A Study on the Molten Cutting of the Thermoplastic Cloth

Hiroshi KIMURA*, Takuzi YAMAGUCHI*, Masakazu UEMATU*

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The apparatus was made for trial, which may examine the possibility and the practicality of welding and molten cutting of thermoplastic cloth. Micro-structure examination of molten parts is also done by this.

INTRODUCTION

This thesis clarifies the method of application of welding technology of plastics to the textile one[1]. Most of now-used textiles are synthetic fiber made of thermoplastics, which makes it possible to apply the welding method of engineering plastics. The attempt to change the three processes to one process of fabrication, cutting, flapping, sewing which are the important factors in the usual sewing process of fabric, is being made, making good use of the essence of fiber. Namely the molding materials as well as fibers, though they are not the same in their forms, have the same molecular stracture. By heating, therefore, they present the typical conditions of viscous fluid, reduction of segment, diminition of micelle structure and similarly that of orientation[2]. These facts explain that it is sufficient to supply enough energy for a carbon atom to jump over the energy obstacle that comes out at the time of its spinning at the circumference of one valence bond of main chain of molecule. The welding will be properly done by compressing fabric under this state of viscous fluid. The molten cutting will also be done by moving the knife under the same state. In order to confirm this, one apparatus was made for trial, which may examine the possibility and the practicality of welding and

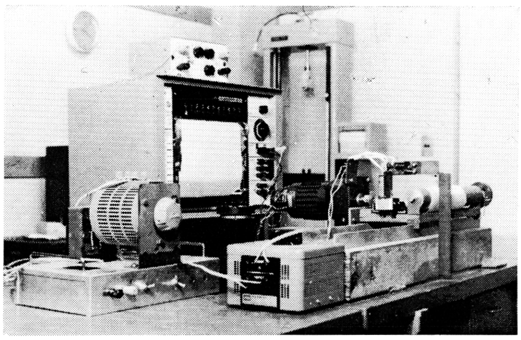


Photo. 1 Apparatus of the molten cutting of thermoplastic cloth

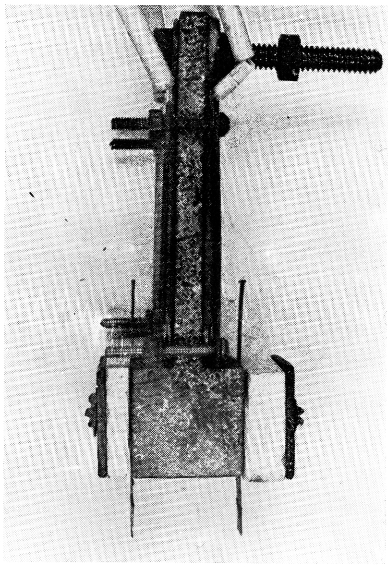


Photo. 2 Trial produced knife for the molten cutting

* Dep. of Textile Eng.

molten cutting. Microstructure examination of molten parts is also done by this.

EXPERIMENTAL RESULTS AND CONSIDERATION

Photo. 3, 4 are microphotographs of molten parts by nichrome wire direct heating

Photo. 3 Microphotograph of molten part by nichrome wire direct heating method

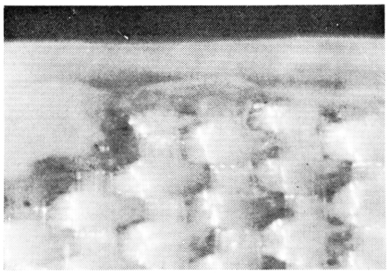


Photo. 4 Microphotograph of molten part by indirect heating method

method and indirect heating method knife, and the latter is superior, proving that it is fundamentaly necessary to combine molten cutting and mechanical cutting. Used specimens both warp weft are plain weaving of 50 denier nylon, using a fabric of 170 warps per inch and 85 weft per inch and a test piece is 25 *mm*. Fig. 1 showing the maximum speed at which molten cutting in each welding temperature is possible, clalifies that this is in the index function relation. Fig. 2~4 presents experimental results, which show the relation

