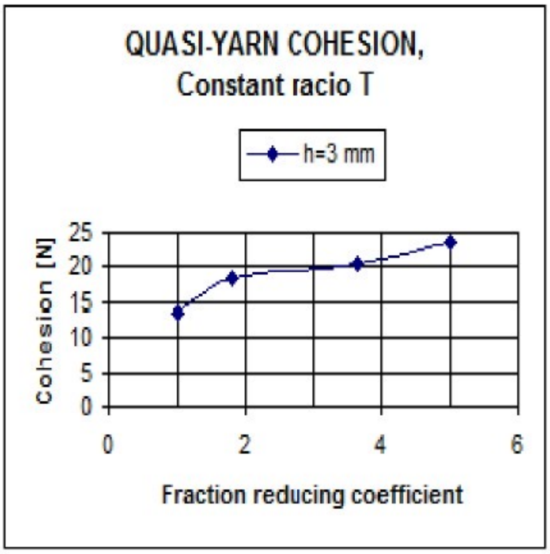


Fig. 15 At constant ratio T=n/v

For studying of technological parameters influence on the quasi-yarn cohesion was consequently used a mentioned cohesion test. That result depends upon the shift velocity v_2 of the nonwovens structure under cylinder body rotating with constant revolutions n – is evident is shown in fig. 16. The dependence of cohesion S [N] fraction reducing constant at constant ratio T shown in fig.15. The dependence of cohesion S [N] upon the revolutions n of rotating cylinder body when the shift velocity v_2 of the structure under rotating body is constant is shown in fig. 17 The eq.2 shows the formula for calculating constant ratio. [• •

$$T = n / v \qquad (2)$$

Where, n= number of revolutions and v=output speed.

2.2.2.3 Systems used for quasi-yarn formation.

Old System for quasi-yarn Formation

Czech patent CZ 192693 (European patent 0 648 877 A1) is used for quasi-yarn formation. A scheme of an appliance enabling the production of 3D textiles which is fixed by quasi yarn is shown in fig.18.

To control the amplitude of the web waves, is used the peripheral velocity v_3 of the working roller 3. To control the frequencies of web waves, the velocity v_2 of the conveyor 2 is used.

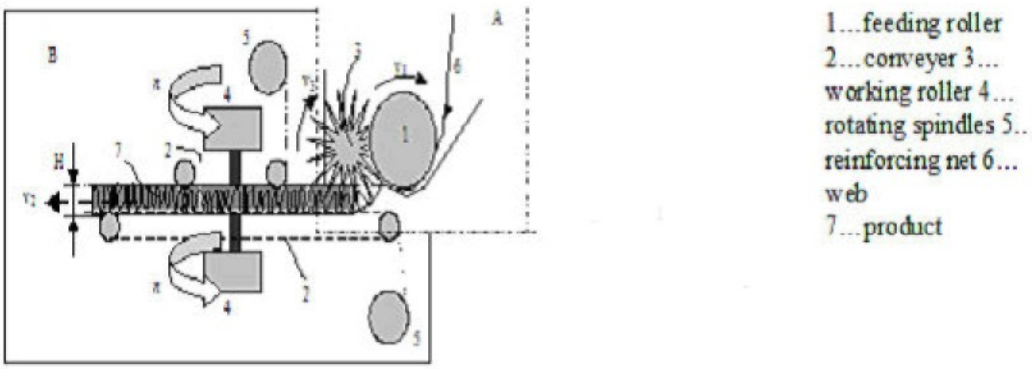


Fig. 18 Old System for 3D non-woven Processing Fixed by quasi yarn and two reinforcing nets

New Systems for quasi-yarn Formation

Principle of a new method (patent application PV 2007 – 293) shown in fig.19. This is derived from the system showed at fig.18 and machine working by this principle is shown fig.20. Precision of web waves made of vertical lapped semi-product is made by two teeth-wheels, omitting of reinforcing nets is allowed by using of more systems for quasi-yarns application arranged more times over. [8]

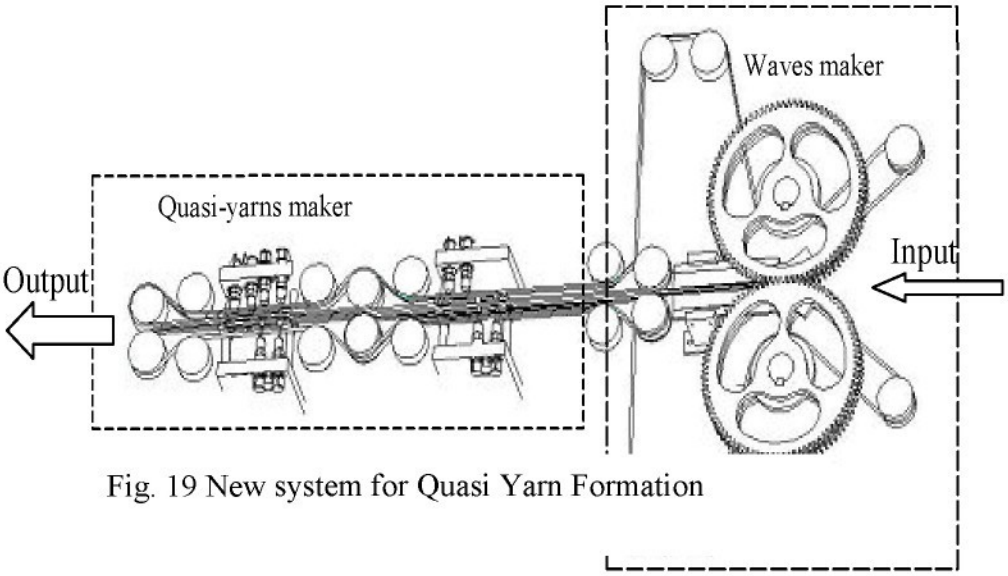


Fig. 19 New system for Quasi Yarn Formation

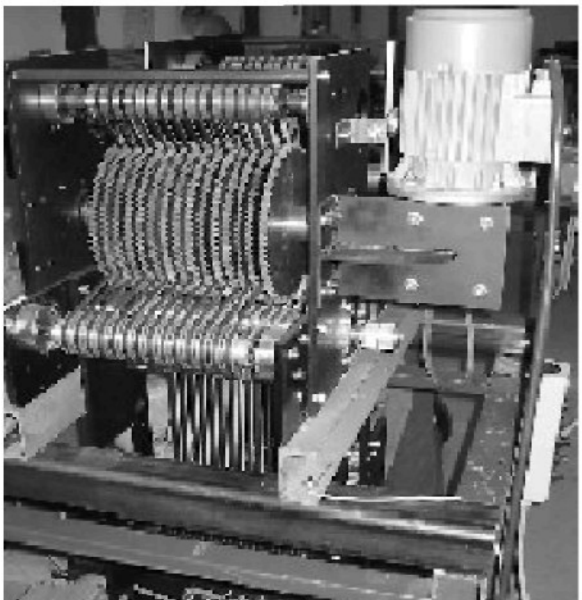


Fig. 20 Model of working machine

2.2.2.4 View of Quasi Yarn Formation by Fast Camera

The fast camera was used to view formation and structure of the quasi yarn. The loose fibers on the surface get entangled with each other by the rough surface of twisting units. The view of quasi yarn formation is shown in fig. 21 and 22. The difference between two pictures is the difference in contact pressure between the surface and rotating unit. [7].

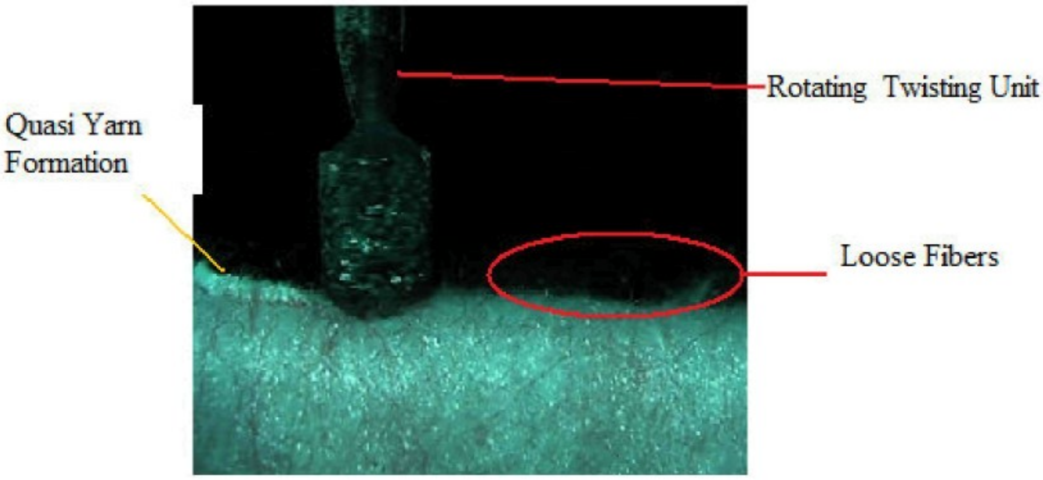


Fig. 21 View of quasi Yarn formation by Fast Camera.

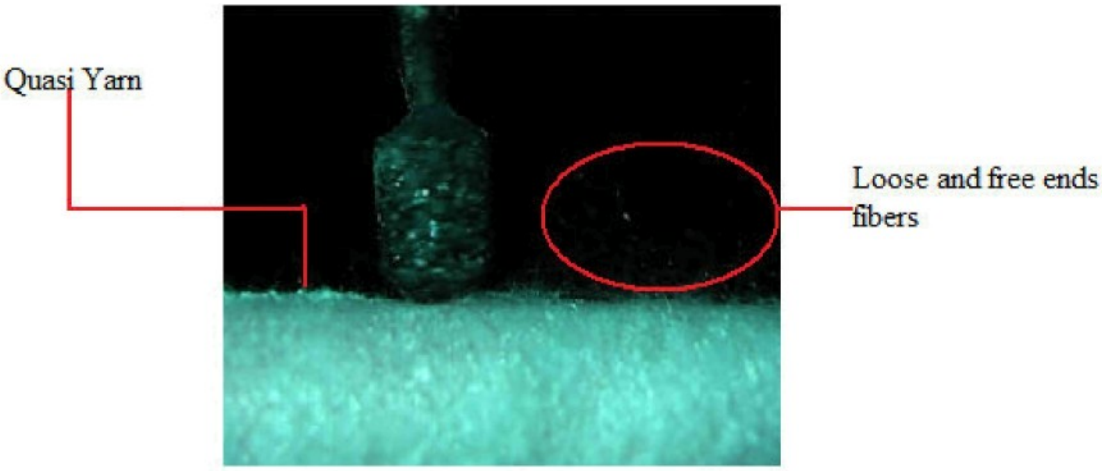


Fig. 22 View of Quasi Yarn formation by Fast Camera.

2.2.2.5 Application of quasi-yarns

As stated already in the introduction, quasi-yarns technology may be used both for fleece fixation and for lamination of specific products. Products suitable for quasi-yarn technology application can be characterized as follows:

Characteristics of advisable final product structures:

The basic characteristic is the fact that fibers have to go through the final product from its one side to the other one. This important condition fulfill all structures perpendicularly composed of a thin layer (carded web, non woven), or pneumatic manufactured structures. Quasi-yarn technology has been developed for 3D textiles structures manufactured through vertical folding of materials with free ends of fibers or free segments of fibers on the surface of material.

Characteristic of reinforcing nets:

Considering that during the quasi-yarn formation a rotating device has to „grip loose segments of fibers“ going through the opening of the reinforcing net and to twist them into quasi-yarn, these openings must be sufficiently large. It is suitable to use reinforcing textiles with openings larger than 2x2 mm.

Characteristic of Textiles for Lamination:

The only condition has to be fulfilled. The surface of the both laminated textile fabrics, between which the quasi-yarn is to be formed, has to contain loose fiber segments or fiber ends that can be „gripped“ and twisted by the rotating device into quasi-yarn[9]

By suitable mutual layout of the rotating body and the textile fabric surface, e.g. according to Fig.23, it is possible to bond textile fabrics together by „surface-broad“ lamination. By repeated lamination it is possible to produce textile fabrics of requested thickness (e.g. 10 to 200 mm). The fig 21 shows the principle of lamination and product formation [5].

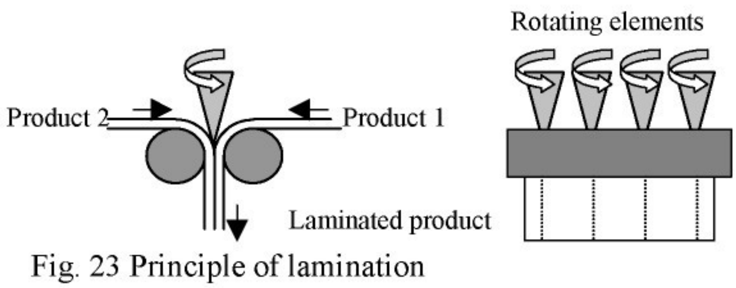


Fig. 23 Principle of lamination

2.3 Suggestion for the experimental work.

Among new technologies developed in last five years belong vertically pleated nonwovens fixed by quasi-yarns. This diploma work was made for an explanation of an effect of technological conditions upon quasi-yarn strength. The aim was defined like this:

1. Suggest material testing methods for production of non-wovens fixed by quasi yarn technique with the aim of maximum quasi-yarns tensile strength.
2. Define the technology parameters important for production of non-wovens fixed by quasi-yarn technique.

2.3.1 Selection of material for experiment.

The material selected for the production are nonwoven like needle punched fabric, jet lace and spunjet fabric made by France patent. The selection of jet lace and spunjet semiproducts are, their having high production of 250 m/min to 400 m/min and they are having light in weight. The more number of free ends on the surface in case of needle punched. The Material used in experiment are shown in tab.1.

. Tab. 1 Shows the Selected materials

Notations	GSM (Gram per Square Meter).	Material	Composition
R1	0,60	Needle Punched	100% PES
R6	0,60	Jet Lace	100% PES
R15	0,60	Spunjet	100%POP

No.R1 Stands for Needle Punched Fabric
No.R15 Stands for Spunjet Fabric
No.R6 Stands for Jet-lace Fabric

The difference in the materials that R15 is made from filaments and R6 is made from staple. The technology of fixation for the both materials remains same. R1 is classical needle punched fabric.

2.3.2 Suggest the technological parameters selected.

In experimental part 1, will be varied the output speed in different intervals and revolutions remains constant then will exam in the effect on the strength. The speed intervals are shown in tab.2.

Tab. 2 Different Speed intervals

Sr No	Speed [m/min]	Revolutions [rpm]
1	1.5	Constant (8120)
2	3.5	Constant (8120)
3	5.5	Constant (8120)
4	7.5	Constant (8120)
5	10	Constant (8120)

In experimental part 2, will be varied the revolutions in different intervals and output speed remains constant then will exam in the effect on the strength. The revolution intervals are shown in the tab. 3.

Tab. 3 Different Revolutions intervals

Sr No	Speed [m/min]	Revolutions [rpm]
1	Constant (2.5)	1624
2	Constant (2.5)	3248
3	Constant (2.5)	4872
4	Constant (2.5)	6496
5	Constant (2.5)	8120

In experimental part 3, will be varied the both revolutions and output speed at a constant ratio, then will exam in the effect on the strength. The out put speed and revolutions intervals are shown in the tab.4

Tab. 4 Different Speed and revolutions intervals at constant ratio T

Sr No	Speed [m/min]	Revolutions [rpm]	Ratio T
1	1	3248	3248
2	1,5	4872	3248
3	2,5	8120	3248

T=n/v

Where, n= no. of revolutions and v=Output Speed

2.3.3 Suggestion for Selecting Testing methods:

The different microscopes will be use to study and view the structure of quasi yarn. Firstly will use normal microscope and then highly magnified scanning electron microscope to see the structure and finally delicate confocal microscope will be used.

