



Conference Paper

# Development of Breathable, Environmentally and Human-Friendly Cloth Mask That Meets Thermal Comfort Conditions and A Continuous Machine That Enables Industrial Production of This Mask

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**Reference:** Okyay, N., Işık, F., Kes, S. Yüksek Uzamalı Dökme Demirin (EN-GSJ-400-18) Uygun Üretim Şartlarının Araştırılması. Orclever Proceedings of Research and Development,3(1), 171-177.

## Abstract

*Ever-changing viruses that have threatened human health from past to present have greatly changed people's lifestyles. The most important precaution in infectious diseases is hygiene. Although hygiene is important in epidemics, the use of masks is the most effective method of protection in respiratory diseases. Since epidemic and infectious diseases remain stable in the incubation phase in people who do not have chronic diseases and have a strong immune system, these people without symptoms of the disease can be carriers. In addition, masks are used as protective equipment to prevent occupational diseases that may occur in sectors such as textiles. For this reason, within the scope of the study, it is suitable for multi-use with the use of sustainable class A natural raw materials, which prevents the formation of bacteria in all social areas even if there are no symptoms of disease, provides comfort with its coolness and soft structure, provides thermal comfort conditions for long-term use with its antistatic feature. It is aimed to develop an*



*environmentally friendly cloth mask and a continuous system that performs serial pleating and ironing processes that will accelerate its industrial production.*

**Keywords:** Antibacterial Cloth Mask, Sustainability, Pleating and Ironing

## 1. Introduction

The use of masks, frequent hand washing and maintaining social distance have long been recommended to prevent the spread of all microorganisms transmitted through the respiratory tract in society. COVID-19, which was detected in Wuhan, China, at the end of 2019 and spread all over the world in a short time, causing a pandemic, has become a very important and urgent public health problem, and the mask has risen to an important position in this epidemic. A face mask is a textile material that creates a physical barrier between the user's mouth and nose and potential contaminants in the immediate environment [1]. Face masks are divided into two: textile (cloth/fabric) masks and medical face masks (medical/surgical). While medical masks are used in healthcare institutions, masks made from different fabrics are widely used by both healthcare professionals and people living in the community. Medical masks and fabric masks prevent the scattering of respiratory droplets larger than 3  $\mu\text{m}$  [2]. Medical masks are produced from a fabric known as "nonwoven". The raw material of this non-woven fabric can be used as polypropylene, polystyrene, polyethylene or polyester fiber. In the document published by the World Health Organization for fabric masks, it is recommended that the mask should be at least three layers, containing fabric containing hydrophilic material in the innermost part and hydrophobic material in the outermost and middle parts[3]. There was no standard for cloth masks until recently, but a "standard for washable cloth mask" document was published by the Turkish Ministry of Industry and Technology and the Turkish Standards Institute. According to this standard, the cloth mask must meet the TSE K 599 standard after a minimum of 5 washings, that is, it must be able to retain more than 90% of particles larger than 3  $\mu\text{m}$ , its breathability rate must be less than 60%, and its microbial cleaning feature must be less than 30%. According to the standard, this fabric production can be woven, knitted or non-woven [4]. The increase in demand for surgical masks and respirators with the COVID-19 epidemic that has affected the whole world has led to a global supply and raw material shortage, and many people have started to produce their own masks with their own means, use disposable masks multiple times, or use more masks than they actually need. They had to start choosing masks that provide less protection [5]. Non-woven masks produced from polyester and polypropylene raw materials, which are currently widely



used, take approximately 1000 years to decompose. According to 2020 statistics, the human population in the world is 7.78 billion. When it is calculated that approximately 7 billion people use and throw away one of these masks a day, this figure reaches 2.555 billion in a year. This situation, which even causes environmental pollution and changes in climate conditions, necessitates the widespread use of masks developed from reusable biodegradable raw materials by reducing the consumption of these raw materials, which are polyester derivatives. However, in today's technology, there is no automatic machine that can mass produce these cloth masks industrially. In this sense, by developing an environmentally friendly cloth mask suitable for multiple uses with the use of sustainable class A natural raw materials, which prevents the formation of bacteria, keeps it cool and provides comfort with its soft structure, provides thermal comfort conditions for long-term use with its antistatic feature, it is aimed to protect human health in the fight against the epidemic, in the prevention of occupational diseases in sectors such as textile or in daily use. In addition, cloth masks produced entirely by manpower cause loss of time, and due to the lack of fast service and the inability to establish the supply-demand balance in cloth masks, serial pleating and ironing system was activated to produce the developed cloth masks.