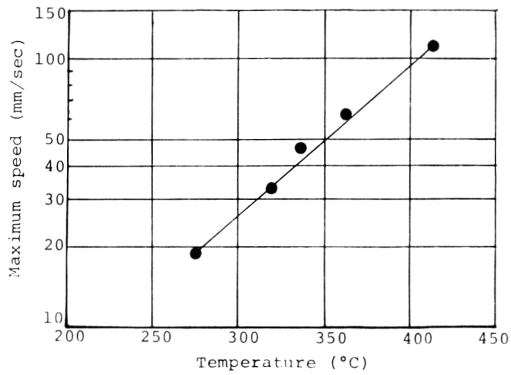


Fig. 1 Relation between maximum speed and temperature

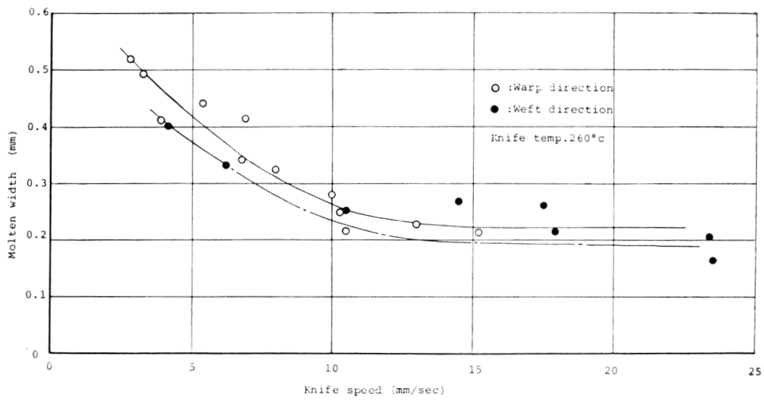


Fig. 2 Relation between molten width and knife speed

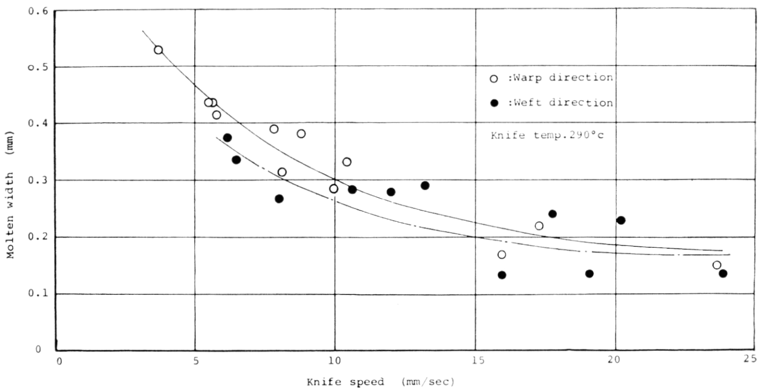


Fig. 3 Relation between molten width and knife speed

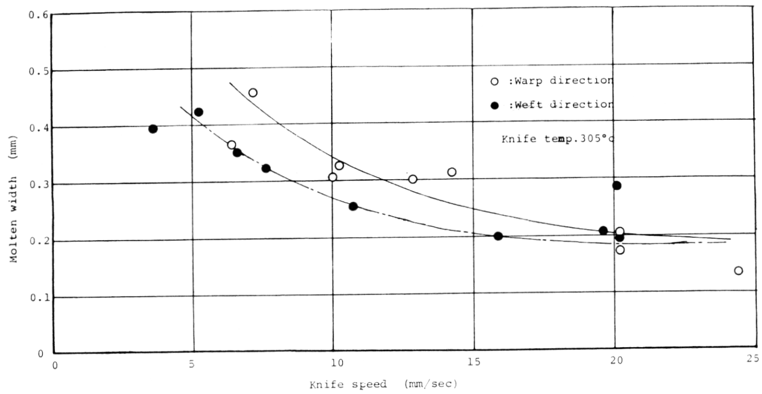


Fig. 4 Relation between molten width and knife speed

between knife and molten width in 260°C, 290°C and 305°C knife temperature and molten width is decreasing in accordance with knife speed, following secondary curves, and converging to the definite value respectivily over 20mm/s knife speed. This molten width is signify the size of heat affective zone by knife and, in case that the knife temperature is high, the influence of knife speed clearly has priority over heat influence, though heat influence is more or less great. The molten cutting is taken when proper knife speed in each knife temperature is slower than the reasonable value and mechanical cutting