For study of quantity of free fibers or free sections on the surface of semiproducts nonwoven-that are important for quasi yarn formation, the pre-testing methods are selected. Martindale abrasion tester and Kwabata testing method. I supposed these tests tells about the number of free ends of fibers and the free segments in the form of pills (Martindale) or the form of MIU and Roughness (Kwabata).

The important parameter is the strength of final product. The strength of single quasi yarn will be measured. The sample of single quasi yarn will be removed very delicately from product and put into frames. Then low amount weight measuring sensor is used to measure the strength. The results of the strength test are shown in tables 8 to 16.

3 *Experimental Part*

To fulfill the mentioned aim, the experimental work was divided into three different parts

1. Selection of semi product for the fixation by quasi yarn technique, the method of testing the semi-products by Kawabata and Martindale abrasion tester
2. Selection of the technological parameters of the machine formation for quasi yarn
3. Quasi yarn strength test.
4. Microscopical study of quasi yarn

In the end the results and comparison of different results are shown in graphs.

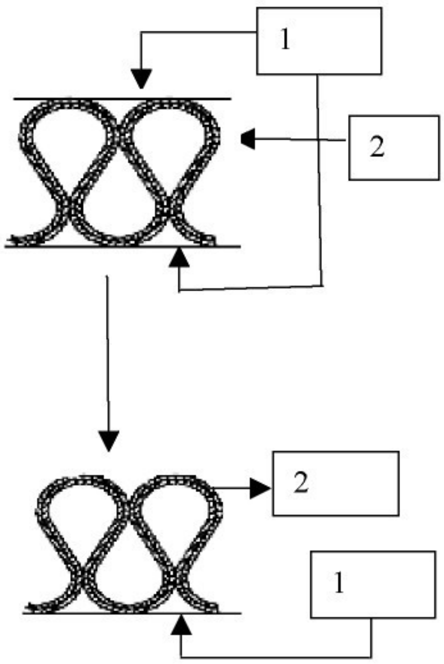
3.1 Sampling of Semi Product for experiment.

For Martindale test was selected of semi-products to test the fabric to fabric friction. In this test, same fabric to fabric were abraded, instead of using cotton or wool as lower base material. So, the upper and lower based materials were the same semi-product used. The samples are marked same as shown in capital 2.3.1. The sample was made 140cm circular fabric as per standards. For Martindale test 10 samples are taken.

For the microscopical study the different samples are prepared. For confocal microscope the normal quasi yarn are removed from material very delicately and the seen under the confocal microscope. In simple microscope the glycerin solution was used to prepare the sample on glass slide. For Scanning Electron microscope the sample is pleated with gold pleating, so that it becomes conductive, then sample is seen under the microscopes by varying the pixels.

To measure the strength of single quasi yarn was very difficult, because it is present on the surface of the material and it cannot be removed. The second problem was that, if i used single final product then quasi yarns was produced on the both sides of the semi- product, then testing of single quasi yarn becomes impossible. In the end, I used two semi-products at same time for final product and afterwards was converted into single semi-product very delicately by opening, so that quasi yarn cannot break as shown in fig. 24 and single quasi yarn is obtained.

Then selecting these single quasi yarns from surfaces from different places and then putted into the frames. After pasting with gums and then keep it for some time. When it gets dried then tested using testing machine. For testing the strength test to around 25 samples of each are tested, so that it can show the appropriate trends in strength.



1 Quasi Yarn on both sides
2 Two layer non-woven Material

1 Single quasi yarn.
2 Single layer non-woven

Fig. 24 Sampling of quasi yarn for Strength test

Fig. 25 Preparation of sample

3.2 Microscopical view of quasi-yarn

The different microscopes are used to see the structure of the quasi yarn. I had used Normal microscope, Scanning Electronic microscope and polar microscope. The different forms of the pictures are obtained shown in Fig. 26, 27, 28 and 29.

Fig. 26 Confocal Microscope with 10x zoom

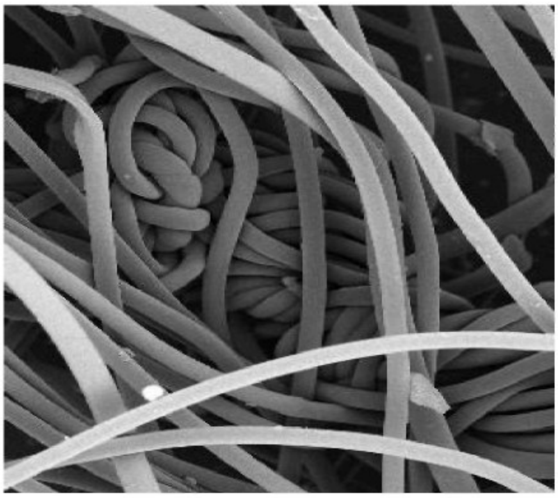


Fig. 27 Electron Microscope with 300x zoom

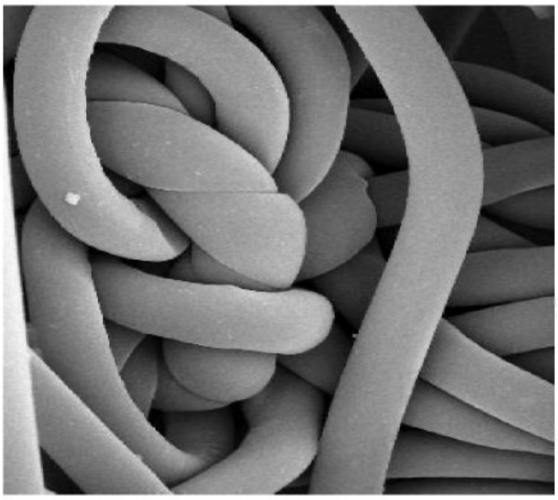


Fig. 28 Electron Microscope with 1kx zoom

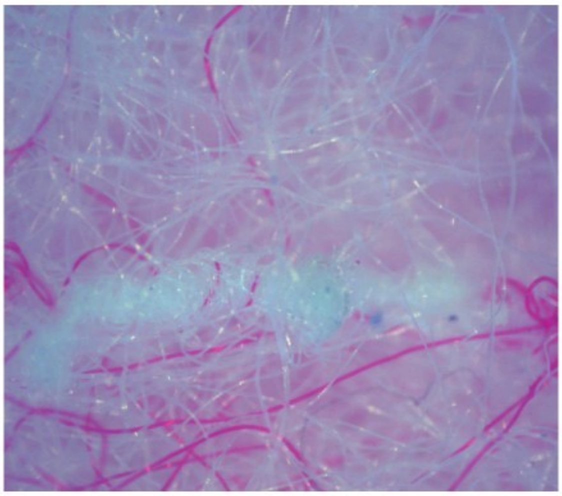


Fig. 29 Normal Microscope with 20x zoom

3.3.1 Abrasion Testing by Martindale

The Martindale abrasion is used to test surface of the fabric, by pill tests. In the Martindale tester the fabric is cut into the 140mm circular fabric, then put into the machine. I had used the same non woven fabric, so that checked the pills on the fabric to fabric. In Martindale instrument the upper part is rotating and lower part the stationary. The 250 cycles were set on the machine for the all the fabrics. The numbers of revolutions are set based on the type of the fabric and the arrangement of the fibers and filaments in the structure of the materials. The pills are depends on the number of free ends present on the material and either made from staple or filament. The staple containing material having loose fibers and can have more ends so that it can easily entangled with each other and the more number of the pills and the fabric having uneven surface having more pills forming tendency.

After the completion of revolutions the material is removed and then checked the pills formed on the fabric by the visual test, there is not any automatic method of grading these samples, this is only done manually by eyes, so that there are not fixed results, it depends on observer to observer. The results of the standard were compared with the samples.

The grading system is shown in tab. 5.

Tab. 5 Grading system of Martindale test.

Grading	Condition of sample
1	Worst too much pills
2	Worse still pills
3	Medium smalls pills
4	Good very small pills
5	Very Good No pills

Fig. 30 Martindale Abrasion Tester

Few Samples from Martindale:

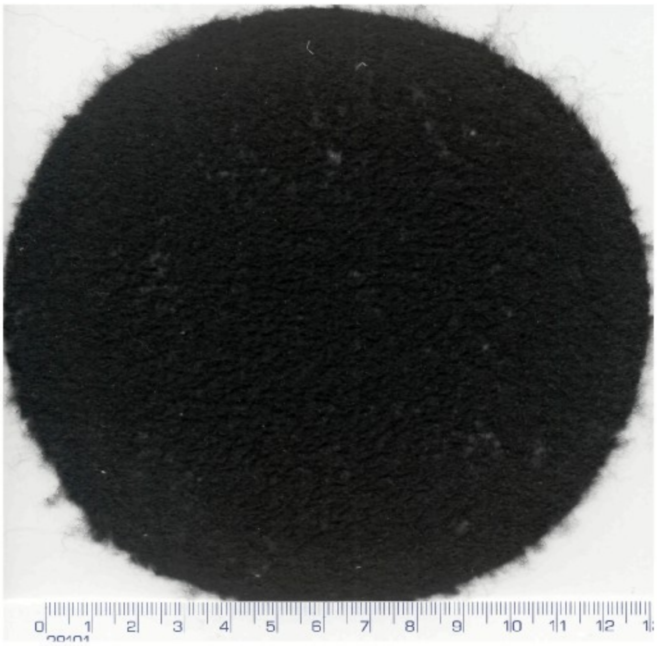


Fig. 31 R1 Samples More Pills

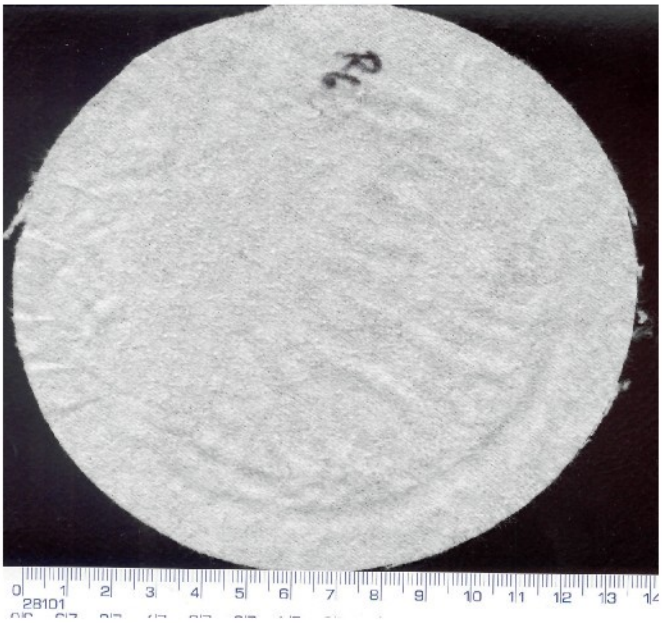


Fig. 32 R6 Samples Almost No Pills

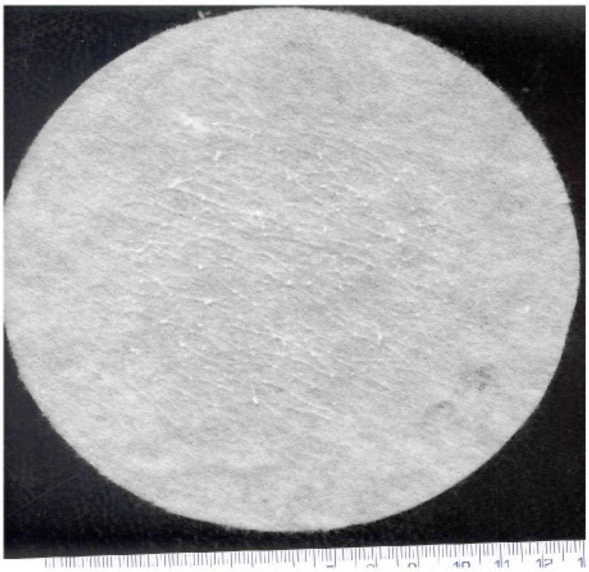


Fig. 33 R15 Samples Pills

Results of Martindale Abrasion Test:

The results of the abrasion test are based on the grading system, shown in tab. 5

Tab. 6 Shows the results of Martindale Abrasion Test

Sr No	Material	Pills Test
1	R1	2,5
2	R6	4
3	R15	3

3.4 Kwabata Test

Kwabata is used for the surface test of the material, there are various versions of kwabata available, these versions are used to test the different properties of the material. I had used this kwabata test to check the friction and roughness measurement of the basic semi product. For measurement 20x20 cm sample is cut. Then put the sample under the machine and respective parameters are set like:

Tension is applied to specimen 20 gf/cm along frictional force direction.

Sweep of displacement of the contactor on the surface of the specimen: 2 cm

Velocity of the displacement of the contractor: 0.1 m

The sample is put under the sensors there are two sensors, one is used for friction measurement and other is for roughness. The sensor goes first forward 1 cm and then back 1 cm. Then graph is obtained with and the change friction is measured.

The data is obtained in small notations like: MIU, MMD and SMD.

