(REFEREED RESEARCH)

ANALYZING THE EFFECTS OF SEWING MACHINE NEEDLE COATING MATERIALS ON THE NEEDLE'S HEATING DURING SEWING

DİKİŞ MAKİNESİ İĞNESİ KAPLAMA MALZEMELERİNİN DİKİM AŞAMASINDA İĞNENİN ISINMASINA ETKİLERİNİN ANALİZ EDİLMESİ

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ABSTRACT

Sewing is the last step of a lengthy mass production process. Garments that break down at this stage due to bad stitching cause a great loss of time, energy and also material. The most important sewing faults are thermal and mechanical faults caused by the sewing needle. During sewing, the fabric resists the penetration of the needle. This frictional resistance between the needle and the fabric produces heat and it causes the needle to overheat during high-speed sewing. Sewing needles coated with three different materials are used in this study. The coating materials of the needles used here are Cr (Chrome), PTFE(Polytetrafluoroethylene) and TiN(Titanium nitride). 50 sewing processes for each kind of coating have been carried out in the study, for a total of 150. Needle temperatures during the sewing process have been measured with an optical pyrometer. According to the findings obtained at the end of the measurements, it's been established that materials used in the needle coating directly affect needle heating. The needles coated with TiN according to data obtained by other needles has been found that less heat.

Keywords: Sewing machine needle, Needle coating, Needle heating, Pyrometre.

ÖZET

Dikim işlemi, uzun bir seri imalat işleminin son halkasıdır. Bu safhada giysinin kötü dikiş yüzünden bozulması çok büyük zaman, enerji ve aynı zamanda malzeme kaybına neden olmaktadır. En önemli dikiş hataları, dikiş iğnesinin neden olduğu ısıl hasarlar ve mekanik hasarlardır. Dikiş sırasında kumaş, dikiş iğnesinin batışına karşı koymaktadır. Dikiş iğnesi ile kumaş arasındaki sürtünme mukavemeti ısı açığa çıkmasına ve yüksek hızlı dikişte iğnenin aşırı ısınmasına neden olmaktadır. Bu çalışmada; üç farklı malzeme ile kaplanmış dikiş makinesi iğneleri kullanılmıştır. Kullanılan iğnelerin kaplama malzemeleri Cr (Krom), PTFE(Politetrafloroetilen) ve TiN (Titanyum nitrür) dir. Çalışmada her bir kaplama türünden iğneler ile 50 adet, toplamda ise 150 adet dikiş işlemi gerçekleştirilmiştir. Dikim esnasında iğne sıcaklıkları optik pirometre cihazı ölçülmüştür. Ölçümler sonucunda elde edilen bulgulara göre iğne kaplamasında kullanılan malzemelerin iğne ısınmasına doğrudan etki ettiği tespit edilmiştir. Elde edilen verilere göre TiN ile kaplanmış iğnenin diğer iğnelere göre daha az ısındığı tespit edilmiştir.

Anahtar Kelimeler: Dikiş makinesi iğnesi, İğne kaplaması, İğne ısınması, Pirometre.

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1. INTRODUCTION

The transformation of a two-dimensional fabric into a three-dimensional garment is the basic research topic for the clothing science. The process of sewing, one of the foundational factors in the creation of a garment, is realized as a result of the interaction between the fabric and the sewing needle (1).

The sewing process is an often-used one in many fields of industry. This process is used in the manufacturing of many products like garments, shoes and airbags in automobiles. Every day, millions of pieces of product from t-shirts to airbags are sewn. This is why even a fractional progress in sewing can provide big benefits (2).

Machine needles are a must in order for the sewing to be done. Properties, shapes, criterion and proper application of these needles directly affect the quality of the sewing (3). The needle’s heating causes various problems that affect the process of sewing. It’s desirable that the needle temperature be kept under 140 °C (4).

The force that resists one surface sliding across another surface is called the frictional force. As surfaces slide across one another, the surface atoms are pulled away until they change places to a certain distance from their equilibrium positions, and after a certain amount of vibrational motion, they can’t return to their equilibrium positions. At the end of this process, the amount of energy equal to the frictional loss is spread in the form of heat (5).