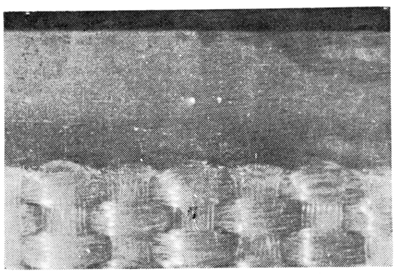


Photo. 5 Microphotograph of molten part
Knife temperature : 260°C
Knife speed : 2.8 mm/s
Molten width : 0.52 mm

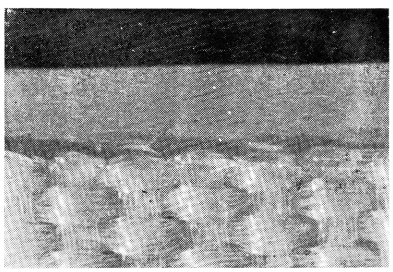


Photo. 6 Microphotograph of molten part
Knife temperature : 260°C
Knife speed : 6.8 mm/s
Molten width : 0.34 mm

is taken when it is faster. Photo. 5~7 are microphotographs of fabric taken when molten cutting is applied at 260°C, 6.8, 15.2mm/s knife speed. Judging from these results, the proper conditions of molten cutting are made in the part in which both factors of melting and

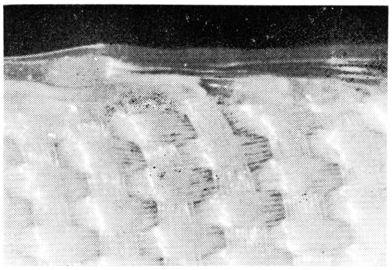
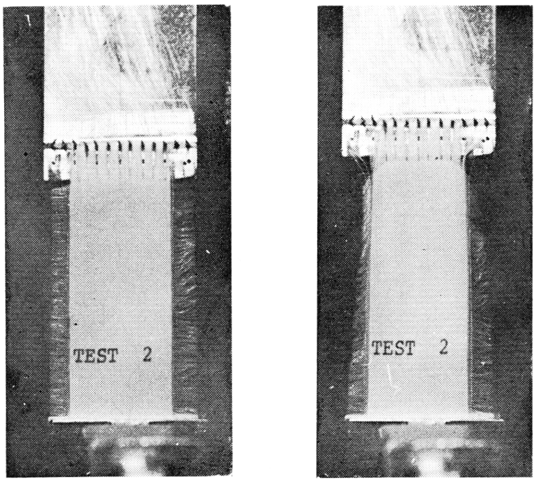


Photo. 7 Microphotograph of molten part
Knife temperature : 260°C
Knife speed : 6.8 mm/s
Molten width : 0.34 mm



(a) Just before tension test

(b) Just after break-down

Photo. 8 Scratch test of molten parts using the jig with needles

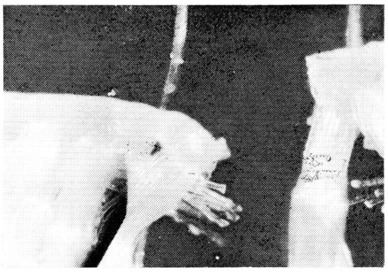
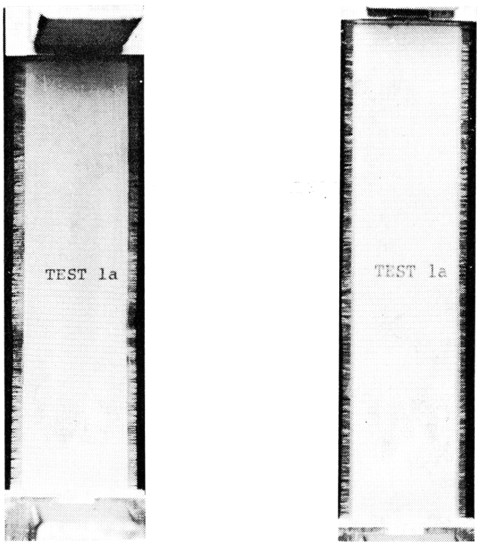
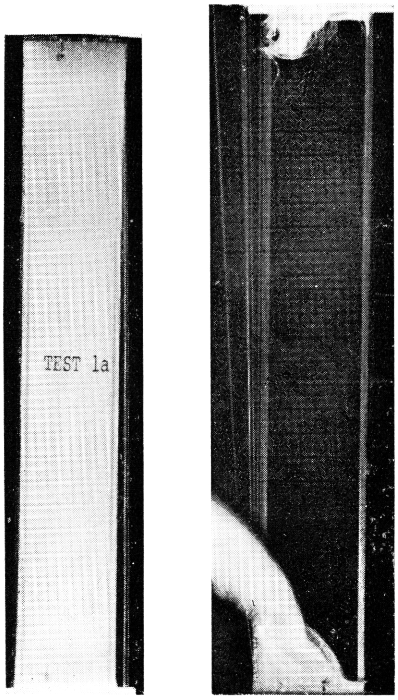