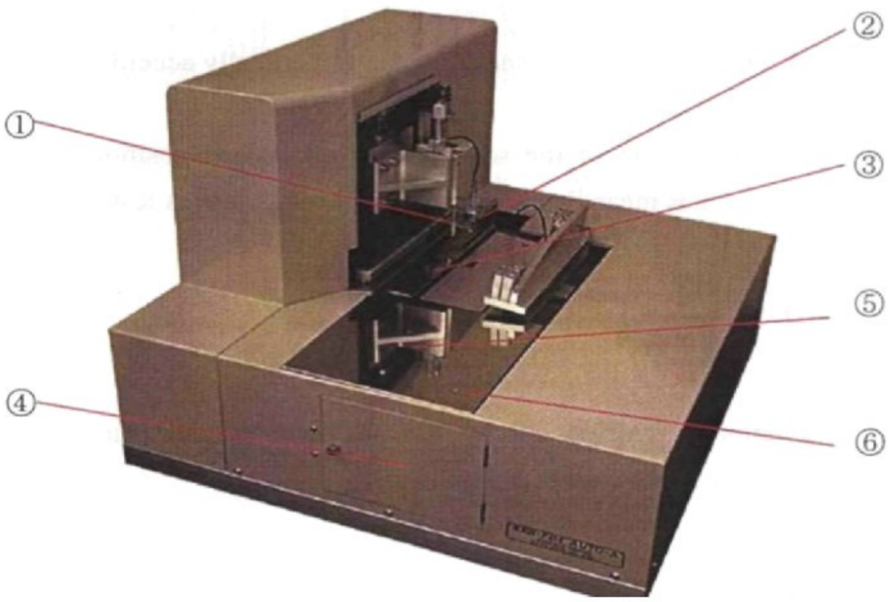


Fig. 34 Kwabata instrument of Surface Test

1. Geometrical Roughness Sensor.

2. Coefficient of Friction Sensor.

3. Bed for Sample.

4. Panel for manual Operations

5 Jaws for the accurate area for measurement

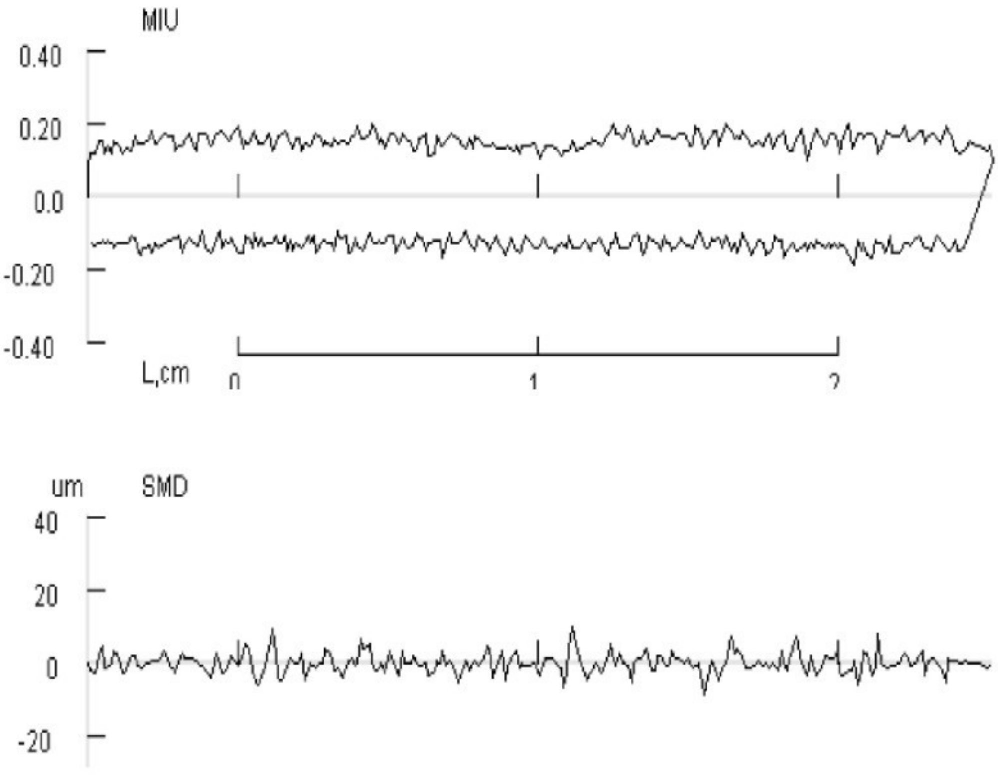


Fig. 35 Kwabata Graph after Surface Test

Results of Kwabata Tests

The graphs are obtained in the machine and data is formed in the form of excel data form.
The kawabata instrument used to test the roughness of the material and the result are shown in tab 1. The MIU denotes the means value of friction a MMD denotes Standard Deviation. And SMD denotes mean value of Roughness in mm.

Tab.7 Shows the results of Kwabata Test

Materials	**Mean(MIU)[unit non]**	**Std Dev(MMD)[unit non]**	**Roughness(SMD) [µm]**
R1	0.22	0.01	4.35
R6	0.21	0.01	2.8
R15	0.22	0.01	2.45

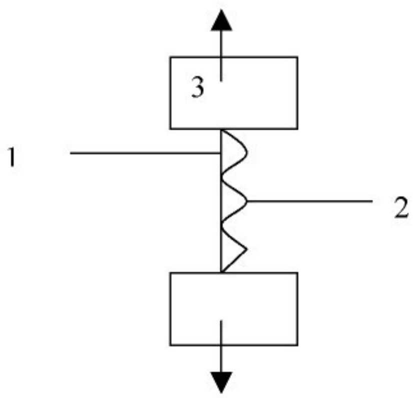
The full detailed results of every test is shown in Annexture 1

3.5 Testing of quasi Yarn.

The strength is the important parameter of the final product, so that to note down that how much it is durable. For testing of quasi-yarn strength it is very delicate to use identical methods as for classic yarn testing, because quasi yarn cannot be removed from the material like other classical yarn, if they are trying to remove the whole material structure gets destroyed. So I had tested the strength of the quasi yarn with its final products and note down the force where these quasi yarn breaks.

For testing of quasi yarn I had used Labor tech strength tester and the sample is placed in the frame and then pasted into it. After this keep it for sometime until it dried, then put into the jaws and paper is cut and allowed to break quasi yarn with 5 N sensor.

Fig. 36 Dynamometer 2.0 Used as Strength Tester



1 Quasi Yarn

2 Nonwoven product

3 Jaws

Fig. 37 Testing view of quasi yarn strength test

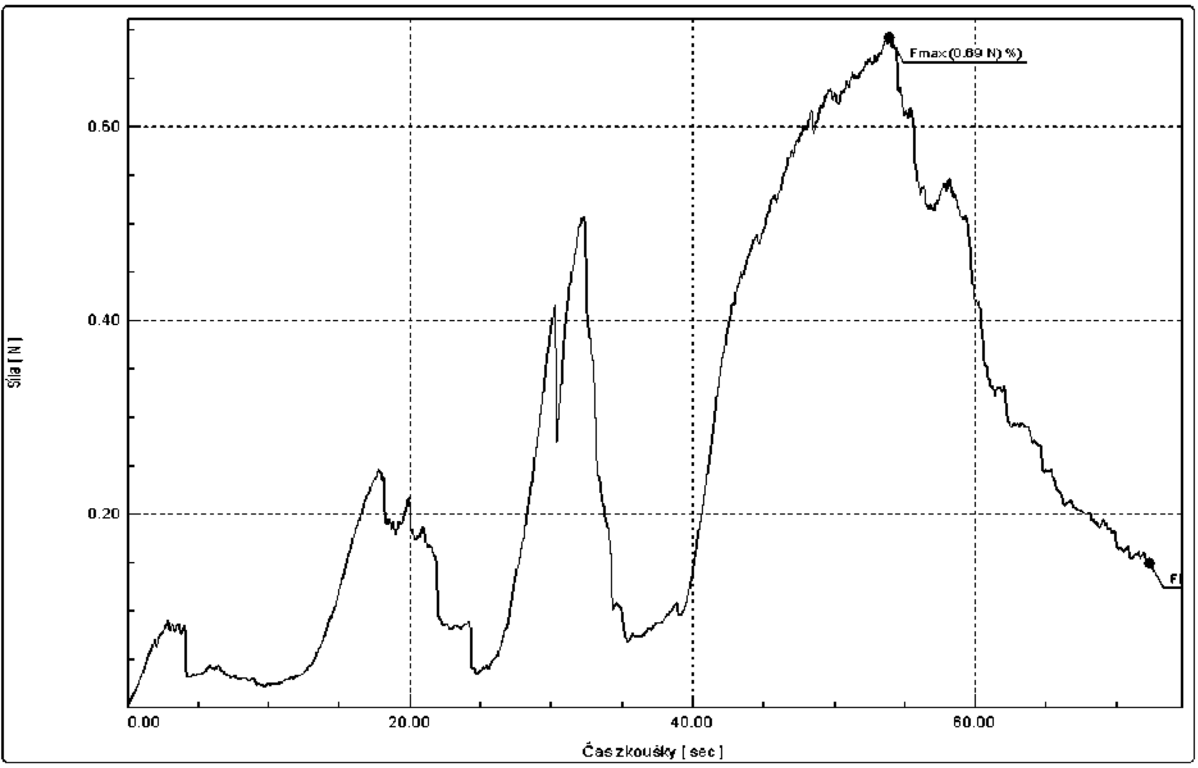


Fig. 38 Shows strength curve for quasi yarn

The Fig.38 is the example of the strength curve. In this curve i had accepted the peaks of the curve, so that where this quasi yarn breaks. The three waves are selected for testing. This every peak belongs to the strength of quasi yarn between two adjacent waves. Other detailed results of strength of quasi yarn is shown in annexure 2

3.5.1 Survey of results of Quasi Yarn strength Test

The strength is measured the peak values of curves. The results of the strength tests are shown in tables. The materials are marked as shown in 2.3.1.

Remarks: A denotes that the samples cannot produce, either due to the low speed or less revolutions.

Results of Tests R1

Tab. 8 Shows the results of strength test at constant revolutions.

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance [%]
1	1.5	8120	1.56	0.32	20.20
2	3.5	8120	1.50	0.51	33.69

3	5.5	8120	1.07	0.37	34.17
4	7.5	8120	0.38	0.15	39.73
5	10	8120	A	A	A

Number of samples taken are 20.

Tab. 9 Shows the results of strength test at constant speed.

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance [%]
1	2.5	1624	A	A	A
2	2.5	3248	0.54	0.26	43.00
3	2.5	4872	1.18	0.44	37.48
4	2.5	6496	1.32	0.50	37.63
5	2.5	8120	1.36	0.53	39.02

Number of samples taken are 18.

Tab. 10 Shows the results of strength test at constant ratio. T

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance [%]
1	1	3248	1.66	0.39	23.49
2	1.5	4872	1.47	0.47	32.22
3	2.5	8120	1.36	0.59	39.53

No. of samples taken are 20.

Results of Tests R6

Tab. 11 Shows the results of strength test at constant revolutions

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance [%]
1	1.5	8120	0.35	0.11	31.31
2	3.5	8120	0.34	0.09	25.00
3	5.5	8120	0.34	0.10	30.86
4	7.5	8120	0.13	0.05	35.52
5	10	8120	A	A	A

Number of samples taken are 22.

Tab. 12 Shows the results of strength test at constant speed

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance [%]
1	2.5	1624	A	A	A
2	2.5	3248	A	A	A
3	2.5	4872	0.18	0.05	29.38
4	2.5	6496	0.21	0.05	25.24
5	2.5	8120	0.24	0.07	28.69

Number of samples taken are 18.

Tab. 13 Shows the results of strength test at constant ratio

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Devation [N]	Variance [%]
1	1	3248	0.228	0.074	32.24
2	1.5	4872	0.232	0.061	26.36
3	2.5	8120	0.236	0.068	28.69

Number of samples taken are 22.

Results of Test R15

Tab. 14 Shows the results of strength test at constant revolutions

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance[%]
1	1.5	8120	1.0	0.41	41.13
2	3.5	8120	0.89	0.30	33.90
3	5.5	8120	0.29	0.08	28.73
4	7.5	8120	A	A	A
5	10	8120	A	A	A

Number of samples taken are 19.

Tab.15 Shows the results of strength test at constant speed

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation[N]	Variance [%]
1	2.5	1624	A	A	A
2	2.5	3248	0.28	0.08	29.14
3	2.5	4872	0.38	0.11	28.69
4	2.5	6496	0.38	0.12	34.43
5	2.5	8120	0.43	0.16	37.56

Number of samples taken are 21.

Tab.16 Shows the results of strength test at constant ratio

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation[N]	Variance [%]
1	1	3248	0.43	0.16	36.98
2	1.5	4872	0.43	0.14	33.37
3	2.5	8120	0.43	0.16	37.56

Number of samples taken are 15.

The full detailed results of every test is shown in Appendix 2

4. Evaluation of Result

4.1 Influence of altering technological parameters on the quasi yarn strength.

Tests for R1:

Varying the speed

In this experimental part we had varied the output speed in different intervals and then examined the effect on the strength of quasi yarn. The speed intervals are shown in tab.17.

Tab. 17 Data for strength at different speed intervals at constant rpm

Sr No	Speed [m/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance [%]

1	1.5	8120	1.56	0.32	20.20
2	3.5	8120	1.50	0.51	33.69
3	5.5	8120	1.07	0.37	34.17
4	7.5	8120	0.38	0.15	39.73
5	10	8120	A	A	A

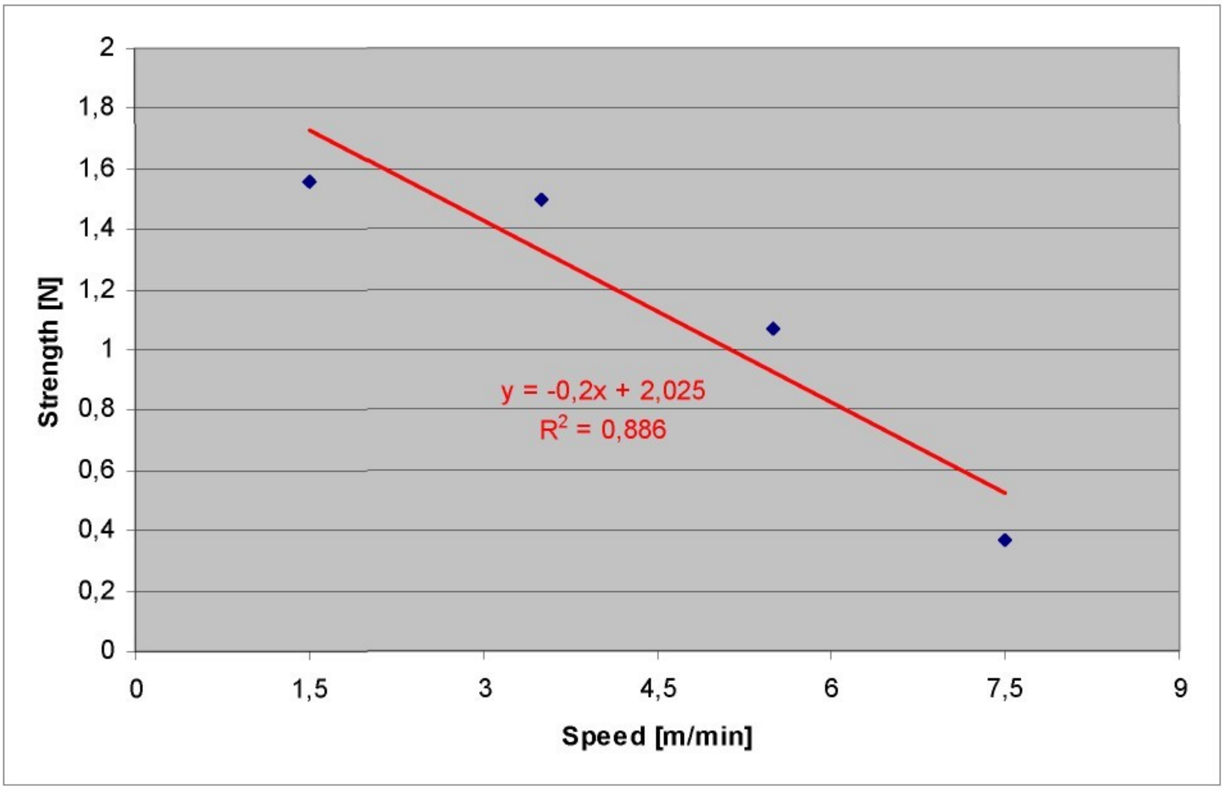


Fig. 39 Shows the trend of strength at different speed intervals

Varying the revolutions

Tab. 18 Data for strength at different rpm intervals at constant speed

Sr No	Speed [m/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance [%]
1	2.5	1624	A	A	A
2	2.5	3248	0.54	0.26	43.00
3	2.5	4872	1.18	0.44	37.48
4	2.5	6496	1.32	0.50	37.63
5	2.5	8120	1.36	0.53	39.02

