

Design, Manufacturing of a New Laboratory Type Filament Yarn Drawing Machine and Featured Yarn Development Studies

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ABSTRACT

In the establishments where continuous filament yarn production is made, the production line covers a fairly large scale, the production continues non-stop all day long and this industrial type machines possess a large number of process parameters. Because of these reasons, during the production activities it is pretty demanding to R&D and P&D studies in industry. In the view of this disadvantageous case, this study was carried out and with this study it was aimed to do continuous and systematic researches towards filament yarns. Thus, this study has two stages. The first one is the study of design, improving and manufacturing lab-type filament yarn production machinery based on melt spinning principle and the second one is the study of original product development done in the manufactured machinery. As a result, many scientific studies about production of filament yarns especially for application of technical textiles can be realized with this lab-type machine.

Keywords: Machine design, manufacturing, yarn drawing machine, filament yarns, functionality.

I. INTRODUCTION

Nowadays, many scientific studies are carried out in order to improve the properties of synthetic filament yarns because functionalized filament yarns are quite important for the development of the textile industry. Thanks to R&D and P&D studies that have been conducted on these products especially in recent years, filament yarns have gained many functional properties such as UV-resistance, flame retardant (FR), anti-bacterial properties, etc. One of the most preferred methods for production these types of products is adding micro and nano scale additives to polymer raw material in the chip form during the filament yarn production in industry and especially, melt spinning method is preferred for these type studies. As a result, end products with unique properties are produced by using this method for different areas of use. However, in the establishments where filament yarn production is made, the production line covers a fairly large scale, the production continues non-stop all day long and this industrial type machines possess a large number of process parameters. Hence, during the production activities it is pretty demanding to R&D and P&D studies in industry.

Laboratory-type production machines are ideal for continuous and systematic R&D studies. These type machines can be controlled easily and thus, production

parameters can be selected and adjusted according to scientific researches. Hence, scientific studies are performed with use of these type machines. When the literature was examined on this subject, we have reached two basic results. The first is, the lab-scale filament yarn production machines have been manufactured by various companies in the world [1-5] and secondly, lots of researches and studies have been carried out on these type machines [6-10]. Because of these situations, this study was carried out and with this study it was aimed to do continuous and systematic researches about filament yarns.

The purpose of this study is to produce high value added products with a new prototype filament yarn machine in our country. In this context, this study is basically two phased; the first phase is comprised of the design and manufacturing of the laboratory-type filament yarn production machine and the second phase is comprised of the product development studies conducted on the manufactured machine. Hereby, many scientific studies about production of filament yarns especially, specific applications for the textile industry can be realized with this machine. From these points of views, the study is in a character that both enlightens the science, and contributes to our country's economy thanks to commercialize this machine.

II. DESIGN AND MANUFACTURING

The scientific studies in related fields can be varied and accelerated with laboratory-type filament yarn drawing machine. Various manufacturers of lab-type filament yarn machines are located in the world and usually researchers in our country have purchased these machines very high amounts from these firms. Also, these filament yarns may not be produced with desired quality according to industrial product. In the view of these situations, this study was realized. The aim with this study was to design, development and manufacture of a lab-type filament yarn machine for the first time in our country and end of this study, this aim has been achieved.

This machinery manufacturing studies are mainly composed of newly design, development and manufacture stages. Before these stages, reviews of the literature and feasibility studies have been carried out. Within the scope of the feasibility studies; studies of design and sizing of machine, determining of basic machine units and calculating of production parameters of these units have been carried out. In addition, these studies have been supported by the results of literature. After these studies, the technical drawings with AutoCAD and SolidWorks programs have been performed for a new machine design study. Also, these technical drawings have been drawn in detail for all machine parts. Hence, these drawing studies have been continued during the manufacturing of machine [6]. Another important stage of this study is determining of materials for machine. This stage has been carried out attentively and all materials of lab-machine have been selected. Then, manufacturing parameters have been calculated. These stages of manufacturing of lab-type filament yarn machine have been provided in Figure 1.

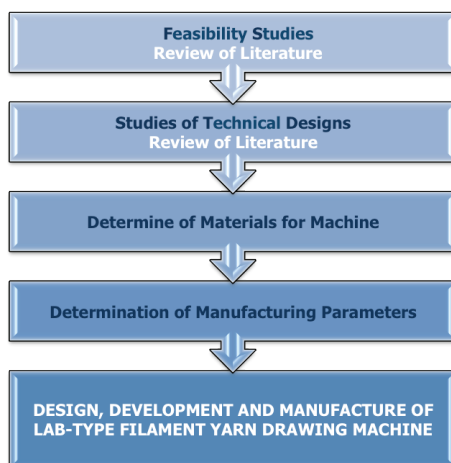


Figure 1. Manufacturing stages of lab-type filament yarn drawing machine

For the first phase of the study, first of all, detailed feasibility studies were conducted and the design of the laboratory-type filament yarn production machine was finalized. Then, a new laboratory-type small-scale machine was manufactured and the first prototype of the developed machine was installed at the “Filament Yarn Production Laboratory of the Çukurova University Textile Engineering Department”. Then, the trial yarn production studies were completed. Currently, there are still several R&D production studies are in progress with the machine. For example, continuous filament yarns have been produced recently with properties such as Flame Retardant, UV Resistance and High Tenacity; and both the mechanic and unique features of these products have been analysed.