Photo. 9 Result of the scratch test





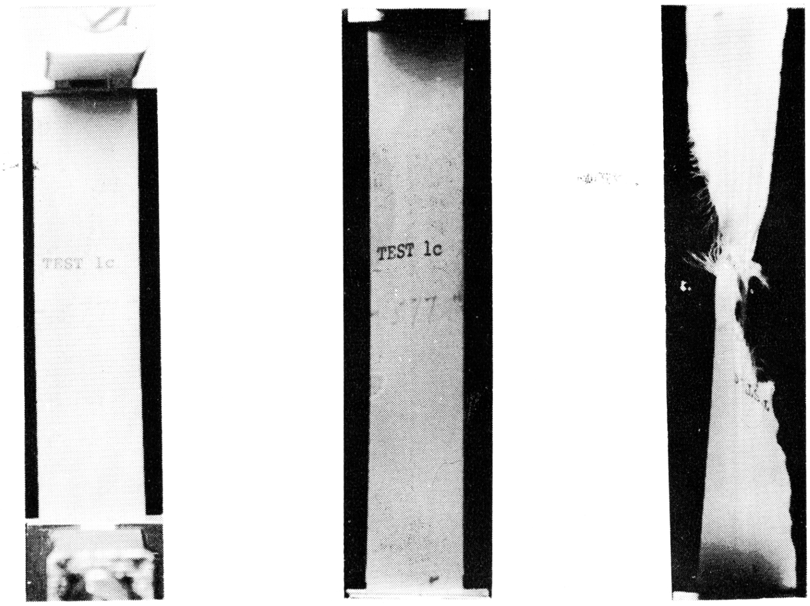
(a) Just before tension test

(b) Be frayed

(c) Just before break-down

(d) Just after break-down

Photo. 10 Fray test of mechanical cutting fabric mechanical cutting at comparatively low temperature exist. Therefore the proper speed is found at the curve changing point of upper figure, that is, 12mm/s at 305°C. The next to be explained is the analysis of fray of molten parts. The photo. 8 shows the scratch test of molten parts by using the jig with needles. The result is presented by photo. 9 in which one can observe that the breakage was produced without any fray at the part of needle touch. The photo. 10~11 presents the result of the fray test done



(a) Just before tension test　　(b) Just before break-down　　(c) Just after break-down