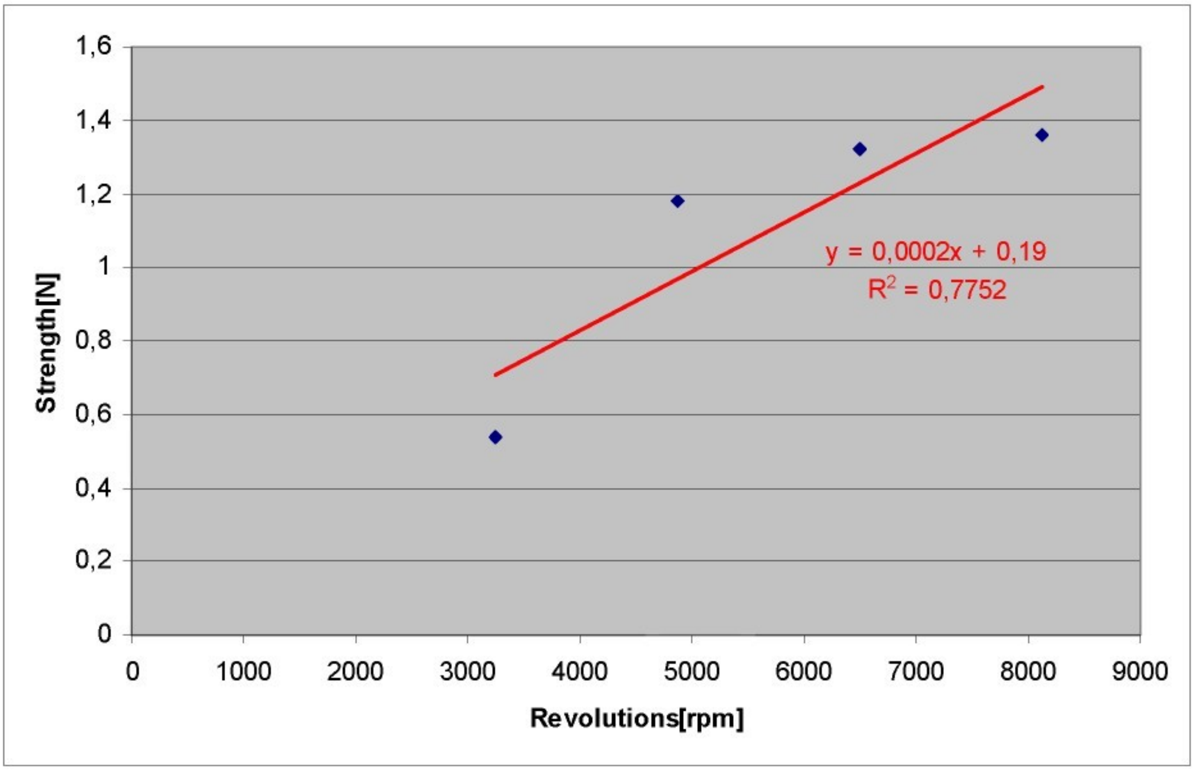


Fig. 40 Shows the trend of strength at different rpm intervals.

At Constant Ratio T

Tab. 19 Data for strength at constant ratio of rpm and out put speed inervals

Sr No	**Speed [m/min]**	**Revolutions [rpm]**	**Average Strength[N]**	**Standard Deviation [N]**	**Variance [%]**	**Ratio T**
1	1	3248	1.66	0.39	23.49	3248
2	1.5	4872	1.47	0.47	32.22	3248
3	2.5	8120	1.36	0.59	39.53	3248

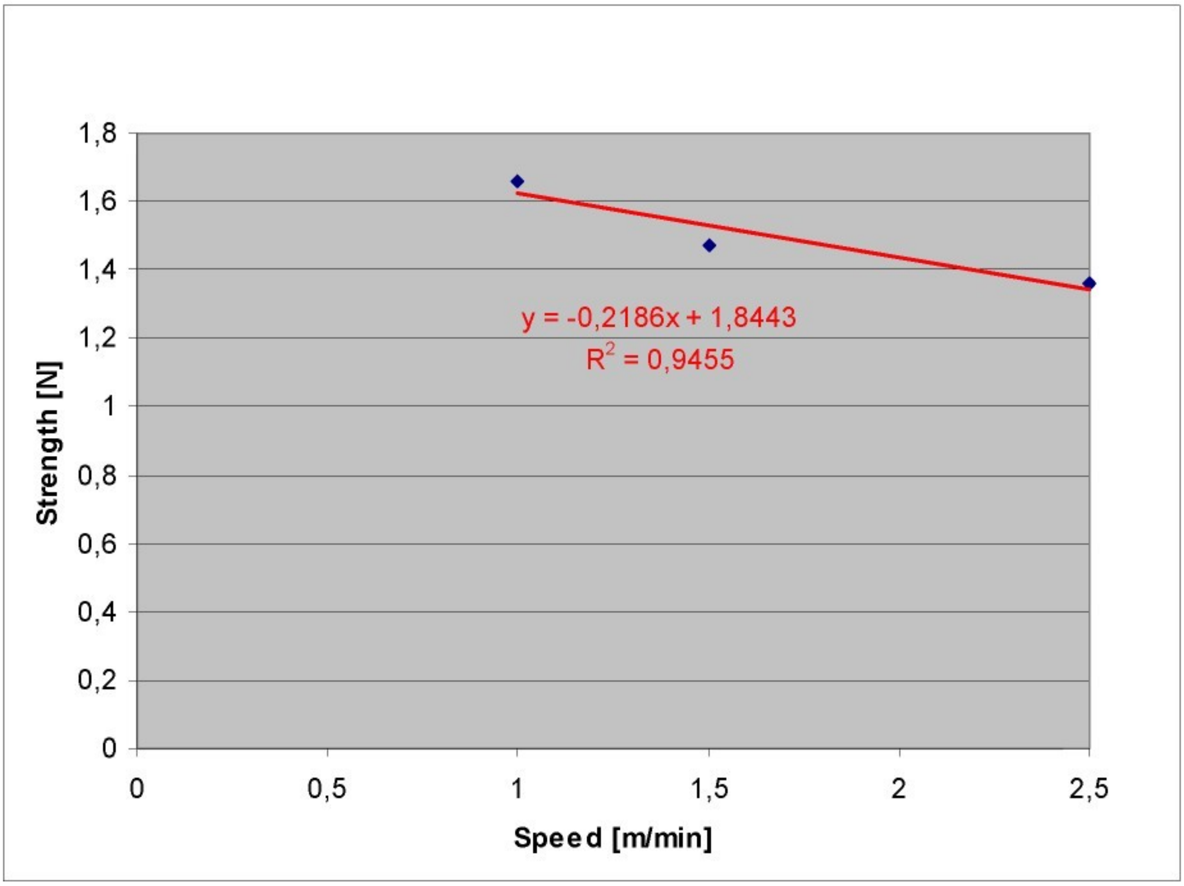


Fig. 41 Shows the trend of strength at constant ratio T

Test for R6

Varying the speed

Tab. 20 Data for Strength at Different out-put speed intervals at constant rpm

Sr No	Speed [m/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance [%]
1	1.5	8120	0.35	0.11	31.31
2	3.5	8120	0.34	0.09	25.00
3	5.5	8120	0.34	0.10	30.86
4	7.5	8120	0.13	0.05	35.52
5	10	8120	A	A	A

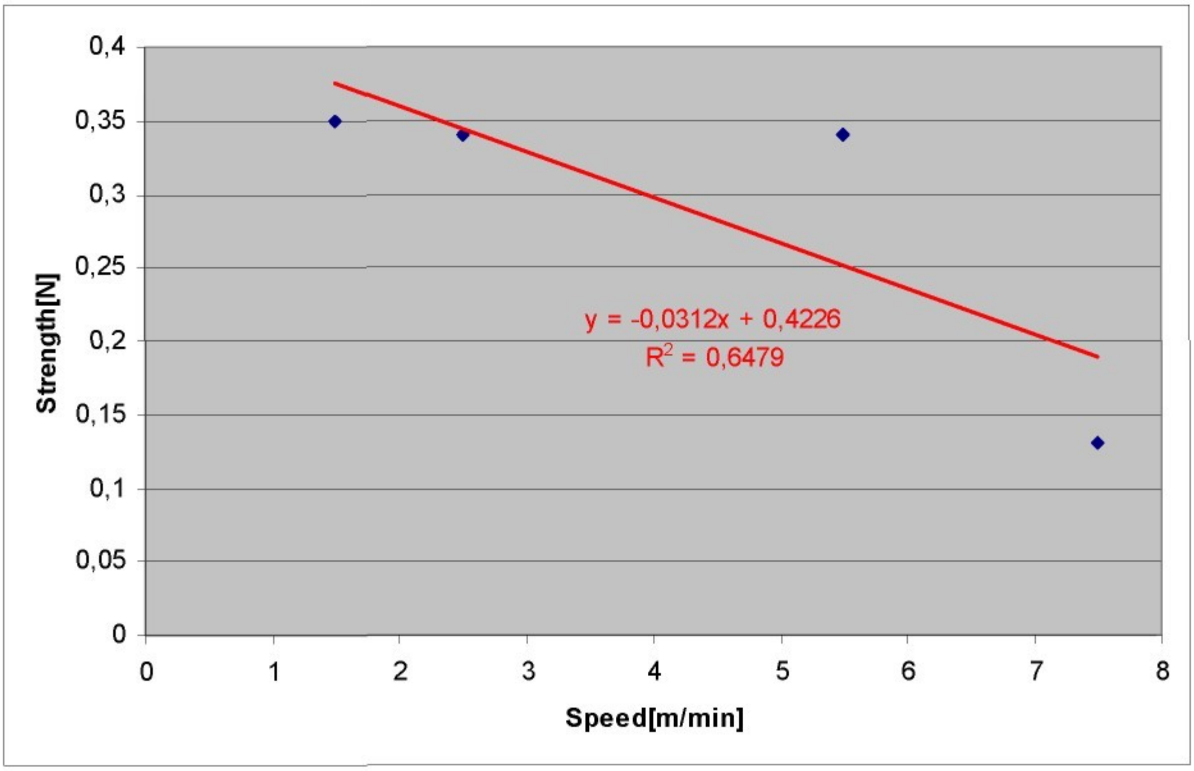


Fig. 42 Shows the trend of strength at different out-put speed intervals

Varying the revolutions

Tab. 21 Data for strength at different rpm intervals at constant speed

Sr No	**Speed [m/min]**	**Revolutions [rpm]**	**Average Strength[N]**	**Standard Deviation [N]**	**Variance [%]**
1	2.5	1624	A	A	A
2	2.5	3248	A	A	A
3	2.5	4872	0.18	0.05	29.38
4	2.5	6496	0.21	0.05	25.24
5	2.5	8120	0.24	0.07	28.69

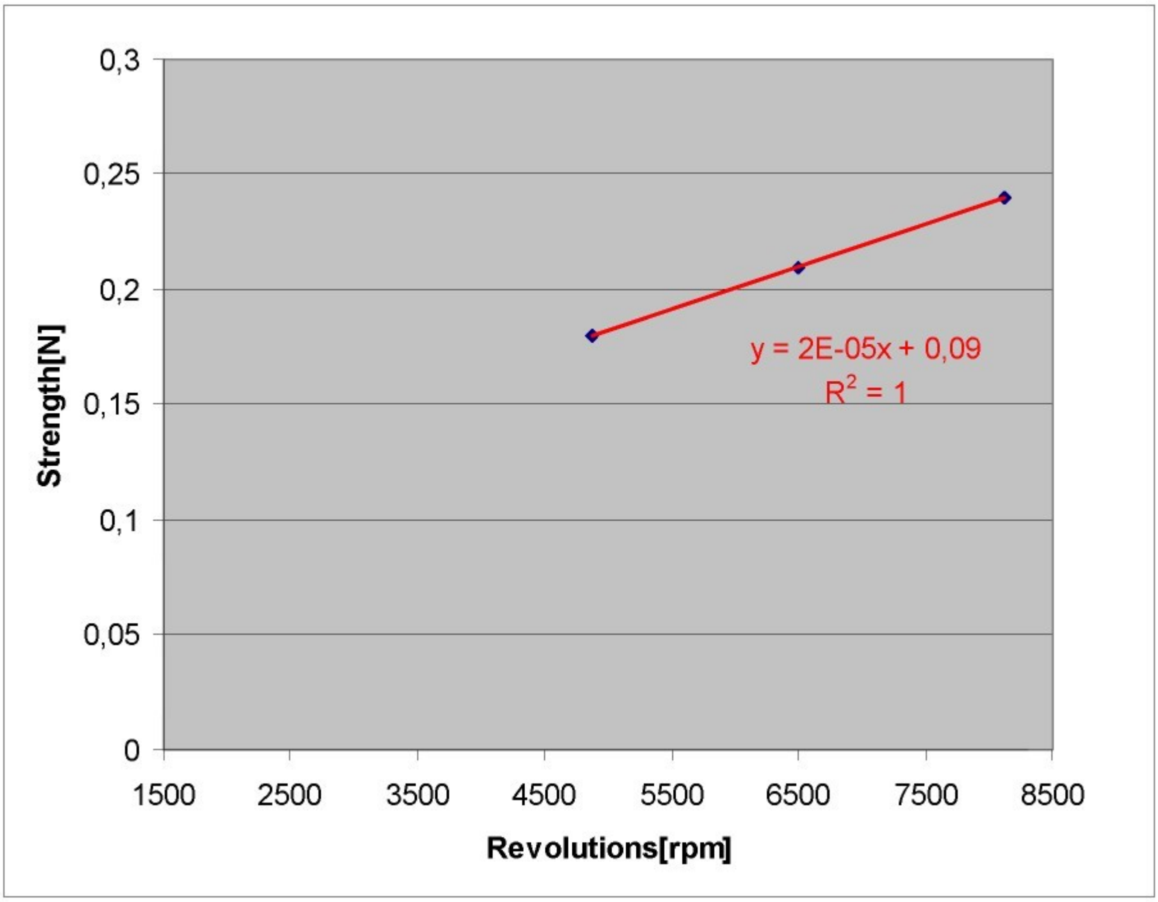


Fig. 43 Shows the trend of strength at different rpm intervals

Constant Ratio

Tab. 22 Data for strength at constant ratio of rpm and speed intervals

Sr No	**Speed [m/min]**	**Revolutions [rpm]**	**Average Strength[N]**	**Standard Deviation [N]**	**Variance [%]**	**Ratio T**
1	1	3248	0.23	0.074	32.24	3248
2	1.5	4872	0.23	0.061	26.36	3248
3	2.5	8120	0.24	0.068	28.69	3248