This machine has been developed based on melt-spinning principle. Laboratory type machine possesses six units basically. These are feeding and extruder units, melt pumping unit, cooling unit (with quench air), drawing unit, texturing unit and winding unit, respectively. Machine has been designed as to can produce flat filament, textured yarn or intermingled yarn products. The basic technical features of the machine are given in Table 1.

Table 1. Technical properties of lab-type filament yarn drawing machine [6]

Technical Properties	Descriptions	
Raw Materials	Polypropylene, Polyethylene, Polyester and Polyamide	
L/D Ratio of Extruder	27	
Number of Spinneret	2	
Cross-Sectional of Spinneret	Round, Trilobal, Hollow and Various Modified Cross-Sections	
Number of Godets	5	
Capacity of Metering Pump	5 cc/rev	
Principle of Texturing Unit	Air-Texturing Jets and Cooling Drum	
Linear Density of Filament Yarns	Flat Filament Yarns	200-1500 denier
	Textured Yarns	500-2500 denier
Production Capacity	72 kg/day	
Installed Capacity of Machine	78,8 kW	

A basic technical drawing of lab-type machine and an image of this machine are given in Figure 2.

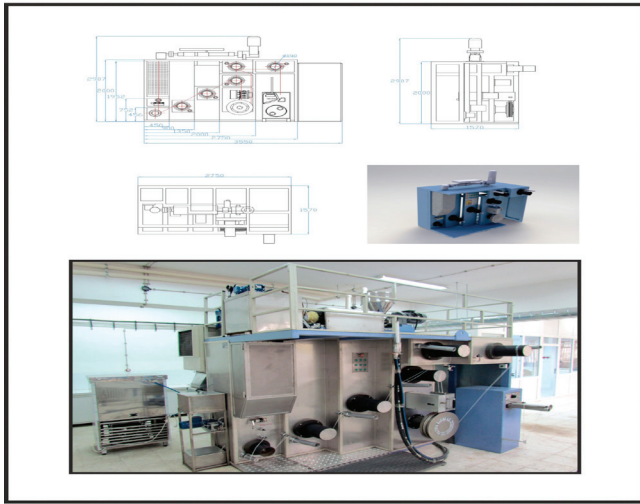


Figure 2. Technical drawing and image of developed laboratory type filament yarn machine [6]

As a result, with this study, laboratory-type filament yarn drawing machine has been manufactured for first time in our country and this machinery have been commercialized.

III. FILAMENT YARN PRODUCTIONS

Today, synthetic yarn properties are developed and enriched thanks to scientific researches on this subject. Realization of these type studies in laboratory type machines provides many advantages such as feasibility, controllability, flexibility, continuity, etc. Hence, usually laboratory type machines are preferred for scientific researches about filament yarns production.

Subjects of scientific researches which are conducted on these type machine in general, studies on the production parameters of machine (spinneret configuration, drawing ratio, winding parameters, etc.), production of functionalized filament yarns with addition of different additive materials (micro or nano scale of FR, UV, anti-bacterial, etc.), production of different types of filament yarns (flat, textured, intermingled yarns) can be listed. As a result of these productions, the yarn properties can be improved or new and useful properties can be imparted to the yarn. Moreover, thanks to these type productions, in-depth researches can be realized about structural, mechanical and original/specific properties of filament yarns.

For instance, we have prepared of PP filaments incorporating micro particles by using this machine and investigate the effects of these particles on flame retardant and mechanical properties of the filament yarns. The PP polymer chips and FR additives were fed into the hopper consisting of a single-screw extrusion system. The heating along the screw was adjusted to obtain a temperature gradient from 220°C to 245°C and a volumetric pump regulated the injection of molten polymer towards the dies at a flow rate of 350 cm³ per minute. Then, the filaments were air cooled and spin finish was applied on the filaments before their passage in the drawing godets. Then filaments were drawn by means of heated godets before being wound. The speeds of the two godets serve to adjust the drawing ratio: the first godet speed was set at 400 rpm, whereas the second one was set at 800 rpm, giving a drawing ratio of 2. Finally, the filament yarns were wound on a cheese package. In addition to, during the production process, all other parameters except for the factors whose effects were aimed to be investigated (ratio of additive material) were kept constant. The filament yarns obtained consisted of 144 individual filaments and linear density of these yarns 918 denier. Also, these yarns have round cross-sectional shape. Technical drawing of units of laboratory type filament yarn machine is given in Figure 3 [7, 8].