Photo. 11 Fray test of molten cutting fabric

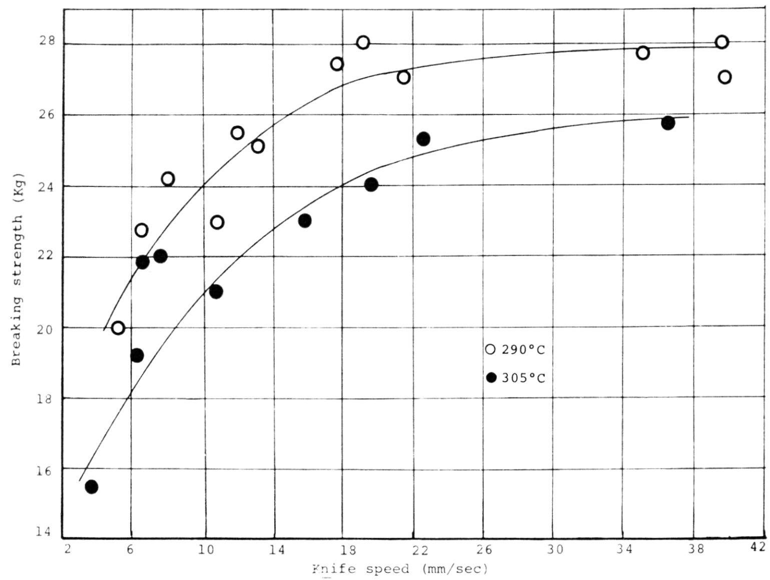
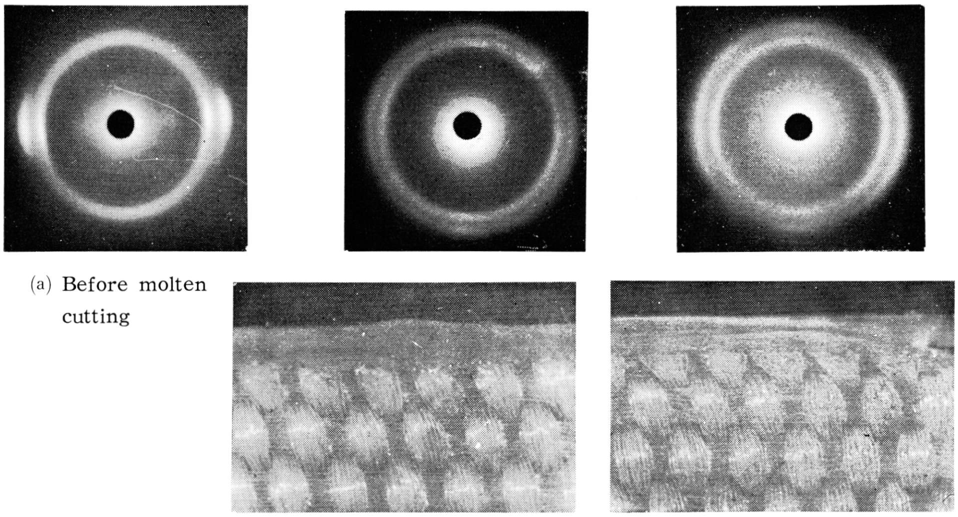


Fig. 5 Relation between breaking strength and knife speed

by the Instron Testing Machine as to the mechanical cutting and molten cutting. The fray is not seen as to the latter because of the strong breaking strength of the molten cutting. This might be explained by the fact that, in the mechanical cutting, there produces the maximum stress which causes the fray at the part of the edge and so it diminishes the load of stresses. In the molten cutting, stress is distributed equally in every part at the last moment due to the existence of molten parts. Fig. 5 shows the experimental results of the relationship between knife speed and breaking strength. The strength decreases step by step under 20mm/s knife speed and it converges almost to the constant value over 20mm/s knife speed. Comparing the above-mentioned fact with the Fig. 2～4, it can be said that molten width has a great concern with knife speed. That is to say, in case of low knife speeds, the molten width becomes wide enough for offering the state in which polymer presents the typical viscous fluidity, like film state, that cause the decrease of microorientation of load direction as well as that of polymer which bears the load. Photo. 12 presents X-ray diffraction photograph and microphotograph of molten parts, which clarify that, by conditions of molten cutting, the microstructure of molten width as well as molten parts are corrected. Fig. 6～10 are the



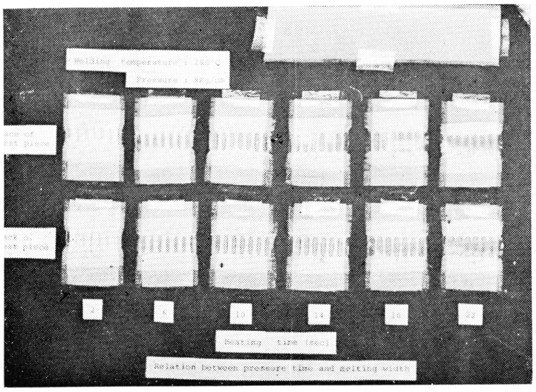
(a) Before molten cutting

(b) After molten cutting
Knife speed : 17.9 mm/sec
Molten width : 0.21 mm

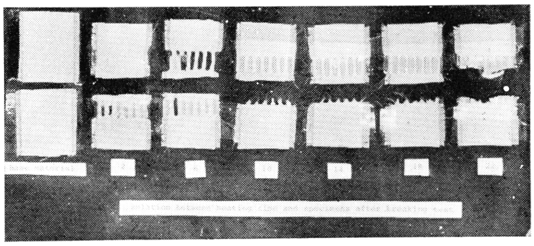
(c) After molten cutting
Knife speed : 23.5 mm/sec
Molten width : 0.17 mm