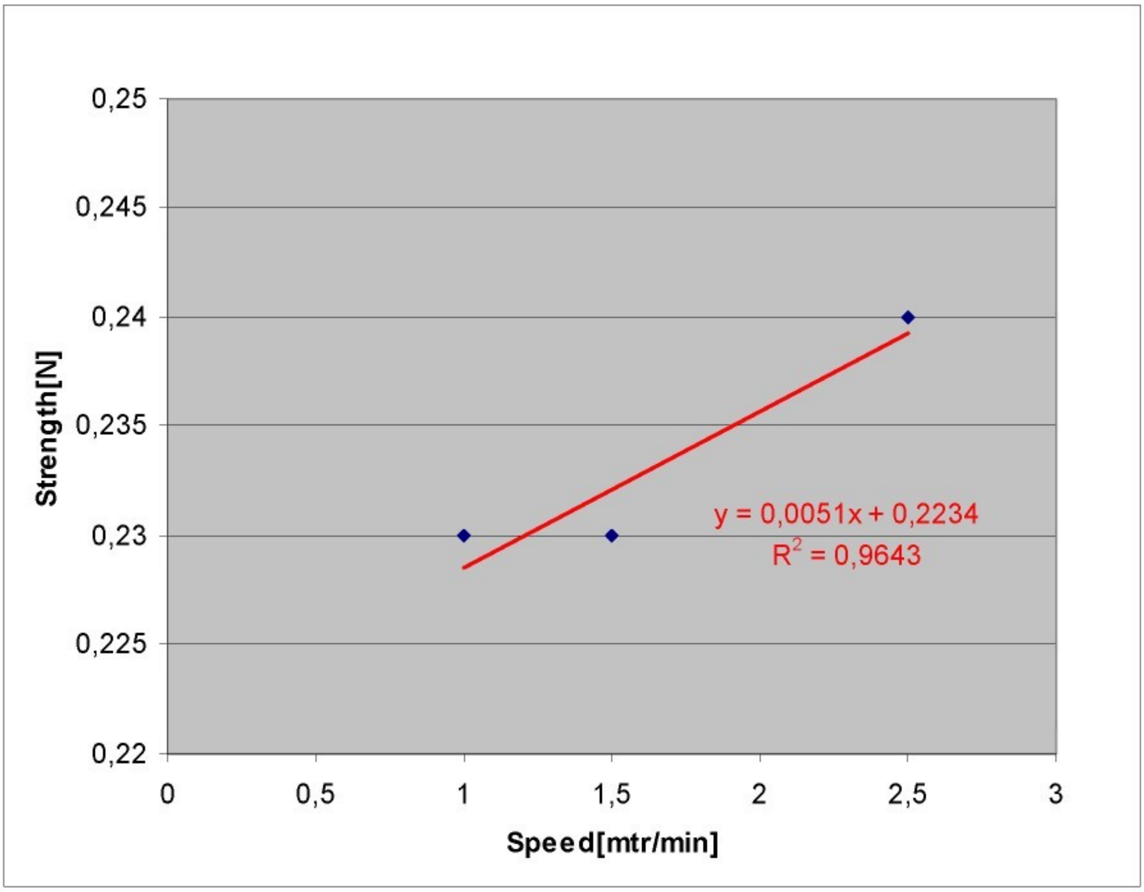


Fig. 44 Shows the trend of strength at constant ratio T

Tests for R15

Varying the speed

Tab. 23 Data for strength at different output speed intervals at constant rpm

Sr No	Speed [m/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation [N]	Variance[%]
1	1.5	8120	1.0	0.41	41.13
2	3.5	8120	0.89	0.30	33.90
3	5.5	8120	0.29	0.08	28.73

4	7.5	8120	A	A	A
5	10	8120	A	A	A

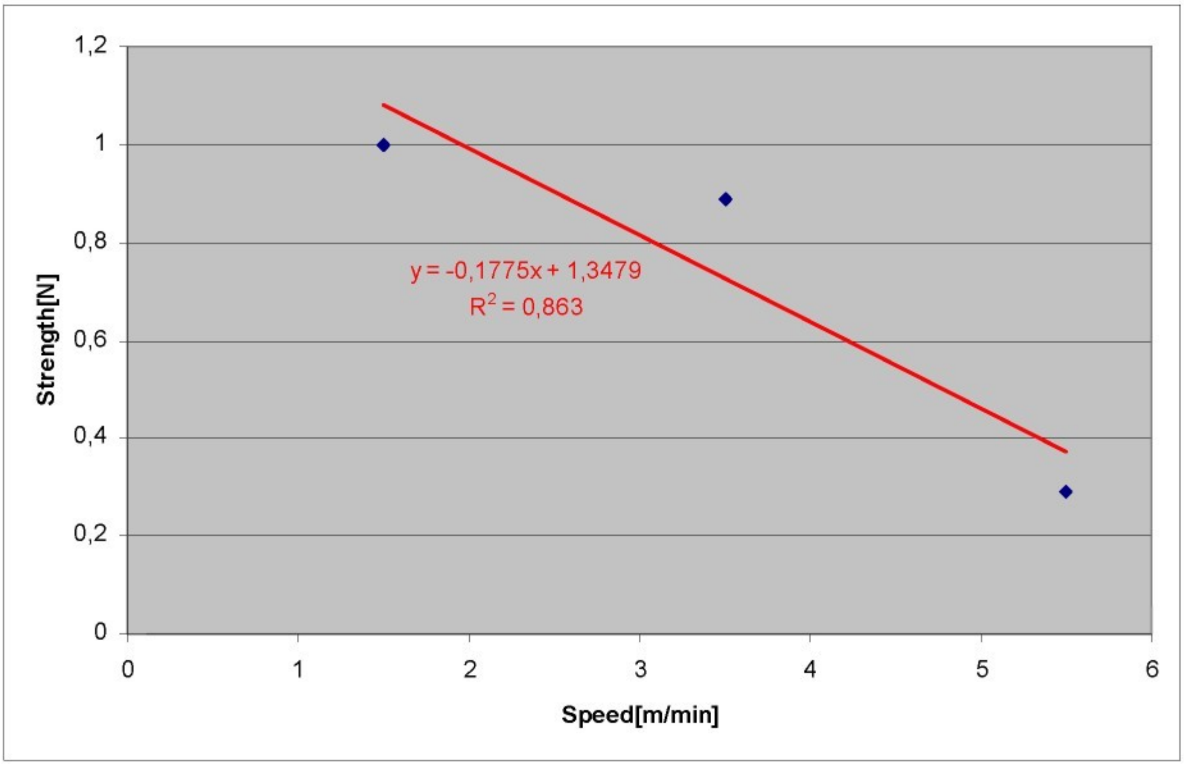


Fig. 45 Shows the trend of strength at different output speed intervals

Varying the revolutions

Tab. 24 Data for strength at different rpm intervals at constant speed

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation[N]	Variance [%]
1	2.5	1624	A	A	A
2	2.5	3248	0.28	0.08	29.14
3	2.5	4872	0.38	0.11	28.69
4	2.5	6496	0.38	0.12	34.43
5	2.5	8120	0.43	0.16	37.56

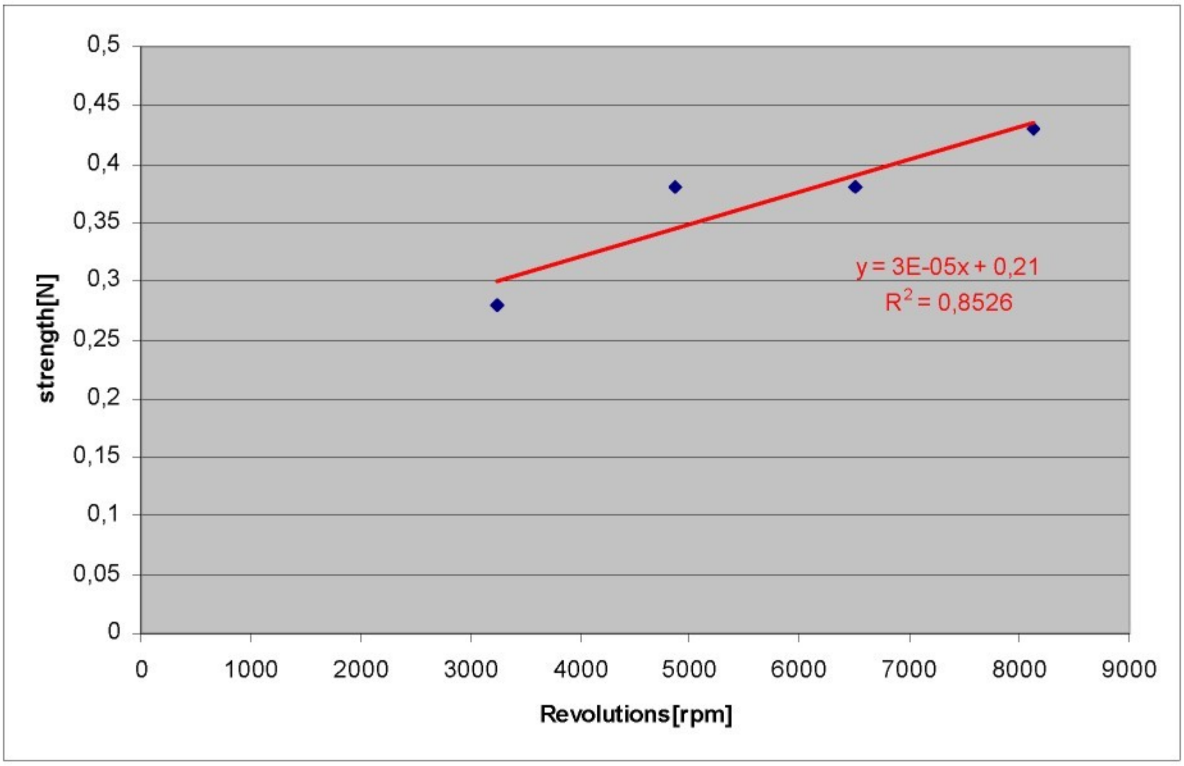


Fig.46 Shows the trend of strength at different rpm intervals

Constant Feed ratio

Tab.25 Data for strength at constant ratio of rpm and speed intervals

Sr No	Speed [mts/min]	Revolutions [rpm]	Average Strength[N]	Standard Deviation[N]	Variance [%]
1	1	3248	0.43	0.16	36.98
2	1.5	4872	0.43	0.14	33.37
3	2.5	8120	0.43	0.16	37.56

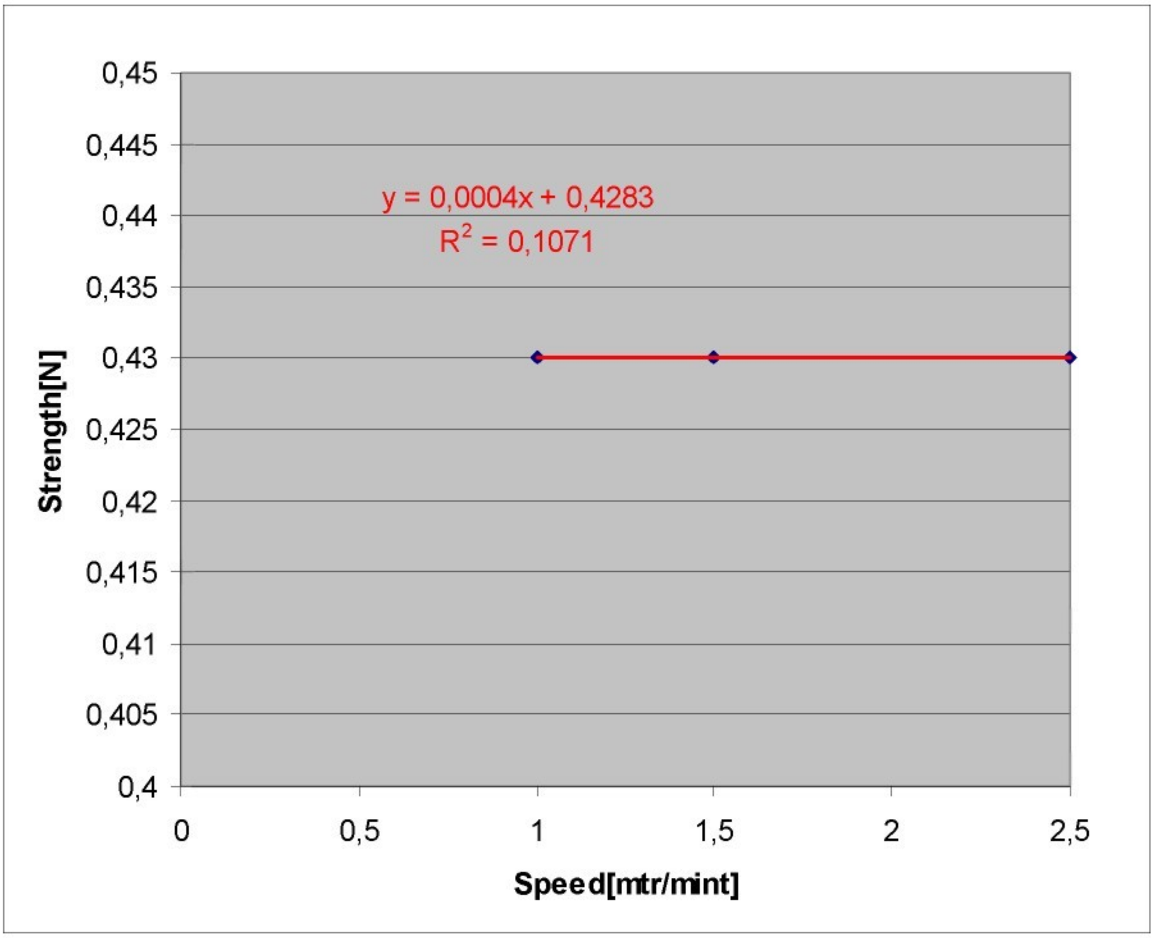


Fig. 47 Shows the trend of strength at constant ratio T

4.2 Effect of semi-product on the strength of quasi yarn.

At Constant Revolutions

Tab. 26 Relationship of change in strength on different materials with varying different speed intervals at constant rpm

Sr No	Revolutions [rpm]	Speed [m/min]	Strength [N]		
			R1	R15	R6
1	8120	1.5	1.559	0.995	0.353
2	8120	3.5	1.502	0.885	0.34
3	8120	5.5	1.071	0.293	0.337

4	8120	7.5	0.375	A	0.128
5	8120	10	A	A	A

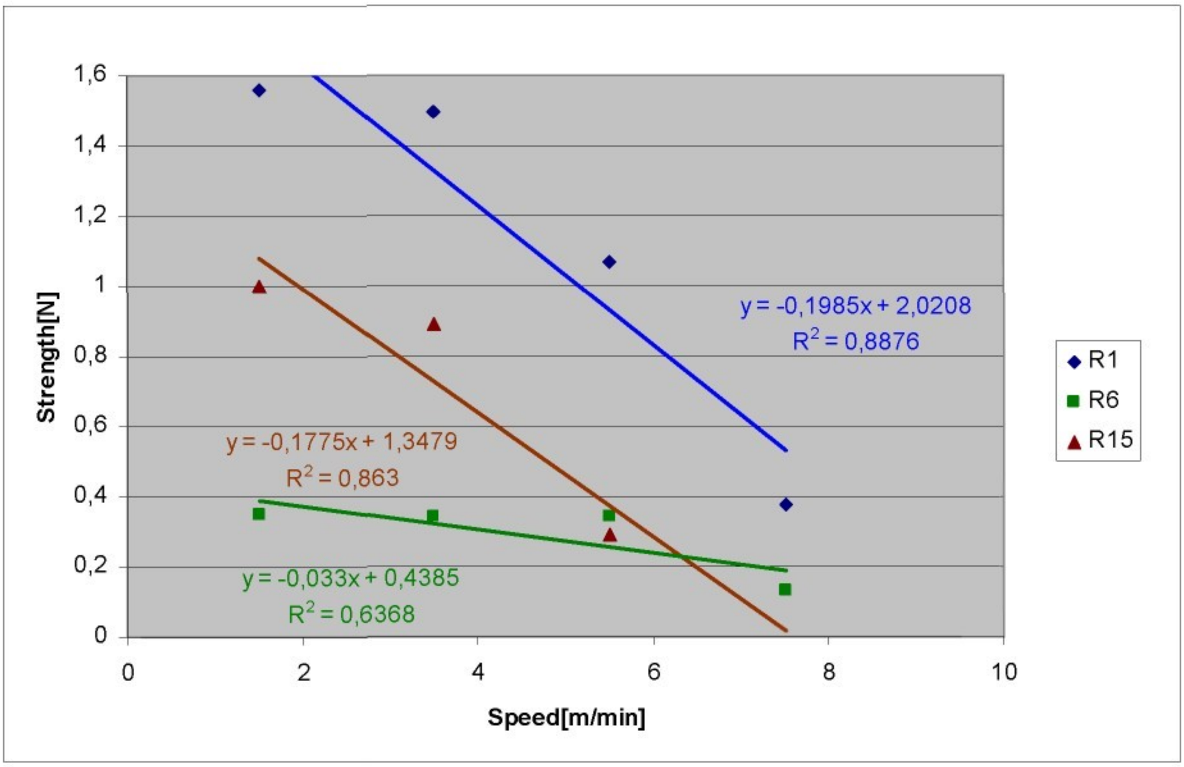


Fig. 48 Shows the trend of strength with different materials in different speed intervals.