## 2. Material and Method

In the thread composition of the cloth mask subject to the study, weft and warp threads of Ne 20/1 fineness were developed using ring spinning technology using 45% tencel, 30% acetate and 25% hemp fiber. Characteristic features of the raw materials used are given in Table 1.

*Table 1: Characteristic Features of The Raw Materials Used*

Raw materials	Tencel	Acetate	Hemp
Fiber Fineness	1.33 dtex	1.33 dtex	17-22 microns
Fiber Length	38mm	38mm	25-40mm

After these yarns obtained were conditioned for 24 hours under laboratory conditions of 20+/-2 °C temperature and 65+/-5% humidity, the yarn strength values were measured on the Uster Tensojet-4 device in accordance with TS 245 EN ISO 2062 standards, for unevenness (%Cvm) and yarn defects thin places(-50%/km), thick places (+50%/km) and neps (+200%/km) were measured on the Uster Tester-6 device using the TS 628 standard. Then, the fabric was woven from these yarns. A cloth mask in accordance with the TSE

cloth mask standard was produced from the obtained fabric using the continuous pleating and ironing machine developed within the scope of this study.

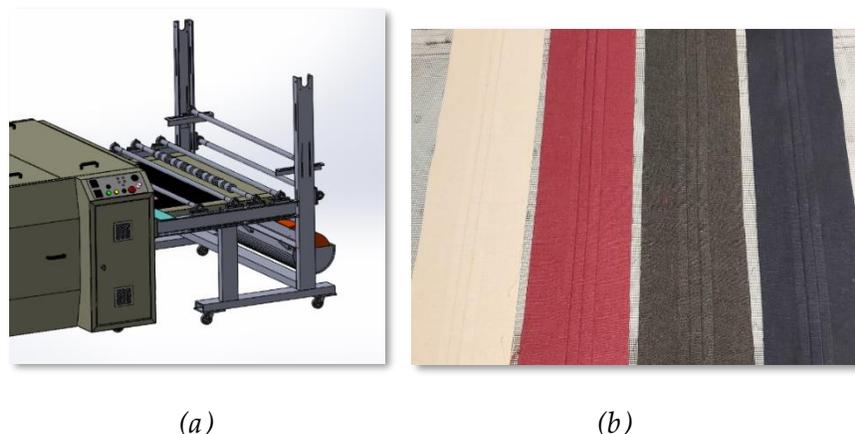


Figure 1. (a) Solid modeling image of the pleating and ironing system, (b) Cloth mask pleated with the continuous pleating and ironing system

The cloth mask developed within the scope of the study was subjected to bacterial filtration test within the scope of EN 14683, breathability and microbial cleaning tests after 5 washings, as well as antibacterial activity tests according to ASTM E2149 standard.

### 3. Results

In the study, the quality test values of tencel acetate and hemp blended yarn are given in Table 2. Bacterial filtration test results of the cloth mask obtained from the developed yarns are given in Table 3, breathability test results are given in Table 4, microbial cleaning test results are given in Table 5, and antibacterial activity test results are given in Table 6.

Table 2 Unevenness and Strength Test Results of 20/1 Tencel Acetate Hemp 45/30/25 Yarn

Quality Parameters	20/1 Tencel Acetate Hemp 45/30/25
Unevenness (%CVm%)	17.79
Thin Places (-50%)	one
Thick Places (+50%)	911
Neps (+200%)	1233
Strength Rkm (kgf.Ne)	17.91
Elongation at break (%)	8.77
B.Work (N.cm)	13.76



As can be seen from the table, the unevenness value of the yarn produced in the ring line from the 20/1 Tencel Acetate Hemp 45/30/25 blend was measured as 17.79 CV%. Its strength was measured as 17.91 Rkm, Elongation value was 8.77%, and B-Work value was 13.76 N.cm.