Photo. 12 Relation between microphotograph of molten cutting-parts and X-ray diffraction photograph

experimental results which show the welding conditions. Used specimens are the same as the case of molten cutting. These figures show the relation between compressed time of heating plate and tensile strength of welded fabric acquired under the condition of welding temperature being 280°C and compressed force being from 8 to 40kg/cm^2. Compressed plate has 13 spots, (2.0×10.0mm rectangular spots) in parallel at 4mm pitch at regularintervals. Fabric is installed on the rubber plate of anvil between teflon



(a) Just before tension test



(b) Just after tension test

Photo. 13 Welded specimens of thermoplastic cloth

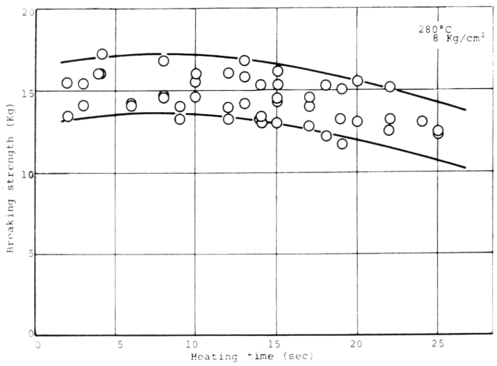


Fig. 6 Relation between breaking strength and heating time

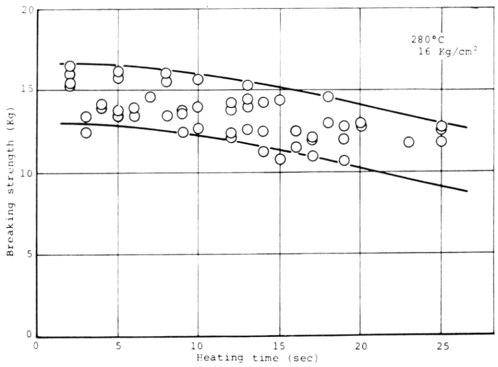


Fig. 7 Relation between heating time and breaking strength

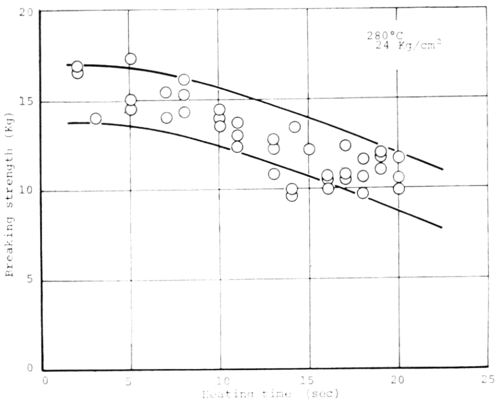


Fig. 8 Relation between heating time and breaking strength

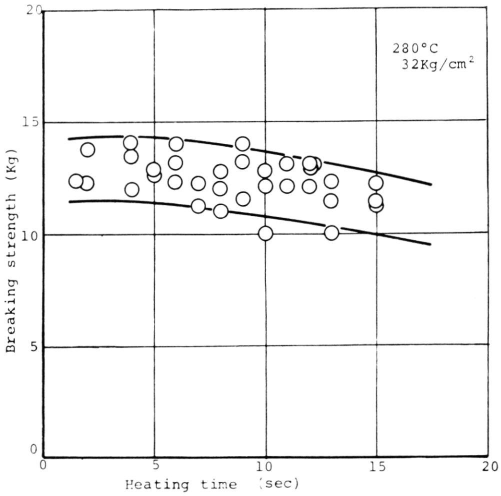


Fig. 9 Relation between heating time and breaking strength

clothes and compressed welded, and is welded from the upper by the heating plate. The relation between heating time and breaking strength at 20~36kg/cm² compressed force, 260°C, 270°C, 280°C, 290°C heating temperature is got in the preliminary experiment of which result requires 280°C welding temperature, but 249°C is desirable for the melting temperature of general molding nylon 6-6 [3].Studing Fig. 6~10 maximum strength is acquired at stronger part of compressed force, but at the same time, it shows downward trend line. The value of thermal conductivity will indicate high value and the penetration of mutual diffusion of segment in viscus fluid part will grow larger with the compressed power becoming stronger. But the maximum strength is weakened by the diffusion of the fluid to the circumference. In consequence, the stable welding is done under the welding condition of 8kg/cm² pressure and 5~12 sec heating time. Fig. 11~14 show the relationships between the compressed force (with the heating time 3~14 sec, at 280°C heating temperature) and welding strengh.