At Constant Speed

Tab. 27 Relationship of change in strength on different materials with varying different rpm intervals

Sr No	Revolutions [rpm]	Speed [m/min]	Strength [N]		
			R1	R15	R6
1	1624	2.5	A	A	A
2	3248	2.5	A	0.28	A
3	4872	2.5	0.59	0.38	0.18
4	6496	2.5	1.18	0.38	0.21
5	8120	2.5	1.32	0.43	0.24

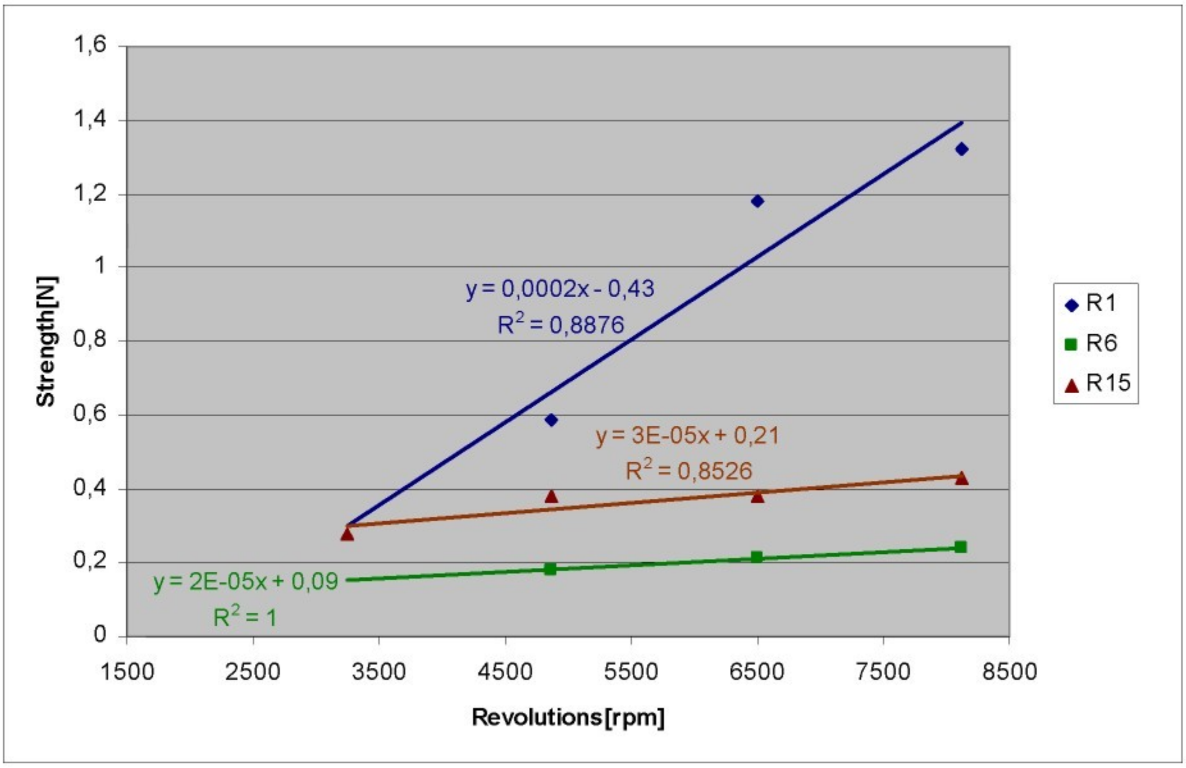


Fig. 49 Shows the relationship between strength with different materials at different rpm intervals

At Constant ratio

Tab. 28 Relationship of change in strength on different materials with constant ratio T.

Sr No	**Revolutions [rpm]**	**Speed [m/min]**	**Strength [N]**		
			R1	**R15**	**R6**
1	3248	1	1.66	0.43	0.23
2	4872	1.5	1.47	0.43	0.23
3	8120	2.5	1.31	0.43	0.24

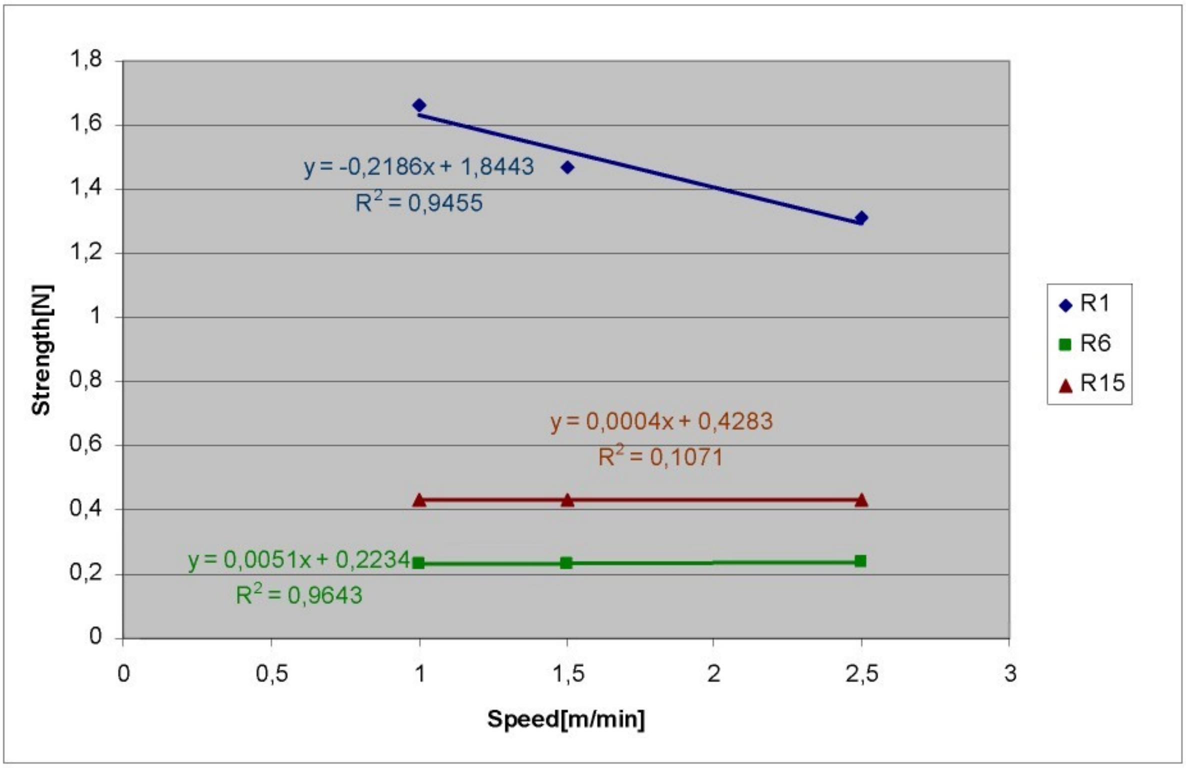


Fig. 50 Shows the relationship between strength with different materials at constant ratio T.

4.3 Co-relation over Martindale test at maximum strength of quasi yarn.

At lowest Speed

Tab. 29 Data for strength and pills test for different materials at lowest speed 1.5 [m/min] and revolutions 8120 [rpm]

Sr No	Material	Pills Test	Maximum Strength [N]
1	R1	2.5	1.56

2	R6	4	0.36
3	R15	3	1.00

Correlation Coefficient = -0.989

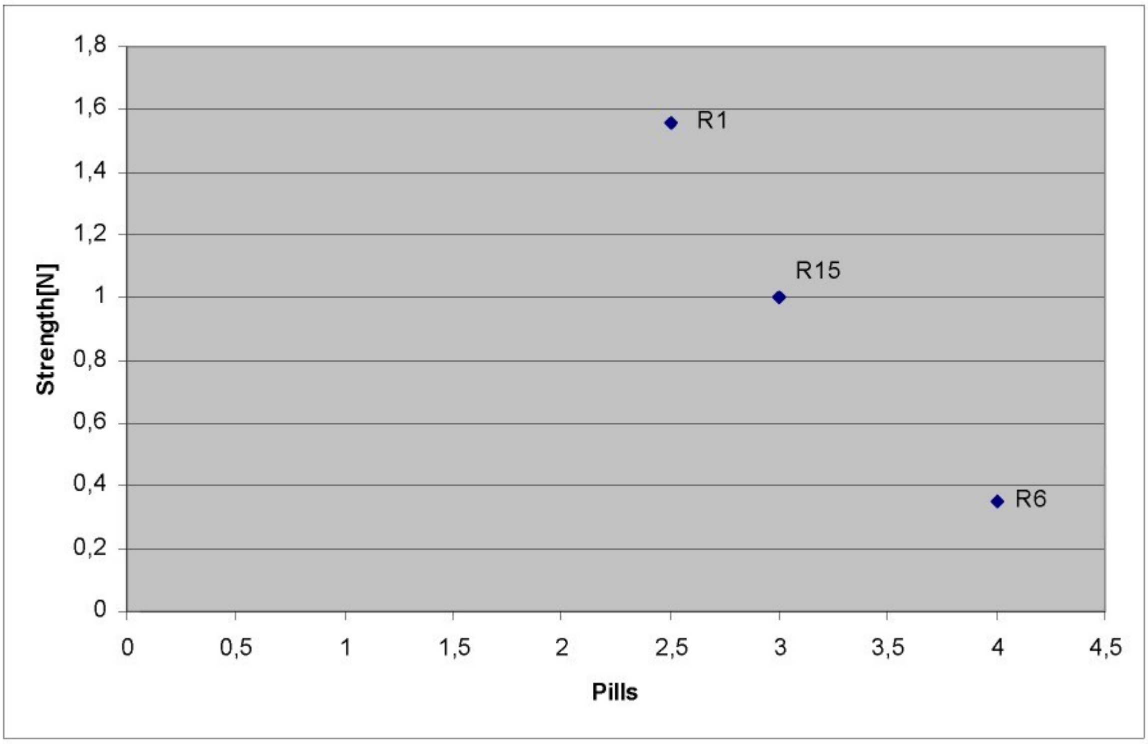


Fig. 51 Shows the relationship between strength and pills test result with different materials at lowest speed 1.5 m/min and revolutions 8120 rpm.

At Maximum Revolutions

Tab. 30 Data for strength and pills Test for different materials at maximum revolutions 8120 [rpm] and speed 2.5 [m/min].

Sr No	Material	Pills Test	Strength [N]
1	R1	2.5	1.36

2	R6	4	0.24
3	R15	3	0.43

Correlation Coefficient =-0.85

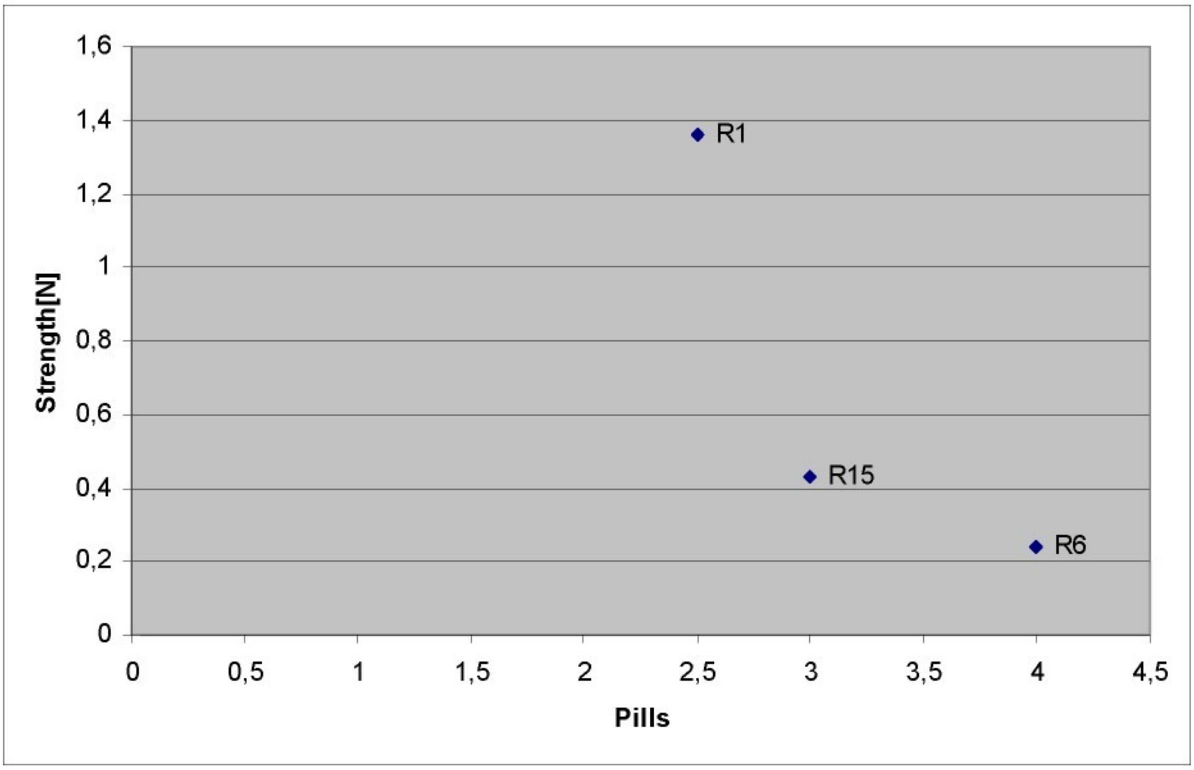


Fig. 52 Shows the relationship between strength and pills test result with different materials at maximum revolutions 8120 rpm and speed 2.5m/min

4.4 Co-relation between Kwabata test at maximum strength of quasi yarn

4.4.1 Co-relation over Roughness at maximum strength of quasi yarn.

At Lowest Speed

Tab. 31 Data for strength and roughness for different materials at lowest speed.1.5[m/min] and revolutions 8120 [rpm]

Sr No	Material	Roughness [µm]	Strength [N]
1	R1	4.35	1.56
2	R6	2.80	0.36
3	R15	2.45	1.0