A great part of the work put into overcoming friction is released as heat. Because the contact area is so small and this heat is released through the contact areas, sectional increase in temperature can be great. When this increase in the surface temperature of the friction surfaces reaches the melting point of the textile surface, the surface melts (5, 11).

In the process of sewing fabrics made of synthetic fibers, rather high temperatures occur. Main reason for this is the high friction between the sewing needle and the material to be sewn, due to the material being too tightly knit or spun, sewing being done at a high rate, and scrooping. The heat produced in the process of sewing is the result of the friction between the fabric and the needle. This high temperature that’s produced has an extreme effect on the sewing quality (6).

The degree of temperature produced is dependent on the speed of the machine; the number, cross section and surface of the needle; density, thickness and finish of the fabric; and the type, thickness and finish of the sewing thread (4, 7).

Two primary points of heat production are the area of thread passing through the fabric, and the area of the loop stuck between the needle and the fabric. Research shows that needle temperatures go as high as 350 °C (4). Overheating damages both the textile material, and the sewing needle. At the same time, melting occurs on the edges of the loops, causing some critical results in the optical evaluation of the stitch (6).

In textile fabrics, sewing damage consists of torn or melted fibers, and it’s generally covered by the sewing thread. The fabric is weaker in these areas, resulting in tears along the sewing lines if it’s strained while being worn. Sewing damage is even more important in knitted fabrics. It results in broken threads, missed stitches and even the knitting structure completely breaking down. Some sewing faults get overlooked while sewing, and they only become visible afterwards, when strained while being worn, as a result of movement and during washing (5).

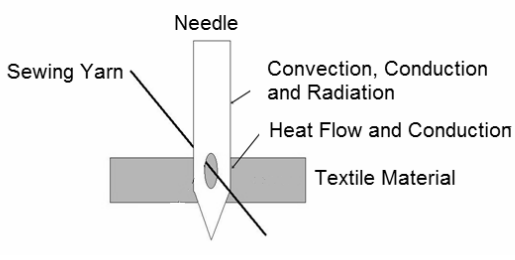

Figure 1. Schematic display of the sewing machine needles’ heating problem (2)

Heat is dispersed from the needle through radiation, conduction and convection. Radiation plays a relatively small part in the needle cooling down. The only way to change the radiation characteristics of a needle is to change the surface structure. A needle with a highly polished surface will radiate less heat, and this movement reduces the needle’s cooling. Conversely, there will be a lot more cooling through radiation in a needle with a black-matt surface (5).

Heat is distributed along the shaft of the needle and to the machine’s needle bar through conduction. This is the most important mechanism induces decreased needle temperatures. 85% of the needle’s heat loss when the machine stops occurs in this way.

As the machine works, the airflow around the needle ensures that heat is dispersed through the convection mechanism. Heat loss through convection is 10% when the sewing machine is stopped, and 60% when it’s working.

Fig. 2. shows the forces that occur when the needle penetrates the fabrics and withdraws from it. These forces are:

1. Maximum penetration force when the needle penetrates the fabric
2. Minimum force when the blade
3. Maximum force when the blade shoulder penetrates
4. Maximum withdrawal force.

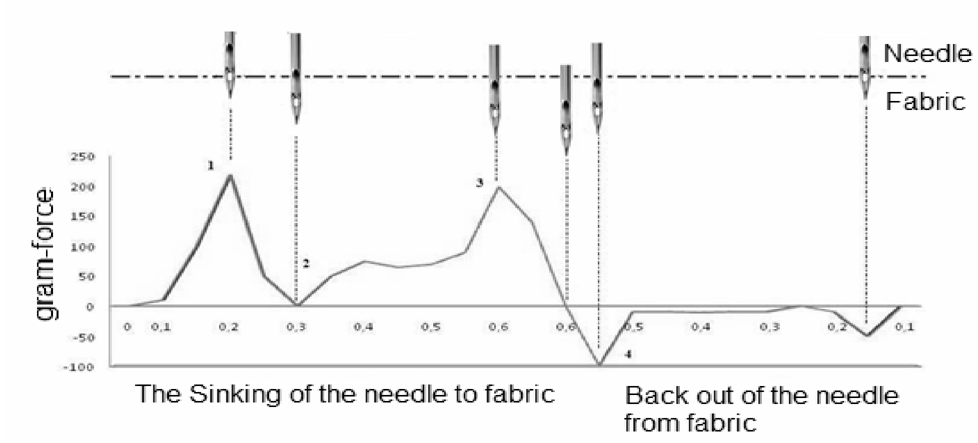

Figure 2. Forces that occur when the needle penetrates the fabric and withdraws from it (5)

