The energy transfer mechanism in the hydroentanglement nonwoven process

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NONWOVENs
Nonwoven fabrics are assembled productions of natural and man-made fibres bonded together mechanically, thermally, chemically or by a combination of these techniques[1]. The nonwoven industry has huge growth potential compared to weaving and knitting which constitute the traditional textiles manufacturing sector. Production is much faster with nonwovens because fibres are converted to finished products in a single operation without having to be spun to yarns first as in weaving and knitting.

APPLICATIONS
Nonwovens can be engineered for numerous applications in a number of different areas with new applications continuously being found. Some of these include geotextiles, building, thermal and sound insulating materials, horticultural products, healthcare, automotive industries, agriculture, construction, and household amongst others[2].

MANUFACTURING NONWOVENs
The production of nonwoven fabrics follows a much shorter route or process from raw material to finished products compared to apparel fabric production through weaving and knitting. The short route of production is the main attraction of this section because of the high production speeds achieved, higher profit margins and the general versatility of the production process. The process involves initially laying loose fibres into a web which is then consolidated by any of the several methods available namely, chemical, spunbonding, thermal, needlepunching and/or hydroentanglement.

HYDROENTANGLEMENT
Hydroentanglement is a mechanical method of bonding fibres together to form a nonwoven fabric. The process relies on high pressure water jets shot from a series of parallel jet-heads (manifolds) to entangling the fibre web which is carried on a perforated belt producing a fibrous structure of high integrity. The high pressure waterjet impinging on fibres are the sources of energy for twisting and entangling them in a complex process of displacement and rearrangement which eventually forms a fabric from a cohesive network of fibres[3,4]. The hydroentanglement process is depicted in Figures 1 and 2.

MATERIALS AND METHOD
The experimental setup of the research comprised of a plant hydroentanglement production machine (Aquajet), a stand designed to hold in place a measuring device, an electronic tensiometer, a stand with an interface/software loaded for data recording, storage, evaluation and analysis. The measuring head by the stand allowed the measuring head to slide across the waterjet column so that the jet pressure could be determined at different positions. The setup is shown in Figure 3.

The energy transfer mechanism in the hydroentanglement nonwoven process involves producing a series of hydroentangled fabric while varying the manifold pressure, speed of the machine, different jet strip sizes and area weight of the fibre-web. For this part, the data of the hydroentangled fabrics produced from the machine at varying jet pressures was used. Three different levels of water jet pressure were selected in the manifolds for the development of filter samples. For filter sample 1 the jet pressures in bar were 10, 120, 200 for the first, second and third manifolds respectively. After hydroentanglement an acrylic chemical binder of 25% concentration was applied on the filtration nonwoven material and cured at 150°C. Dust particles in the range of 0.6-180 μm are fed at a constant rate to the filtration device and deposited on the samples having an area of 0.0095 m². The pore size and its distribution are measured on capillary flow parameters.

Advantages of nonwovens from hydroentanglement process[3,4]
• Higher strength and work products (tensile x elongation)
• Excellent absorbance properties
• High softness and smoothness
• High drop and fabric-like feel
• High permeability (air and liquid)
• Environmentally friendly since no additional chemicals used
• High productivity

RESEARCH OBJECTIVES
The main objective of the research is to address the high energy utilization of the non-woven production process which has limited investment in this technology in South Africa despite the nonwoven industry having a higher growth potential compared to other traditional textile fields (such as weaving). The research aims to quantify the energy supply, losses, and unit of the process, and ultimately develop an optimised system which can be utilized to manufacture nonwovens in an energy efficient way. Quantifying the energy used and impact forces responsible for entanglement has previously been a challenge.

OUTCOME
Preliminary results obtained are shown in Figure 4. The mean impact force of the water jets increased with an increase in manifold jet pressure. The results support the strong view of characterizing the hydroentanglement non-woven in terms of quantified energy transferred to the fibrous web. The energy usage of the system depends on the manifold pressures used because the largest amount of energy is consumed in pressurising the water but the transference of that energy to bond the fibres needs further investigation.

The surface topography and pore size and filtration distribution of the hydroentangled filter material produced at 120 and 200 bars of water jet pressure is shown in Figures 5 and 6 respectively.

refs.
1. www.edana.org
2. www.kashan.co.za

The ultimate objective of this study is to optimise the energy efficiency of the hydroentanglement process for non-woven production such that less energy is required in the process to produce fabrics and would then make this process more attractive for investment. Further investigations are currently on-going at the CSIR in Port Elizabeth.

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