Correlation Coefficient =0.7375

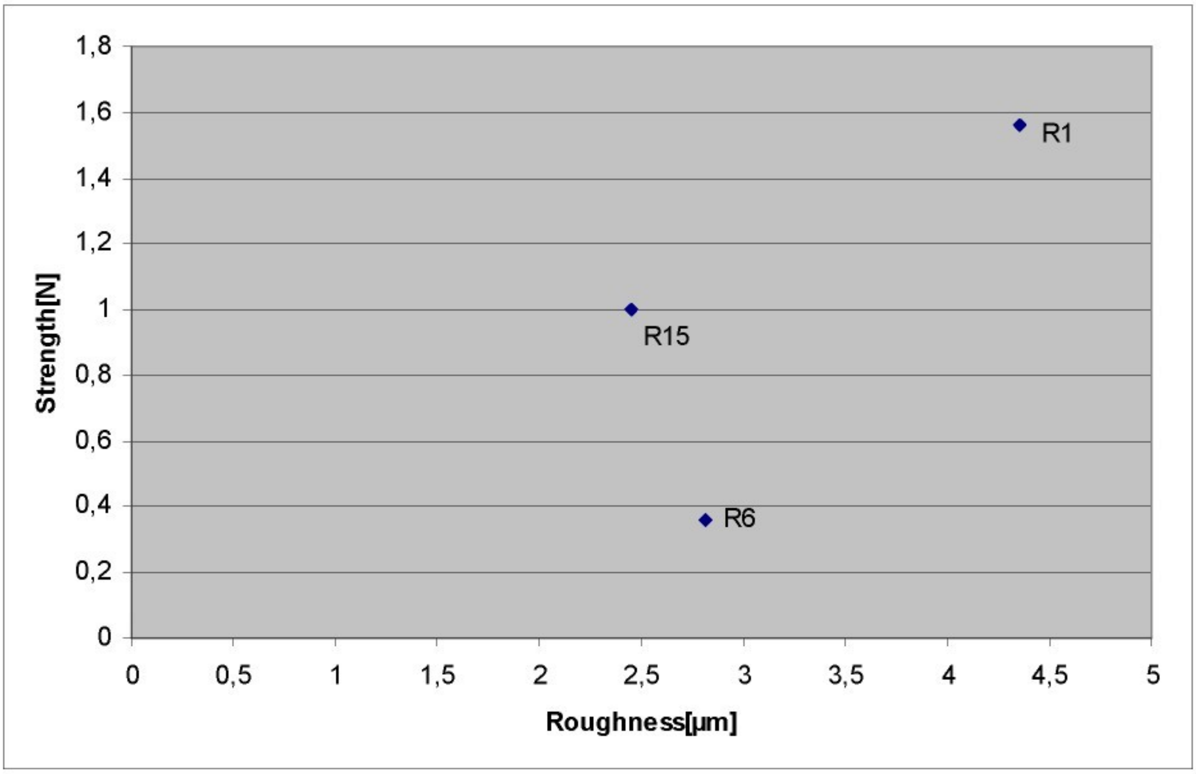


Fig. 53 Shows the relationship between strength and roughness with different Materials at lowest speed 1.5 m/min and revolutions 8120 rpm

At Maximum Revolutions

Tab. 32 Data for strength and roughness for different materials at maximum revolutions 8120 [rpm] and constant speed 2.5 [m/min].

Sr No	Material	Roughness [µm]	Strength [N]
1	R1	4.35	1.36

2	R6	2.80	0.28
3	R15	2.45	0.43

Correlation Coefficient =0.9622

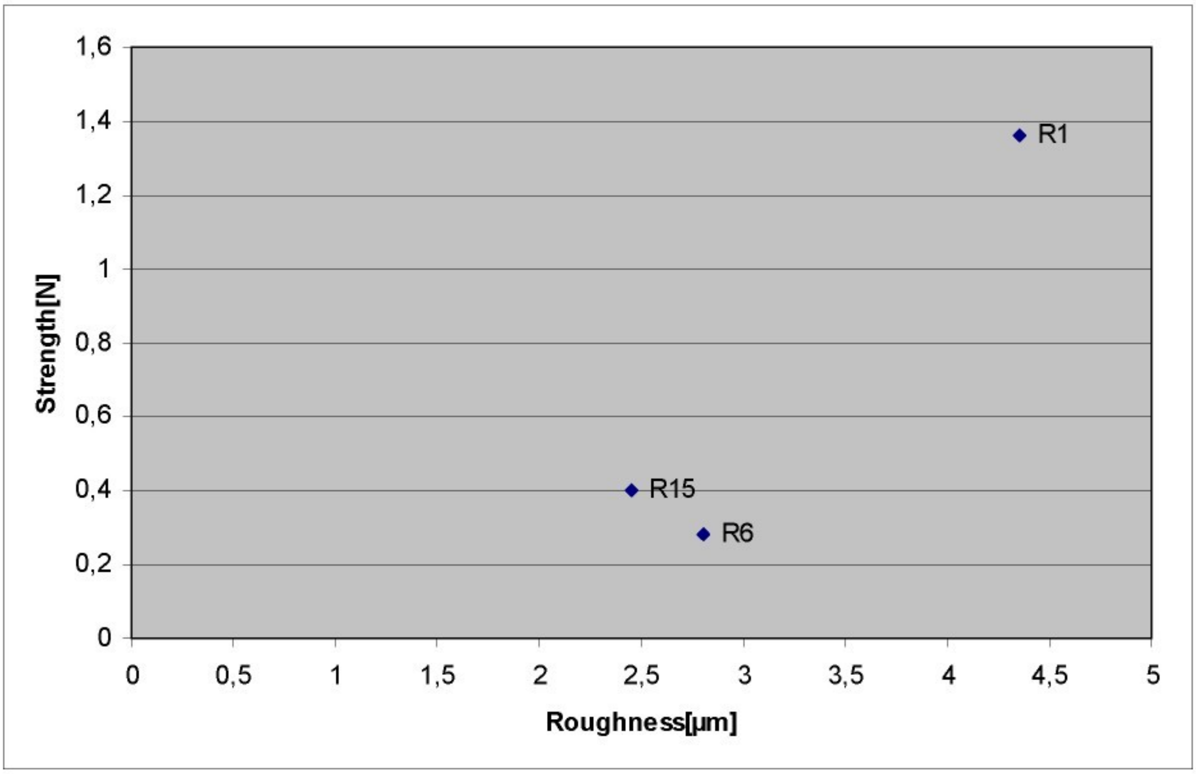


Fig. 54 Shows the relationship between strength and pills test result with different materials at maximum revolutions 8120 rpm and speed 2.5 m/min.

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4.4.2 Co-relation over MIU at maximum strength of quasi yarn

MIU at Lowest Speed

Tab. 33 Data for strength and MIU for different materials at maximum revolutions 8120 [rpm] and lowest speed 1.5 [m/min]

Sr No	Material	MIU[unit non]	Strength [N]

1	R1	0.22	1.56
2	R6	0.21	0.36
3	R15	0.22	1.0

Correlation Coefficient = 0.89

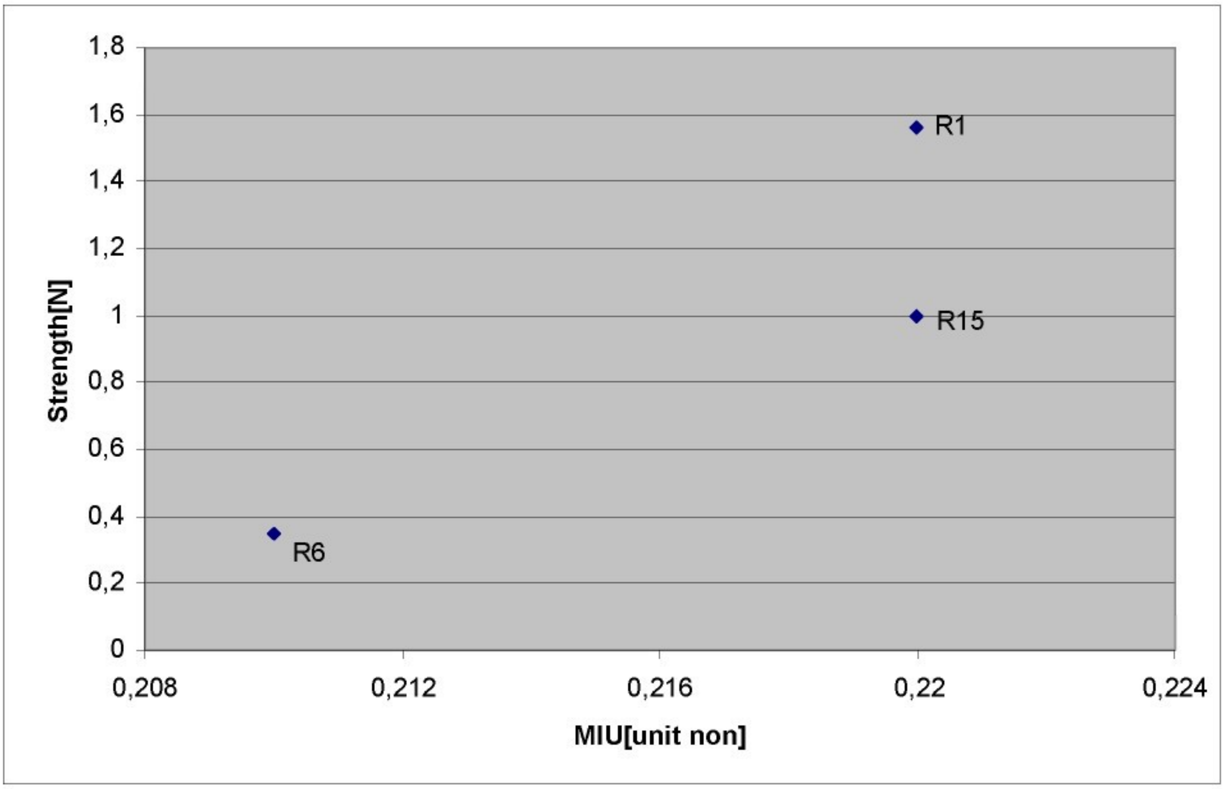

Fig. 55 Shows the relationship between strength and MIU test at maximum revolutions 8120 rpm and lowest speed 1.5 m/min

Maximum Revolutions

Tab. 34 Data for strength and roughness for different materials at maximum revolutions- 8120 [rpm] and constant speed 2.5 [m/min]

Sr No	**Material**	**MIU[unit non]**	**Strength [N]**

1	R1	0.22	1.36
2	R6	0.21	0.28
3	R15	0.22	0.40

Correlation Coefficient =0.5852

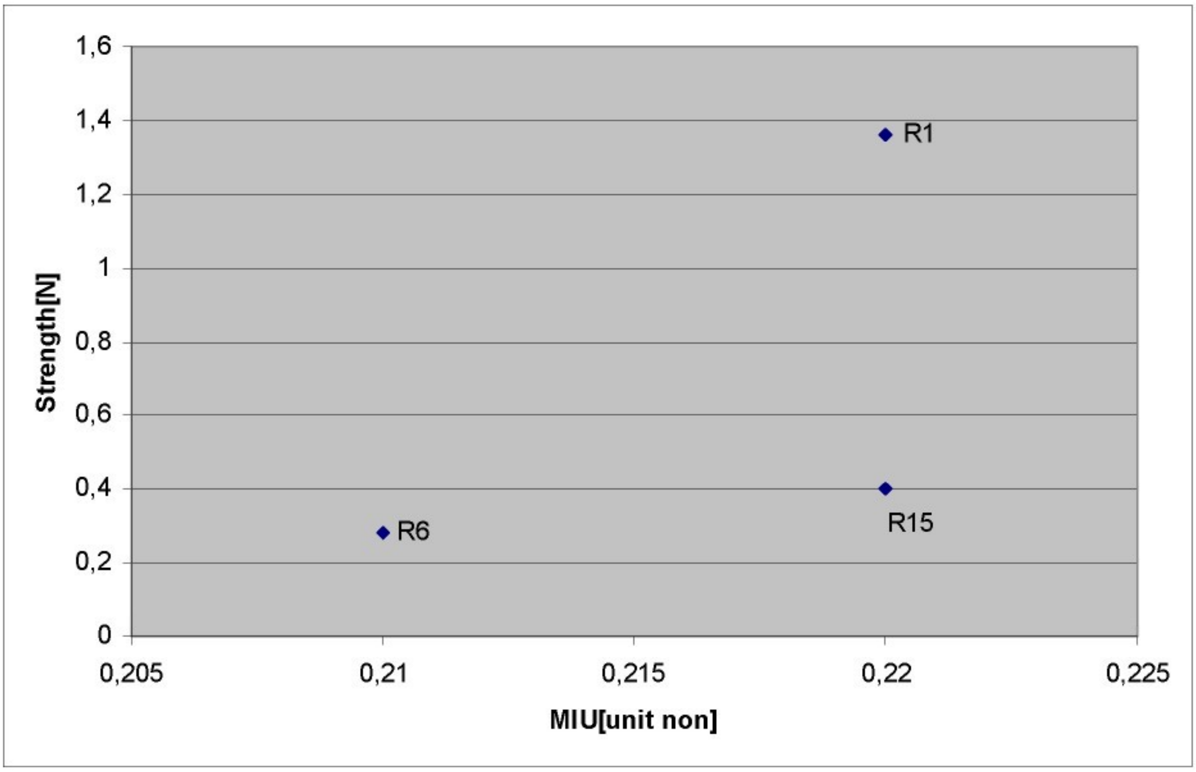

Fig. 56 Shows the relationship between strength and MIU test result with different materials at maximum revolutions 8120 rpm and speed 2.5 m/min.

Relationship between Kwabata and Martindale Tests:

Tab. 35 Results of pills tests and roughness test

Material	Roughness [µm]	Martindale
R1	4.35	2.5

R6	2.80	4.0
R15	2.45	3.0

The correlation between the Kwabata and Martindale is -0.667.

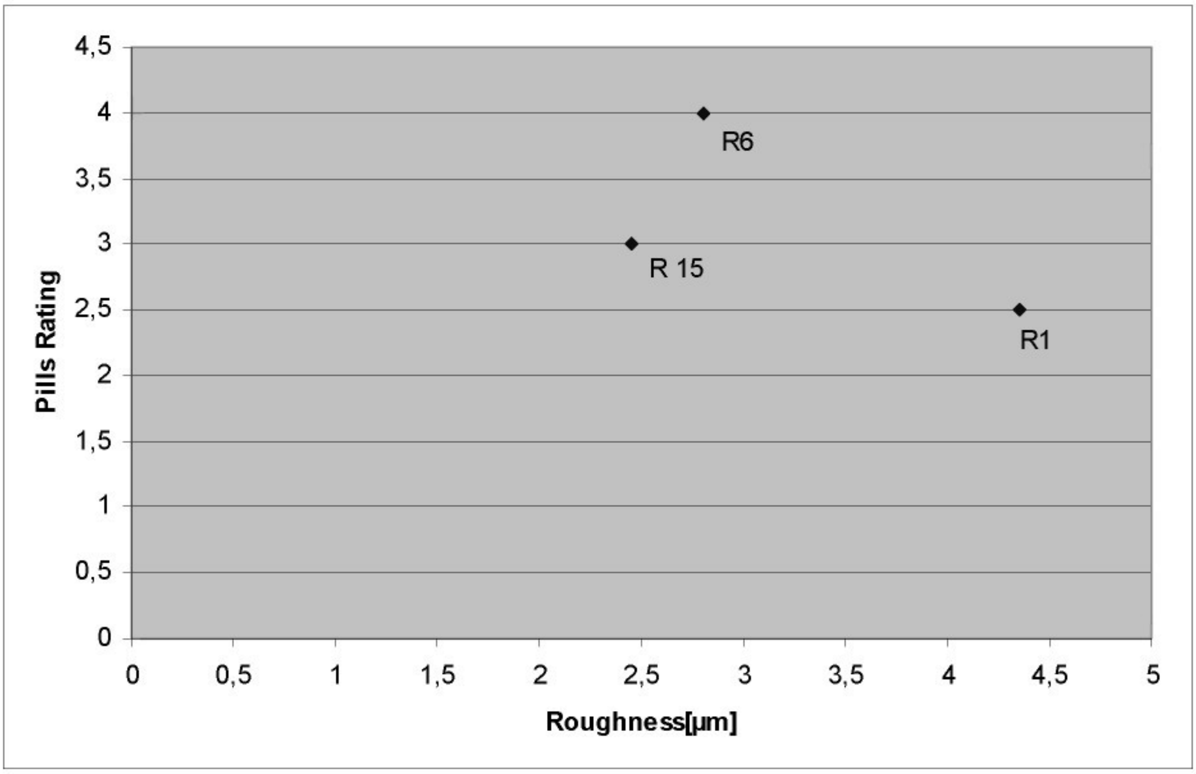

Fig. 57 Roughness test results with pills tests

5. *Discussion*

1. Methods of semi-product testing:

For the relation between the selection of semi-product and strength were used correlation coefficient see capital 4.3 and 4.4. In spite of data obtained was low, so that correlation is quite high. The correlation over the results of strength test of quasi yarn and semi-product tests were calculated by using Microsoft excel (CORREL). So, these results show only the trend rather than giving the appropriate value.

