THE STUDY ON A NUMERICAL CONTROLLED MULTI-PINS INSERTING SYSTEM FOR Z-PINNED COMPOSITE LAMINATES PREPARATION

Liping.Ding, Junwei.Qi, Biao.Yan, Jun.Xiao, Liwei.Wen

Material Science and Technology College, Nanjing University of Aeronautics and Astronautics, Nanjing, China

Introduction

The Ultrasonically Assisted Z-Fiber (UAZ) technique is the most common method to manufacture Z-pinned composite laminates and the manufacturing process is inserting Z-pins from a polymer foam carrier into prepreg laminates by an ultrasound horn. Compared with a couple of existing methods of inserting pins into a certain polymer foam, this paper proposes a numerical controlled multi-pins inserting device, which insert several continuous pultruded small diameter fiber reinforcing pins (less than 0.5mm) into the polymer foam synchronously. Firstly, based on the UAZ technique, a device is designed to meet the function requirements. Secondly, a control strategy matched with the above device is also designed through the kinematic and dynamic analysis. At last, function debugging experiments are done to verify the feasibility of this plan on the independent developed machine.

The inserting system research and development

Function analysis and the device design

Inserting process is shown in Fig. 1. The device should meet all these requirements as following:

1) Feed pins in designed length.
2) Since raw materials are continuous pins, the device should cut them into designed size with appropriate angle and minimize the damage to pins.
3) Insert multi-pins at the same time.
4) Insert pins into the foam in required depth.

Therefore, the device has to contain four parts: pin feeding driver, director, cutter and foam feeding driver as shown in Fig.2.

Kinematic and dynamic analysis

In order to insert pins into the foam in a precise length, pins and the rolls have to be relatively static when feeding pins. So pins' velocity, rolls' spindle speed should satisfy the following equation:

$$V(t) = R\omega(t) \tag{1}$$

$V(t)$ *-pins' velocity,* $\omega(t)$ *-rolls' spindle speed,*

R-radius of primer roll

v is a single-valued function of ω, so we can control inserting depth and pins' length by primer roll's spindle speed and rotation angle of driving motor.

Dynamic analysis for pin is shown as Fig.4. In order to feed pins successfully, parameters appearing in the diagram should satisfy following equation：

$$f \le \mu F \tag{2}$$

$$f \ge F_r \tag{3}$$

Control strategy

Choosing primer drive roll as research object, Create dynamic moment balance equation according to Fig.4.：

$$M(t) = (\mu F - F_r)R + \dot{J}(t)\omega(t) + J(t)\dot{\omega}(t) + M_f(t) \tag{4}$$

Where： $(\mu F - F_r)$ -feeding force on pins；

$M(t)$ -moment created by motor；

$J(t)$ -converted inertia of primer roll mechanism;

$\omega(t)$ -spindle speed of primer.

By derivation and fixing mathematical model, We can obtain transfer function $G_2(s)$. So, combined with motor's transfer function $G_1(s)$, we can obtain this system's transfer function(Fig.5.). Where,

$U(t)$ is control voltage of motor， $M(t)$ is moment created by motor， $V(t)$ is pins'velocity。

Conclusion

Fig.6. shows inserting flow of the process. And ,the prototype machine has already been designed and made. Further study and function debugging experiments is carrying out to verify the feasibility of this plan on the machine, and results will be shown in full-text paper.