*Table 3 : Bacteria Filtration Test Results of the Developed Cloth Mask*

Sample	Cloth Mask
Bacteria Filtration Efficiency %B	90.8%

According to the bacterial filtration test results within the scope of EN 14683, the developed cloth mask showed 90% resistance against the penetration of bacteria.

*Table 4 : Breathability Test Results of the Developed Cloth Mask*

Sample	Cloth Mask
Breathability	20.7 Pa/cm <sup>2</sup>

According to the breathability test results within the scope of EN 14683, it was observed that the developed cloth mask provided comfortable breathability to the user by showing a low pressure difference of 20.7 Pa/cm<sup>2</sup> after 5 washings.

*Table 5 : Microbial Cleanliness Test Results of the Developed Cloth Mask*

Sample	Cloth Mask Before Washing	5 Cloth Mask After Washing
Microbial Cleaning	6 cfu/g	3 cfu/g

According to the microbial cleaning test results before and after 5 washes within the scope of EN 14683, microbial contamination on the cloth mask was found to be low at 3 cfu/g.

*Table 6 : Antibacterial Activity Test Results of the Developed Cloth Mask*

Microbiological Tests	Inhibition Zone (mm)	Microorganism Reproduction	Conclusion
Staphylococcus aureus ATTC 6538 P(Gram(+))	0	None	Effective
Escherchia Coli ATTC 8739(Gram(-))	0	None	Effective
Candia Albicans	0	None	Effective



According to the antibacterial activity test results applied to the cloth mask before washing and after 20 washings in accordance with the ASTM E2149 standard, in the evaluation of activity against E. Coli, C. Albicans and S. aureus bacteria, bacteria did not grow around the test sample, there was no microorganism growth under the sample and it showed antibacterial activity.

In today's world where infectious and epidemic diseases constantly threaten human health, a continuous system of pleating and ironing has been designed and manufactured within the scope of the study in order to be able to produce these cloth masks, which are produced from natural raw materials and whose yarn and fabric performance tests are given above, and to double the cloth mask garment process speeds. In production, the fabrics in the form of rolls are fed by motors and flowed to the developed pleating apparatus. While continuous flow is ensured in this system, the tension of the flowing fabric is also controlled in the feeding section by means of tensioner shafts. The flowing fabric is smoothly transferred to the pleating apparatus with the help of 6 standard size centralizers. Subsequently, the continuous cloth mask passes through the automatic ironing machine and becomes ready for ready-made garments in accordance with TSE standards.

#### **4. Discussion and Conclusion**

Within the scope of this study, the performance tests of the antibacterial cloth mask were developed during the pandemic and the serial pleating and ironing system was examined for the industrialization of the said cloth mask. When the unevenness and strength tests of the yarn of the developed cloth mask were examined, it was seen that the values obtained were at the optimum level and did not cause any performance problems. When the performance test results of the developed cloth mask are examined, it is seen that it is 90% resistant to the penetration of bacteria, has a breathable structure with the use of tencel and acetate fibers, and shows antibacterial activity and low microbial contamination values on the mask surface with the use of 25% environmentally friendly, natural antibacterial hemp fiber in the yarn composition which shows that microbes cannot survive on the mask surface. Although the pandemic has ended in the current situation, possible epidemics are likely to occur due to the increasing world population and changing climate conditions. In this sense, the use of disposable synthetic-based nonwoven masks, which increase the environmental burden of the textile industry, should be reduced and the use of the multi-use washable antibacterial cloth mask developed within the scope of the study should be expanded in the fight against epidemics. In addition, considering that today's cloth masks are produced by human



power without any automation, a serial pleating and ironing system has been designed to accelerate the production of cloth masks. It is thought that the use of ecological and environmentally friendly products will be the biggest gain for our country with the development of this mask and continuous machine, which will increase the consumption of natural, sustainable and biodegradable fibers.

## 5. Acknowledge

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