When sewing the material, the heat that the friction between the needle and the fabric produces is closely related to the needle's surface quality. Thermoplastic threads that melt as a result of the needle's heating and get stuck to the needle result in stitching damages, torn threads and the needle deteriorating. Various needle surface coatings have been developed to reduce friction and to prevent the melting materials from sticking to the needle during sewing. Steel needles have polished surfaces. But after long use and incorrect storage, they rust. (3) Steel needles are quick to heat, which is why using them with synthetic or synthetic blend fabrics is ill-advised. If the sewing needle is also synthetic, threads will melt and stick to the needle eye and the fabric, causing a great deal of damage (3).

Needles are produced of steel and polished in the last stage of production. They're coated with electrolysis to provide resistance to corrosion and mechanical weathering, to reduce friction during sewing and to give the needle a good look. The coating material is usually chrome or nickel. Another important feature expected from the needle coatings is to prevent the melted particles of synthetic fabrics or threads, which occur when the needle overheats during sewing, from sticking to the needle to some extent. PTFE-coated needles are developed for this purpose and they are used for special applications (8).

Nickel-coated needles prevent rusting and protect the needle from corrosion and heating, but they deteriorate at high temperatures and change color. These needles, coated with nickel to prevent rusting, quickly conduct heat due to nickel's property. For this reason, using them in high-speed machines is ill-advised (3).

Chrome coating protects the needle from corrosion, and especially hard chrome coating gives the sewing machine needle a high abrasion resistance. But chrome coated needles rust and deteriorate quickly. Cr coated is the most used coating material on sewing needles coating. Cr coated needles can be used in all types of sewing machines of all types of stitches.

Titanium nitride is used in sewing needle surfaces (TiN) to give them a homogeneous, hard and smooth surface. This coating gives the needle properties of being extremely hard and flexible. Titanium nitride can expand sewing machine needles' expected lifetime. TiN coated is used in the fabrics that the needle is easily deformed and get more needle warming due to the friction. TiN coated needle is much more resistant to the friction than PTFE coated needles. Primarily is used in the denim fabrics with overlock and lock stitch sewing types.

Non-metal needles like polytetrafluoroethylene (PTFE) are polymer-impregnated surfaces and are stated to reduce needle penetration force and thread damage thanks to their low friction characteristics. They also prevent melted material from sticking to the needle. "Blukold" (PTFE) needles are developed towards needle heating problems and they absorb heat. PTFE coated is used in the fabrics that has too much needle heating problems. Primarily in thick fabrics such as denim and knitted fabrics made of synthetic fibers. It is used in the sewing machines that are making lock and overlock stitch types.

Ceramic coating is developed towards use in specific sewing machines. It reduced heat by 20-25% and prevent static electricity before it occurs. Value of materials and coatings used in the coating properties are shown in Table 1.

2. MATERIAL AND METHODS

2.1. Material

Properties of the materials used in the application study are listed as follows.

Sewing Machine Needle

Nm 120/19 sewing machine needles coated with Cr (Chrome), PTFE (Polytetrafluoroethylene) and TiN (Titanium nitride) have been used in the study. Whole surface of the needles were coated with the same materials. Needlepoint of all needles is Normal(R)

Properties of the Denim Fabric Sewing Thread Used

Needle yarn and one of sewing threads used are number 30 poly/poly CoreSpun while the lower yarn is number 50 poly/poly CoreSpun.

Sewing Machine and Measurement System

"Brother DA 9290 D" high-speed, feed-off-the-arm industrial sewing machine with cylinder bed has been used for the study. This is a full-speed machine with a looper in its lower thread feed. An Optris CT3M pyrometer has been used in the study to measure the needle temperature.