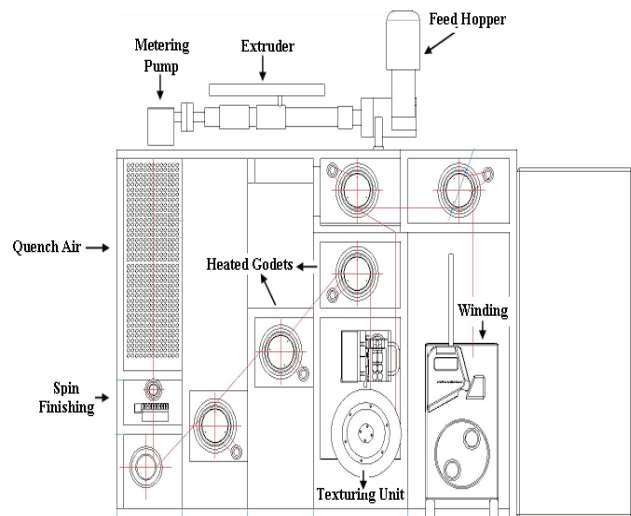


Figure 3. Basic units of laboratory type filament yarn machine [7, 8]

Based on the results of the study, filament yarns have been concluded to have desired flame retardant properties. Image of produced PP filament yarns with FR additive is given in Figure 4.



Figure 4. Produced PP filament yarns in this study [6]

As a result of flammability tests, the LOI values of all phosphorus-containing PP knitted fabrics were determined between 25% and 30%. On the other hand, some differences in the properties of the produced yarns such as tenacity, breaking elongation, unevenness have been observed and surface images of these yarns have been examined using SEM analysis. This study shows that in addition to functional properties, structural and mechanical properties such as tenacity, breaking elongation, unevenness etc. are also important for functionalized filament yarns. Hence, these important properties should be at specific values for the production of high quality filament yarn. As a result, functionalized filament yarns can be produced on this lab-type machine with this method, properties of filament yarns have been examined and flame retardant filament yarns were produced successfully.

IV. FUTURE WORKS

Many studies about filament yarn technology can be performed by using laboratory type filament yarn drawing machine. Some of them are listed below.

- Effects of production parameters on the structure, mechanical and specific properties of flat or textured yarns can be carried out.
- Studies of development of production conditions/parameters of lab-type machine can be carried out.
- Filament yarns can be produced with different/various additive materials such as UV, antimicrobial, etc. and then, properties of these yarns can be examined.
- Filament yarns can be produced with different sized

additive materials (micro and nano scale). Then, properties of these yarns can be examined.

- Studies can be performed for development of texturizing properties of yarns (Changing production parameters: spinneret configuration, drawing ratio, texturizing conditions; air pressure, air temperature, nozzle configuration, etc.)
- Filament yarn can be produced with newly features (by using new additive material).
- Properties of filament yarns can be developed.
- New designs of machine materials can be carried out. Yarn product features can be developed with these designs.

If some or all studies described above are achieved, results of these studies will contribute to textile science and technology. Moreover, newly results can be patented.

V. CONCLUSIONS

Thanks to this study, a newly designed lab-type machine has been manufactured and also, functionalized products have been produced on this machine, too. This performed study has two fundamental outputs: a laboratory type filament yarn production machine and products with high added value/technology based products. The direct impacts of the study on science, industry and economy are listed below;

- With the manufacturing of a machinery that can also be commercially marketed, speeding up the scientific research aimed at synthetic filament yarn production and conduct research and trials on these type of prototype machinery aimed at resolving the possible problems of the industry.
- Contribute to science by issuing many publications based on the knowledge to be obtained as a result of the research studies to be conducted on the prototype machine,
- As such a machine has now become possible to be manufactured domestically, eliminating the problem of purchasing this type of machine from abroad at very high prices and by creating an opportunity for the researchers, wishing to buy this machine, to buy it at a cheaper price, contributing both to them and the regional industries thereof,

- Considering that machinery, textile and raw material industries significantly contribute to the development of the country, obtaining gains for both branches of industry with this study,
- By promoting this laboratory type filament yarn production machine both nationally and internationally, contributing to the export figures of machinery and parts of our country provided that this machine receives demand from abroad,
- Furthermore, creating a fine example for university-industry cooperation with this study and being able to become an exemplary with the production studies performed on the machine.

As a result, the machine manufactured in the scope of this study forming a concrete example of University-Industry Collaboration, has been added on to the capabilities of our country in a format that can be made commercialized and in a manner to contribute to the national technological know-how. Furthermore, several original product development/production activities are also taking place on the machine. Thus, this study can both illuminate a path for scientific research and also contribute to the national economy.

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