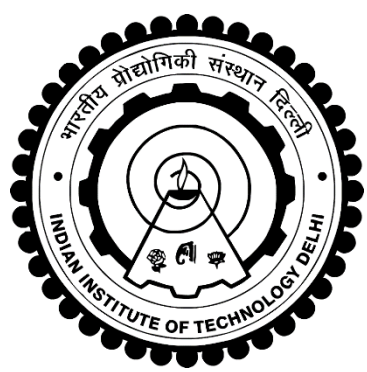
INVESTIGATING DYNAMIC RESPONSE OF THIN SHEET STRUCTURES TOWARDS HIGH RATE OF LOADING

DANISH IQBAL



DEPARTMENT OF APPLIED MECHANICS

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INVESTIGATING DYNAMIC RESPONSE OF THIN SHEET STRUCTURES TOWARDS HIGH RATE OF LOADING

by

DANISH IQBAL

submitted

in fulfilment of the requirements for the degree of Doctor of Philosophy

to the

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Dedicated to my Parents & Teachers

CERTIFICATE

The thesis titled **"Investigating Dynamic Response of Thin Sheet Structures towards High Rate of Loading"** being submitted by **Mr. Danish Iqbal** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy,** is a record of original bona-fide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which has attained the standard required for a Ph.D. degree of this institute.

The results represented in this thesis have not been submitted elsewhere for the award of any degree or diploma.

Dr. Vikrant Tiwari
Assistant Professor
Department of Applied Mechanics
Indian Institute of Technology Delhi

Place: New Delhi

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Danish Iqbal

Abstract

In this thesis a dedicated research effort has been made to understand the dynamic response of multilayered sheet structures under dynamic and impact loading conditions. Both numerical and experimental evaluations were utilized for the above stated purpose. In chapter 2 and chapter 3 of this thesis a standard SHPB investigation on the dynamic response of the homo-stacked and hetro-stacked configurations was performed. It was established that it is possible to achieve the necessary force equilibrium even for such complex specimens by using pulse shaping technique. A 2 *mm* thick disc of the specimen material was used as a pulse shaper for homo-stacked specimens. For achieving a force equilibrium in case of hetro-stacked specimens, a composite pulse shaper was employed. Utilizing Johnson-Cook based numerical model and values of inter-layer dynamic coefficients of friction, experimental results were successfully validated. Projectile impact response of monolithic and stacked sheet specimens was evaluated in chapter 4 and chapter 5. A single stage gas gun was instrumental in launching the projectiles while high speed 3D digital image correlation was used in capturing the full-field response of the specimens. The effect of projectile's nose shape and impact velocity on, both, the transient as well as post impact response were investigated in detail. Also, the effect of stacking sequence on the related perforation mechanisms of different projectile shapes was also studied. Closeness of the numerical predictions with experimental outcomes was verified using a suitable error measure criterion.

सार

इस थीसिस में, गतिशील और प्रभाव लोडिंग स्थितियों के तहत बहुस्तरीय शीट संरचनाओं की गतिशील प्रतिक्रिया को समझने के लिए एक समर्पित अनुसंधान प्रयास किया गया है। दोनों संख्यात्मक और प्रायोगिक मूल्यांकन उपर्युक्त उद्देश्य के लिए उपयोग किए गए थे। इस थीसिस के अध्याय 2 और अध्याय 3 में, होमो-स्टैक्ड और हेट्रो-स्टैक्ड कॉन्फ़िगरेशन की गतिशील प्रतिक्रिया पर एक मानक SHPB जांच की गई थी। यह स्थापित किया गया था कि पल्स शेपिंग तकनीक का उपयोग करके ऐसे जटिल नमूनों के लिए भी आवश्यक बल संतुलन प्राप्त करना संभव है। 2 मिमी मोटी डिस्क का उपयोग होमो-स्टैक्ड नमूनों के लिए पल्स शेपर के रूप में किया गया था। हेट्रो-स्टैक्ड नमूनों के मामले में एक बल संतुलन प्राप्त करने के लिए, एक समग्र पल्स शेपर को नियुक्त किया गया था। जॉनसन-कुक आधारित संख्यात्मक मॉडल का उपयोग और घर्षण के अंतर-परत गतिशील गुणांक के मूल्यों, प्रयोगात्मक परिणामों को सफलतापूर्वक मान्य किया गया। अखंड और स्टैक्ड शीट नमूनों की प्रोजेक्टाइल प्रभाव प्रतिक्रिया का मूल्यांकन अध्याय 4 और अध्याय 5 में किया गया था। प्रोजेक्टाइल को लॉन्च करने में एक एकल चरण गैस बंदूक का महत्वपूर्ण योगदान था, जबकि नमूनों की पूर्ण क्षेत्रीय प्रतिक्रिया को कैप्चर करने में उच्च गति 3 डी डिजिटल छवि सहसंबंध का उपयोग किया गया था। प्रोजेक्टाइल की नाक के आकार और प्रभाव के वेग पर प्रभाव, दोनों, क्षणिक के साथ-साथ पोस्ट-प्रभाव प्रतिक्रिया की विस्तार से जांच की गई। साथ ही, विभिन्न प्रक्षेप्य आकृतियों के संबंधित छिद्र तंत्र पर स्टैकिंग अनुक्रम के प्रभाव का भी अध्ययन किया गया था। प्रयोगात्मक परिणामों के साथ संख्यात्मक भविष्यवाणियों की निकटता को एक उपयुक्त त्रुटि माप मानदंड का उपयोग करके सत्यापित किया गया था।

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