Table 1. Coating properties of coatings (9, 10)

Coating property	Coating				Special coating				
Coating Material	TiN	TiCN	TiCN-MP	TiAlN	AlTiN	ZrN	CrN	CBC	TiAlCN
Coating Structure	Sngl	Mltpl	Mltpl	Single	Sngl	Sngl	Sngl	Mltpl	Multiple
Force (GPa) gigapascal	24	37	32	35	38	28	18	20	28
Coefficient of friction	0.55	0.2	0.2	0.5	0.7	0.55	0.3	0.15	0.25
Coating thickness **(µm)**	1-5	1-4	1-4	1-4	1-3	1-4	1-4	0.5-2	1-4
Temperature (°C)	600	400	400	800	800	600	700	400	500
Coating Color	Golden	Blue-Gray	Bright Red	Violet	Blue-Black	Light Yellow	Silver	Charcoal Grey	Reddish Copper

Warp Yarn	Ring Ne 6.5
Weft Yarn	Ring Ne 6.3
Fabric Pattern	D 3/1 Z
Yarn Type	% 100 Cotton
Weight of Fabric	500 g/m^2
Width of Fabric	150 cm

Table 2. Properties of the denim fabric used in the study

2.2. Method

Process of sewing was completed under the conditions of 20°C (±2) temperature and 65% (±2) relative humidity. Five needles of each coating were used for ten sewing processes each. Therefore 50 sewing processes for each kind of coating was completed, for a total of 150 sewing processes.

Denim pants inside leg assembly seams were chosen for the measurement. Because lockstitches are used to sew inside legs, the fabric is sewn four-folded. This process was preferred in the study because friction was assumed to be greater. Denim fabric was prepared as trouser leg, as seen in Fig. 3. The length to be sewn is 160 cm. The sewing process was completed along this length without stopping.

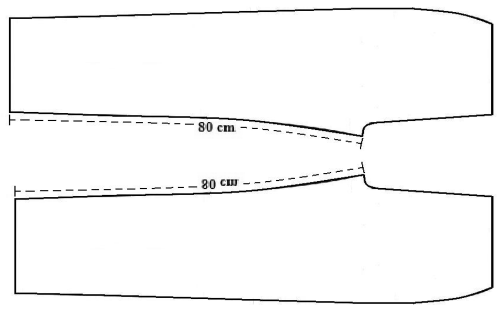

Figure 3. Trouser legs sewn in the application

Sewing conditions were set as follows for the application. Also, higher and lower thread tensions were kept constant.

Sewing Machine	: Brother DA 9290 D
Stitch Type	: Double thread lockstitch (401)
Machine Speed	: 3600 rpm
Stitch Density	: 5 stitches/cm

2.3. Experiment Setup

There are different methods for the measure of the temperature of sewing needle machine. These methods, thermal camera, attached thermocouple and inserted thermocouple. In this study, the optical pyrometer system without non-contact temperature measuring technique was used. (12)

Pyrometer's laser was aimed at the sewing machine's needle, as seen in Fig. 4. The optical pyrometer's laser rays were focused exactly on the needle eye (Fig. 5). During sewing, with each movement of the needle, 100 temperature measurements per second were taken from different spots on the needle. Emissivity value for the sewing machine was accepted at 0,08. The distance of the optical pyrometer to the needle is 7 cm. In order to prevent the optical pyrometer from being affected by the machine's vibrations, it was mounted on a tripod and aimed at the sewing machine needle independently from the machine.

3. RESULTS AND DISCUSSION

Temperature values obtained from sewing tests with PTFE, chrome and TiN coated needles can be seen in Fig.6. PTFE-coated needles have a highest temperature value of 199,5 °C, and a lowest temperature value of 130,2 °C with a standard deviation of 15,4. At the end of the sewing test with chrome-coated needles, the highest temperature measured as 146,4 °C and the lowest temperature as 63,5 °C, with a standard deviation of 11,8. TiN-coated sewing needles have a highest temperature value of 155 °C, a lowest temperature value of 107,1 °C and a standard deviation of 10,9.

These results show that needles coated with PTFE have the highest temperature values. Values for chrome and TiN coated needles don't show great differences.