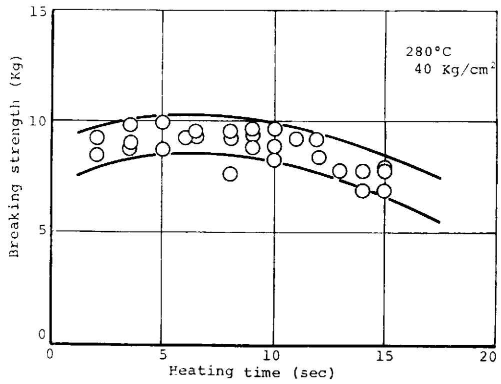


Fig. 10 Relation between heating time and breaking strength

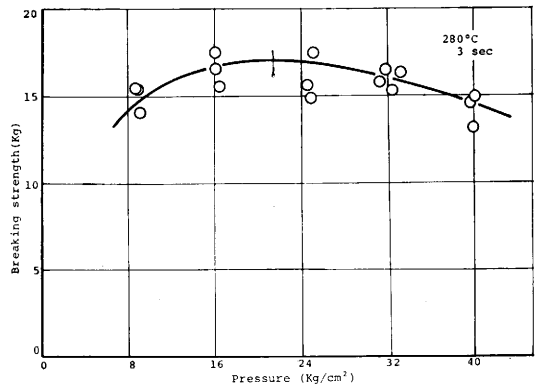


Fig. 11 Relation between pressure and breaking strength

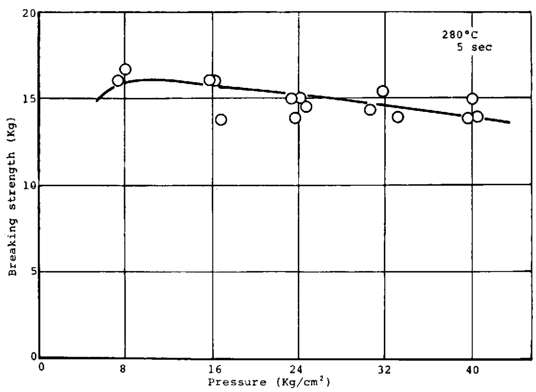


Fig. 12 Relation between pressure and breaking strength

CONCLUSION

The following summary can be made from the results of the present experiment.

1) It is clarified that there must be the possibility of fabric molten cutting.

1) It is advisable to take the indirect heating method with the knife of the maximum width.

1) The index function is found between knife temperature and the maximum knife speed possible for molten cutting.

1) The value of molten width as well as knife speed converge to the constant point near-by 20mm/s speed with the

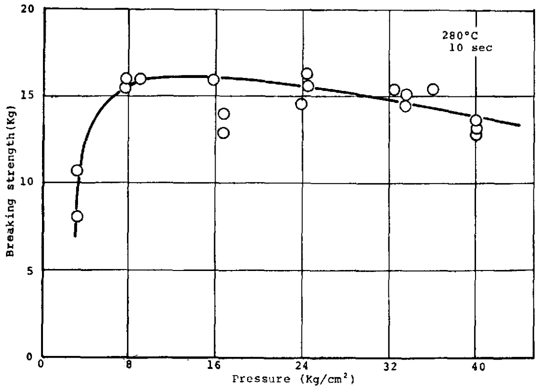


Fig. 13 Relation between pressure and breaking strength

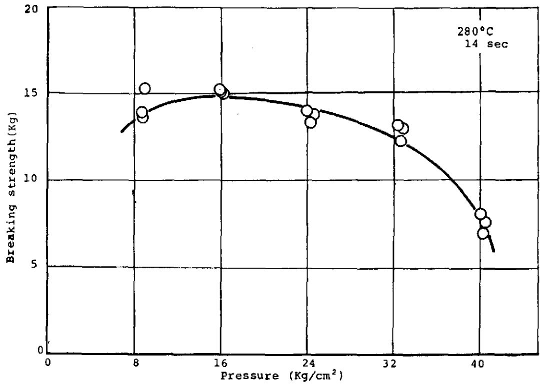


Fig. 14 Relation between pressure and breaking strength

increasing knife speed.

1) Proper result is acquired at 290°C knife temperature and 20mm/s knife speed.
1) The fray is not seen in molten parts.
1) It is clarified that there must be the possibility of fabric welding.
1) The stable result is acquired under 8 kg/cm² pressure and 5~12 sec heating time welding conditions.

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