Martindale test is more practical applicable than Kwabata for the selection of the semi-products for quasi yarn formation. The Martindale is more economical than Kwabata. This statement should be confirmed for more data.

Martindale and Kwabata roughness test values of the semi-products results are shown in tab. 35. The correlation over MIU and strength is very low and cannot be used is shown in tab.33 and 34.

For the same materials, they are having different values in case of R6 and R15 in semi-product testing. In case of R6 Martindale test value is higher and the Kwabata is lower. These tell us significant difference in grading for same materials

2. Technological parameters and quasi yarn strength

The results obtained from single quasi yarn confirm the conclusion measured in capital 2.2.2.2, in spite of using different testing methods. The variance is higher shown in capital 4.1 around 30%. The reason for this is non-uniformity of quasi yarn or maybe the their preparation of samples as shown in capital 3.1. Effects of Semi-products (R1, R6 and R15) on different strength of quasi yarn and influence on the final product also are shown in fig. 48 and capital 4.2. The effects are very significant.

Interesting effects are seen at constant ratio T, when increasing speed and revolutions in different intervals by keeping ratio constant is shown in fig. 50. It allows us to think on the possibility to increase the production of operating machine up to the parameters of model machine arrangement.

3. Microscopical study of quasi yarn

The capital 4.2 shows that for the study of structure quasi yarn confocal microscope and for detail study electron microscope can be used.

6. Conclusion

My diploma work was concerned around the mechanical fixation technique for nonwoven textiles by the quasi yarn. The aim of my work was as follow:

1. Suggest material testing methods for production of non-wovens fixed by quasi-yarn technique with the aim of maximum quasi-yarns tensile strength.
2. Define the technology parameters important for production of non-wovens fixed by quasi-yarn technique.

For the aim1:

Two testing methods were selected for semi-product testing: Martindale abrasion test and Kwabata (MIU and Roughness).

- • Correlation over Martindale (pills) and strength test is: -0.989.
- • Correlation over roughness and strength test is: 0.7375.

The results are widely oriented only because the testing of less number of semi-products samples. These are first tests, still other tests weren't suggested. These tests are needs for conformation.

For aim 2:

These tests carried out it confirm that: maximum strength is obtained at maximum revolutions of rotating element and at minimum speed of the material resp. for high T. This same principle implies to the classical yarn also at optimum strength of yarn.

At optimum arrangement of machine, will need to find out the dependence upon type of semi-product like is shown in fig.48.

In Diploma work studied the technological parameters that influence on the strength of quasi yarn extensively shown in tab. 26 and 27.

Recommendations

Samples for Diploma work were made at constant contact pressure between surface material and rotating element. It would be useful study to see the influence of contact pressure on the strength of quasi yarn.

It will be more useful if higher the number of tests and more the semi-products will be made to confirm the correlation over pills or roughness and strength of quasi yarn.

References

[1] Old•ich J., Non Woven Textiles, p.11.

[2] Danková M., Flammability of highloft Textile Containing Flame Resistant Fibers, Diploma Thesis,TUL-KNT, Liberec, 2003.

[3] Avaliable on http://www.engr.utk.edu/mse/pages/Textiles/index.html, author LarryC. adsworth, lwadswor@utk.edu, Date 22.9.2009.

[4] Hanuš J. & Šev•ik L., New Quasi Yarn Application 14th International Conference, Nov 2007, TU Liberec.

[5] Avaliable on http://www.rieter.com/ by Rieter group, Date 22.9.2009.

[6] Avaliable on www.wikipedia.com, Date 25.09.2009.

[7] Hanuš J. & Militký J.: Mechanical Fixation of Thick Textile Structure, TULiberec.

[8] Hanuš J. & Militký J.: Quasi Yarn Application in Nonwoven Production, In HPTEX 2004, Coimbatore, July 7-9, India.

[9] Hanuš J. & Šev•ik J.: New Quasi Yarn Application 14th International Conference, Nov 2007, TU Liberec.

Appendix.1

Semi-Product No.1 and R1 Stands for Needle Punched Fabric

Semi-Product No.2 and R15 Stands for Spunjet Fabric

Semi-Product No.3 and R6 Stands for Jet-lace Fabric

Kwabata Test for R1:

The results are shown in table 2, is have been seen that R1 having maximum. The kawabata instrument used to test the roughness of the material and the result are shown in tab 36. The MIU denotes the means value of frition a MMD denotes Standard Deviation. And SMD denotes mean value of Roughness in mm.

Tab. 36 Results of roughness and MIU tests for material R1.

	R1		
Sr no	Mean(MIU)	Std Dev(MMD)	Roughness(SMD)
1	0,22	0,01	4,18
2	0,23	0,01	5,07
3	0,22	0,01	3,94
4	0,21	0,01	3,58
5	0,22	0,01	4,11
6	0,25	0,10	6,08
7	0,24	0,01	3,83
8	0,23	0,01	4,68
9	0,22	0,01	4,05
10	0,21	0,01	4,01
11	0,22	0,01	3,82
12	0,20	0,01	3,67
13	0,21	0,01	4,00
14	0,20	0,01	4,40
15	0,22	0,01	5,80
Average	**0,22**	**0,01**	**4,35**

Results of Tests R6

Tab. 37 Results of roughness and MIU tests for material R6.

	R6		
Sr no	Mean(MIU)	Std Dev(MMD)	Roughness(SMD)
1	0,20	0,01	2,31
2	0,21	0,01	2,79
3	0,23	0,01	2,84
4	0,22	0,01	2,90
5	0,23	0,01	2,53
6	0,23	0,01	3,06
7	0,20	0,01	3,04
8	0,21	0,01	3,30
9	0,22	0,01	3,64
10	0,20	0,01	2,51
11	0,21	0,01	2,93
12	0,19	0,01	2,55
13	0,20	0.01	2,14
14	0,21	0,01	2,51
15	0,22	0,01	3,04
Average	**0,21**	**0,01**	**2,80**

Results of Tests R15

Tab. 38 Results of roughness and MIU tests for material R15.

	R15		
Sr no	Mean(MIU)	Std Dev(MMD)	Roughness(SMD)
1	0,20	0,01	2,16
2	0,22	0,01	2,67
3	0,24	0.01	2,50
4	0,20	0,01	2,31
5	0,23	0,01	2,66
6	0,23	0,01	2,29
7	0,23	0,01	2,24
8	0,23	0,01	2,49
9	0,24	0,01	2,49
10	0,21	0,01	2,35
11	0,21	0,01	2,35
12	0,21	0.01	2,33
13	0,25	0,01	2,40
14	0,22	0,01	2,62
15	0,25	0,01	2,87
Average	**0,22**	**0,01**	**2,45**

Appendix :2

The Strength Test Results:

The material and the tests are defined by following numeric symbolic. Like 1.1.2- it can be abbreviated that first number denotes the material and second number denotes the experiment number and the third denotes the arrangement of machine which is carried out for experiment. The semi-product marked shown in Appendix 1

Tab. 39 Results of strength tests for material R1

Sr no.	**1,1,1**	**1,1,2**	**1,1,3**	**1,1,4**	**1,2,2**	**1,2,3**	**1,2,4**	**1,2,5**	**1,3,1**	**1,3,2**
1	1,80	1,26	1,13	0,37	0,92	1,66	1,73	1,87	1,84	2,27
2	1,33	0,51	0,67	0,19	0,17	0,85	0,54	1,02	1,45	2,15
3	1,24	2,05	1,15	0,22	0,26	1,61	0,79	1,34	1,92	1,71
4	1,99	1,74	1,51	0,35	0,39	1,27	1,30	1,65	1,40	1,39
5	2,21	1,91	1,52	0,23	0,43	1,61	0,82	1,57	1,40	1,02
6	1,37	0,79	0,56	0,46	0,63	0,96	0,55	1,47	1,20	1,07
7	1,25	1,80	0,59	0,38	0,26	1,16	0,88	0,86	1,54	0,89
8	1,37	0,68	1,41	0,43	0,89	0,91	1,95	2,05	1,87	1,09
9	1,16	1,86	1,40	0,20	1,00	1,26	1,00	0,97	2,29	0,86
10	1,84	1,90	0,98	0,57	0,22	0,93	1,73	0,64	2,54	0,77
11	1,52	0,74	0,90	0,46	0,31	2,18	1,54	0,56	2,32	0,91
12	1,15	1,51	0,72	0,30	0,24	1,80	1,46	0,83	1,58	1,01
13	1,84	0,89	0,62	0,62	0,46	0,73	1,42	1,96	1,26	2,14
14	1,32	1,62	1,44	0,26	0,64	1,24	2,02	2,32	1,61	1,65
15	1,25	1,81	1,40	0,40	0,84	0,67	1,91	0,89	1,10	1,82
16	1,41	1,81	1,60	0,27	0,35	1,16	1,45	1,65	1,09	1,64
17	1,90	2,05	1,13	0,51	0,61	0,69		0,77	1,92	1,58
18	1,75	1,09	1,30	0,65	0,74	0,61		1,67	1,64	2,03
19	1,94	1,89	0,44	0,56	0,55			1,39	1,66	1,08
20	1,68	1,76	1,13	0,18	0,74			2,29	1,32	2,10
21	1,42	1,90	0,87	0,22	0,65			1,09	1,39	1,53
22								1,03	1,84	1,68
23									1,92	1,44
Mean	**1,56**	**1,50**	**1,07**	**0,37**	**0,54**	**1,18**	**1,32**	**1,36**	**1,66**	**1,47**
Std Dv	**0,31**	**0,51**	**0,37**	**0,15**	**0,25**	**0,44**	**0,50**	**0,53**	**0,39**	**0,47**

The Strength Test Results:

Tab. 40 Results of strength tests for material R6

Sr no.	3,1,1	3,1,2	3,1,3	3,2,2	3,2,3	3,2,4	3,2,5	3,3,1	3,3,2
1	0,94	0,83	0,37	0,37	0,35	0,48	0,91	0,45	0,38
2	0,93	0,88	0,18	0,39	0,33	0,32	0,43	0,65	0,37
3	0,72	0,59	0,40	0,21	0,40	0,30	0,35	0,53	0,26
4	0,56	0,61	0,27	0,33	0,39	0,54	0,36	0,45	0,36
5	1,94	1,78	0,26	0,23	0,27	0,26	0,52	0,48	0,66
6	0,75	1,25	0,44	0,41	0,43	0,35	0,58	0,75	0,76
7	0,69	0,71	0,28	0,37	0,37	0,42	0,27	0,24	0,29
8	0,89	1,01	0,33	0,26	0,58	0,55	0,35	0,29	0,44
9	0,62	1,07	0,24	0,27	0,27	0,62	0,54	0,31	0,36
10	1,51	0,52	0,23	0,36	0,27	0,26	0,31	0,64	0,34
11	1,13	1,36	0,21	0,19	0,31	0,44	0,52	0,30	0,40
12	0,71	0,58	0,48	0,26	0,33	0,37	0,46	0,38	0,57
13	0,68	0,93	0,30	0,22	0,46	0,59	0,25	0,31	0,52
14	1,67	1,00	0,28	0,19	0,64	0,29	0,28	0,41	0,46
15	0,88	0,79	0,30	0,15	0,37	0,32	0,50	0,24	0,28
16	0,65	0,59	0,35	0,32	0,26	0,25	0,30		
17	0,92	0,70	0,15	0,29	0,43	0,42	0,38		
18	1,38	0,88	0,29	0,31	0,57	0,31			
19	0,66	0,72	0,23	0,18	0,35	0,37			
20	1,65	0,90	0,26	0,17	0,34	0,42			
21	1,03			0,37	0,25	0,17			
Mean	**1,00**	**0,88**	**0,29**	**0,28**	**0,38**	**0,38**	**0,43**	**0,43**	**0,43**
Std Dv	**0,41**	**0,30**	**0,08**	**0,08**	**0,11**	**0,12**	**0,16**	**0,16**	**0,14**

The Strength Test Results:

Tab. 41 Results of strength tests for material R15

Sr no	2,1,1	2,1,2	2,1,3	2,1,4	2,2,3	2,2,4	2,2,5	2,3,1	2,3,2
1	0,29	0,25	0,18	0,12	0,21	0,15	0,18	0,12	0,23
2	0,53	0,30	0,21	0,13	0,19	0,15	0,26	0,23	0,24
3	0,46	0,60	0,55	0,21	0,12	0,18	0,20	0,25	0,16
4	0,59	0,26	0,30	0,11	0,08	0,12	0,25	0,38	0,19
5	0,30	0,26	0,34	0,10	0,30	0,19	0,23	0,11	0,27
6	0,20	0,33	0,47	0,06	0,13	0,20	0,40	0,19	0,16
7	0,25	0,38	0,35	0,06	0,19	0,21	0,17	0,31	0,32
8	0,40	0,35	0,31	0,14	0,19	0,18	0,27	0,27	0,17
9	0,32	0,37	0,50	0,19	0,14	0,18	0,28	0,14	0,29
10	0,33	0,22	0,37	0,17	0,14	0,30	0,25	0,14	0,23
11	0,42	0,48	0,42	0,12	0,21	0,16	0,38	0,27	0,27
12	0,27	0,36	0,35	0,12	0,17	0,19	0,20	0,17	0,21
13	0,29	0,33	0,28	0,14	0,25	0,18	0,23	0,27	0,27
14	0,28	0,26	0,33	0,12	0,14	0,20	0,27	0,17	0,24
15	0,33	0,34	0,35	0,05	0,15	0,11	0,20	0,27	0,37
16	0,25	0,37	0,31	0,20	0,24	0,24	0,22	0,29	0,28
17	0,28	0,23	0,37	0,11	0,16	0,21	0,19	0,29	0,12
18	0,28	0,31	0,18	0,17		0,30	0,20	0,22	0,21
19	0,49	0,32	0,34	0,15		0,22	0,23	0,32	0,21
20	0,40	0,43	0,22	0,09		0,17	0,34	0,14	0,20
21	0,53	0,27	0,23			0,29	0,10	0,19	0,14
22	0,47	0,30	0,28			0,29	0,20	0,22	0,24
23	0,23	0,41	0,53			0,22	0,20	0,26	0,20
24	0,26	0,40				0,26		0,28	0,34
		0,39				0,27			
Mean	**0,35**	**0,34**	**0,34**	**0,13**	**0,18**	**0,21**	**0,24**	**0,23**	**0,23**
Std.Dv	**0,11**	**0,08**	**0,10**	**0,05**	**0,05**	**0,05**	**0,07**	**0,07**	**0,06**