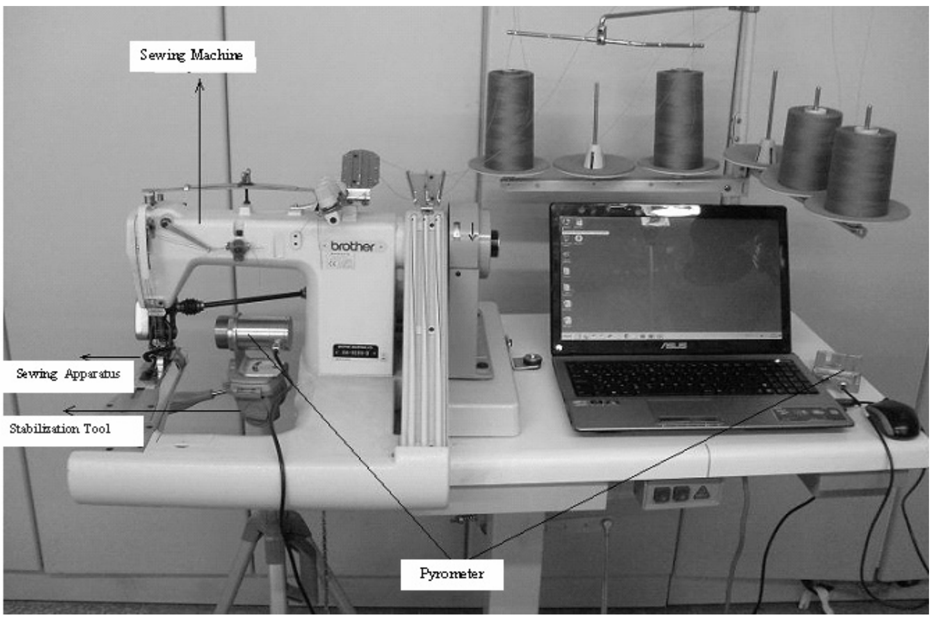

Figure 4. Experiment setup

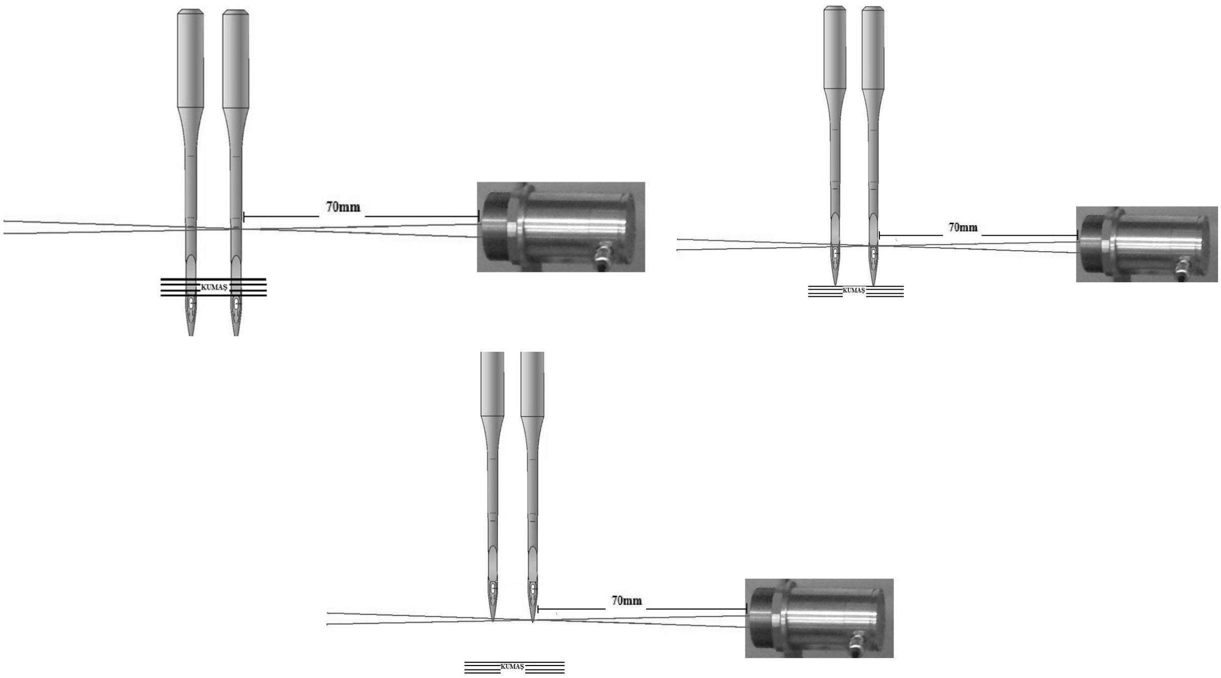

Figure 5. Measuring temperatures along the needle during sewing

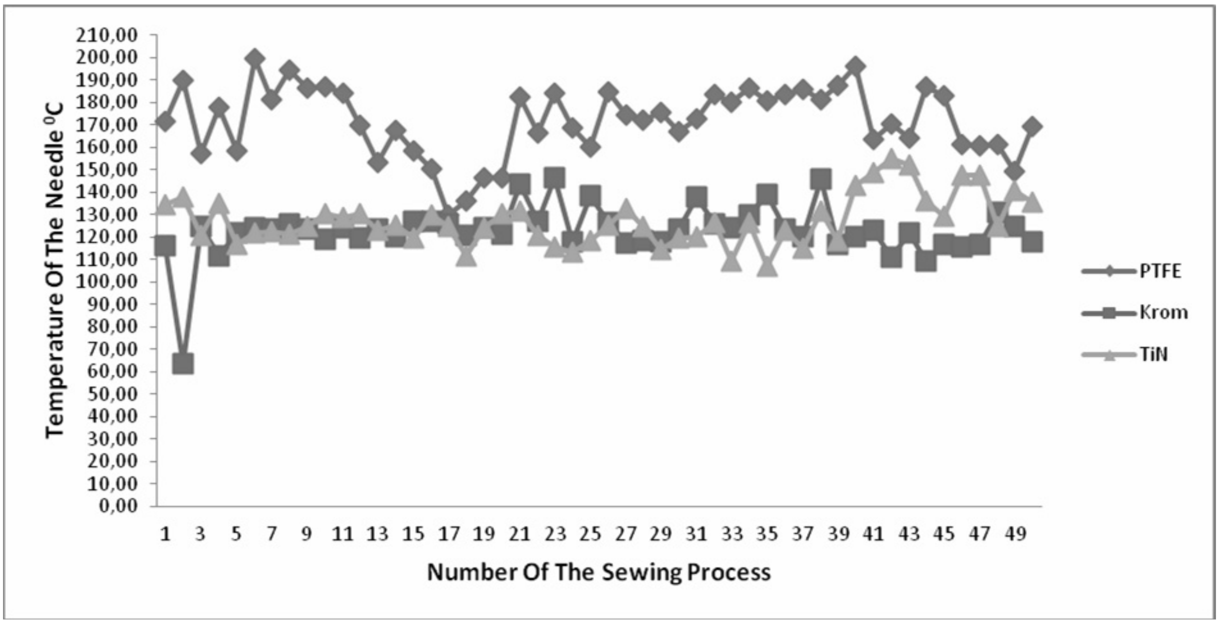

Figure 6. Temperature Values of Needles

4. CONCLUSION

Mistakes that occur in garment production negatively affect product quality and productivity, as well as causing production costs to rise. Sewing is the foundational process in garment production. Stitching, the most important factor in determining quality and durability in garment production, is the process of moving sewing thread through the material to be sewn with the help of a needle, for strengthening or embroidering purposes. This activity is the foundational step in the production process, and carrying it out as desired has an impact on utilizing resources and time spent in production more effectively, as well as fulfilling the expected level of quality in the final product.

With the help of technical and electronic advancements, sewing machines used in the garment sector are getting faster by the day. This increase in machine speed itself increases the importance of preventing the needle heating problem, in order for the sewing machines to be used more effectively.

The effect of different materials used in coating sewing machine needles on the needle heating during sewing has been investigated in this study.

According to the results obtained in the study, coating materials were found to have an effect on the sewing machine needle temperatures during the process of sewing. In the study made with PTFE-coated needles, higher temperature values were observed in comparison to needles coated with different materials. Similar temperature values were observed in TiN and Cr-coated needles. As a result of this study, it can be said that coating materials have an effect on temperatures during production. Considering the effects of needle heating on sewing quality, it can be said that sewing machine needle coating is a factor affecting the quality of production.

In sewing of denim fabrics and especially knitted synthetic fabrics, where the needle heating during sewing due to the friction between the surface of the needle and the fabric is high, it is advisable to use PTFE and TiN coated sewing machine needles. It is also advisable to use PTFE and TiN coated needles in high-speed sewing machines, like overlock and feed-of-arm bed.

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