Diagrams

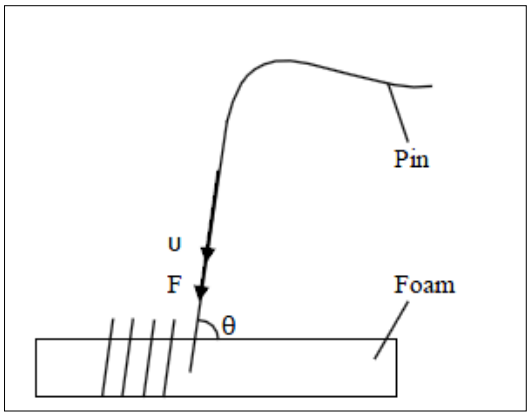

Fig.1. Process of inserting pins into foam

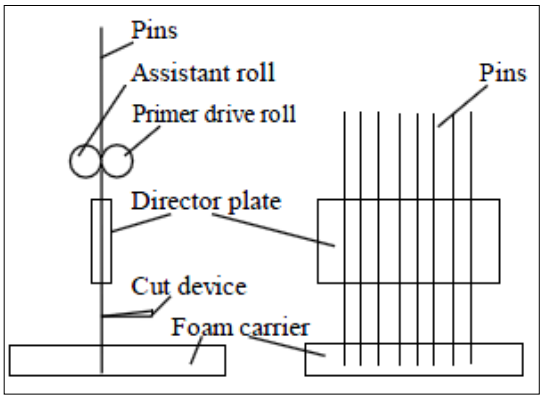

Fig.2. Diagram of inserting device

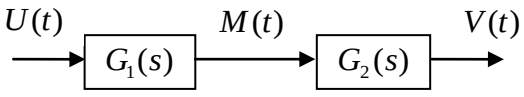

Fig.5.This system's transfer function

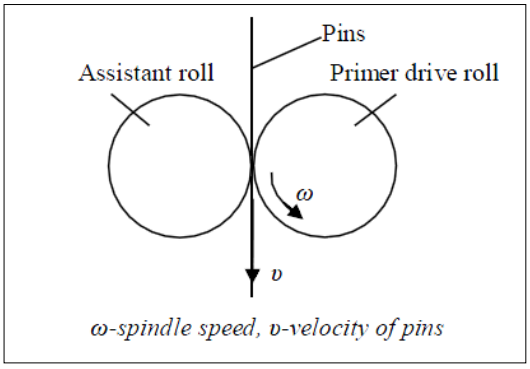

Fig.3. Kinematic analysis for pins when feeding them

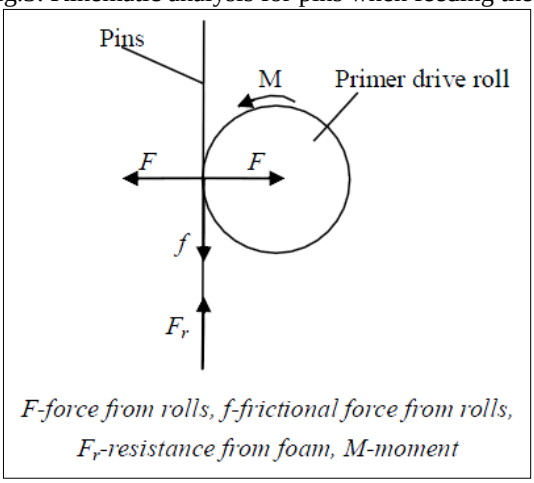

Fig.4. Dynamic analysis for pins

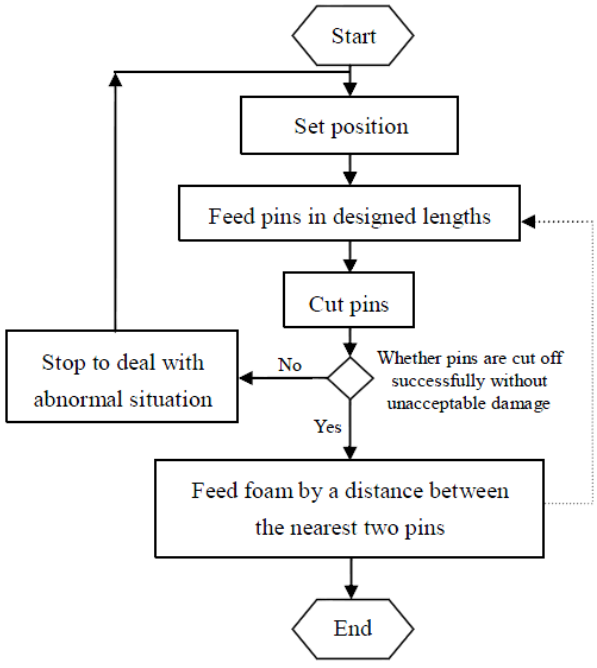

Fig.6. Insert flow chart